THE NATIONAL GRID ELECTRICITY TRANSMISSION PLC (GRAIN TO TILBURY) COMPULSORY PURCHASE ORDER 2024

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Ministry of Housing,
Communities &
Local Government

UK Government

Clean Power 2030 Action Plan: A new era of clean electricity

December 2024

Any enquiries regarding this publication should be sent to us at CleanPower2030@energysecurity.gov.uk

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List of Abbreviations

AGR	Advanced Gas-cooled Reactor
BECCS	Bioenergy with Carbon Capture and Storage
CB	Carbon Budget
CCUS	Carbon Capture Usage and Storage
CfD	Contracts for Difference
CHP	Combined Heat and Power
CM	Capacity Market
DESNZ	Department for Energy Security and Net Zero
DPA	Dispatchable Power Agreement
DSR	Demand Side Response
DNOs	Distribution Network Operators
EEP	Energy and Emissions projections
H2P	Hydrogen to Power
H2PBM	Hydrogen to Power Business Model
gCO2e/kWh	Grams of carbon dioxide equivalent per kilowatt-hour of electricity
GBE	Great British Energy
GDP	Gross Domestic Product
GW	Gigawatt
LAES	Liquid Air Energy Storage
LDES	Long-duration Electricity Storage
MHHS	Market-wide Half Hourly Settlement
MoD	Ministry of Defence
MW	Megawatt
NESO	National Energy System Operator
NSIP	Nationally Significant Infrastructure Projects
NSTA	North Sea Transition Authority
OBR	Office for Budget Responsibility
Ofgem	Office of Gas and Electricity Markets
REMA	Review of Electricity Market Arrangements
SSEP	Strategic Spatial Energy Plan
TNUoS	Transmission Network Use of System

Foreword from the Secretary of State

We will usher in a new era of clean electricity for our country, with our plan to deliver the most ambitious reforms to our energy system in generations.

Since Russia's invasion of Ukraine, Britain has experienced a devastating cost of living crisis caused by our exposure to volatile fossil fuel markets. Every family and business in the country has paid the price and we remain exposed to future energy shocks. In an increasingly unstable world, our dependence on fossil fuels leaves us deeply vulnerable as a country – and that is true no matter where they come from.

But there is a solution: by sprinting to clean, homegrown energy, we can take back control from the dictators and the petrostates. That is why the Prime Minister has put delivering clean power by 2030 at the heart of one of his five missions and Plan for Change.

The age of clean electricity is about harnessing the power of Britain's natural resources so we can protect working people from the ravages of global energy markets. This plan will provide the foundation for the UK to build an energy system that can bring down bills for households and businesses for good. And it is also about creating the sort of country that we know people want to see - reindustrialising our heartlands with good jobs and tackling the climate crisis.

This plan sets out how the government will work with the clean power sector, including industry, trade unions, investors, policy makers and others to achieve our clean power goal. 2030 is just six years away, and we are under no illusions about the scale of the task ahead, but mission-driven government is about acting with urgency and determination to rise to the challenges we face.

That is why, in my first week in office, I appointed Chris Stark as Head of Clean Power 2030 in my department, leading a new mission control to drive progress towards our target. As a first step we commissioned the National Energy System Operator (NESO) to provide independent, expert advice on delivering clean power by 2030. Their advice, published earlier this year, showed that we can achieve our goal, protecting consumers and delivering a more secure energy system.

This plan builds on that advice, setting out the government's view of the pathway to 2030 and the steps needed to get there.

Ultimately, we need to move fast and build things to deliver the once-in-a-generation upgrade of our energy infrastructure Britain needs. In our first five months, we've already lifted the onshore wind ban, established Great British Energy, consented almost 2 GW of solar, delivered a record-breaking renewables auction, and kickstarted our carbon capture and hydrogen industries. This is the speed at which we will continue to work.

As the Prime Minister has made clear, clean power is an urgent priority for our country. The clean power sprint is the national security, economic security, and climate justice fight of our time - and this plan gives us the tools we need to win this fight for the British people.

Foreword by the Rt Hon Ed Miliband MP

Secretary of State for Energy
Security and Net Zero

Foreword from the Head of Clean Power 2030

Cleaning up our power system has long been understood as central to decarbonising the whole economy. With a clean electricity supply, the electrification of heat, transport and industry open up as routes to net zero. But the wider benefits of clean power have also become clearer. In Britain, we have pioneered policies to grow renewable industries, attract investment and deploy clean energy technologies at a scale that was once thought impossible. There is now a route to more stable energy bills for households and businesses, as they increasingly go electric. We have also experienced the harsh repercussions of Britain's over-reliance on fossil fuels, which left us badly exposed to the cost of globally traded oil and gas in the wake of recent global insecurity.

Achieving clean power is now a broader goal, key to a growing economy, our national security and improving our standards of living. We should be in a hurry to achieve it.

This year, Britain closed its final coal-fired power station, completing a successful transition from the most polluting energy source. Clean power by 2030 is our next milestone, but it requires us to act with much greater urgency. Britain has some of the world's greatest clean energy resources, but we have planning and consenting processes that are far too slow to build the infrastructure needed to exploit them. That must change.

NESO's recent analysis shows the pipeline of projects needed for clean power by 2030. Their pragmatic advice is that security of power supply can be provided if we maintain

Britain's fleet of gas power stations but reduce their use to no more than 5% of total generation. That clarifies the task: build the grid that Britain needs, overturning decades of delay; install clean sources of power at a pace never previously achieved; identify the energy mix needed for the 2030 power system and reorder the connection queue to achieve it; develop a flexible system that can accommodate and store Britain's renewable resources; deliver these benefits to consumers, people, households, and businesses as swiftly as possible.

This requires a mission-focus – industry and government working in partnership at pace. The steps in this Action Plan will reform planning and consenting processes, contract new renewable power generation at the scale required, encourage long-duration energy storage and first-of-a-kind flexible clean capacity and open the path to clean power and new opportunities for consumers to save.

For the first time, we will have eyes on a programme of clean power investment estimated to be around £40 billion per year for the next 6 years. That visibility allows a more active focus on removing the barriers to its achievement, supporting greater coordination of supply chains, with more UK-based production, and ensuring there are trained workers to meet the requirements across the country. This is the real prize, ensuring we are ready to meet the growth in electricity demand that we expect over the 2030s and 40s.

Britain's clean power mission is now underway.

Foreword by Chris Stark

Head of Clean Power 2030

Summary

Clean Power by 2030 will herald a new era of clean energy independence and tackle three major challenges: the need for a secure and affordable energy supply, the creation of essential new energy industries, supported by skilled workers in their thousands, the need to reduce greenhouse gas emissions and limit our contribution to the damaging effects of climate change. Clean power by 2030 is a sprint towards these essential goals.

We have accepted independent advice from the National Energy System Operator (NESO), on the energy infrastructure required to deliver Clean Power 2030. In a typical weather year, the 2030 power system will see clean sources produce at least as much power as Great Britain *consumes* in total over the whole year, and at least 95% of Great Britain's *generation*; reducing the carbon intensity of our generation from 171gCO_2e/kWh in 2023[1] to well below 50gCO_2e/kWh in 2030.

The path to 2030

Successful delivery will require rapid deployment of new clean energy capacity across the whole of the UK, reflecting the shared renewable ambitions of the UK, Scottish and Welsh Governments. In this plan, we are accepting government's central role in steering the creation of this new energy system, setting our expectations for the 2030 capacities of key technologies at national and regional level.

We have high ambition. That means 43-50 GW of offshore wind, 27-29 GW of onshore wind, and 45-47 GW of solar power, significantly reducing our fossil-fuel dependency. These will be complemented by flexible capacity, including 23-27 GW of

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[1] Department for Energy Security and Net Zero (DESNZ) (2024), '*Digest of UK Energy Statistics (DUKES) 2024*' (viewed in December 2024).

battery capacity, 4-6 GW of long-duration energy storage, and development of flexibility technologies including gas carbon capture utilisation & storage, hydrogen, and substantial opportunity for consumer-led flexibility[2].

In line with the NESO advice, this new capacity must be underpinned by the rapid delivery of 80 network and enabling infrastructure projects, most of which are already at an advanced stage of planning and development.

Over the period to 2030, security of supply will be protected with the maintenance of an expected 35 GW of unabated gas reserve capacity.

Growing our clean energy system in this way will see once-in-a-generation levels of energy investment – an estimated £40 billion[3] on average per year between 2025-2030, spreading the economic benefits of clean energy investment throughout the UK with the collaboration of the Scottish and Welsh Governments. These investments will protect electricity consumers from volatile gas prices and be the foundation of a UK energy system that can bring down consumer bills for good. Every choice we make will be scrutinised to maximise the impact it can have in reducing consumer bills.

The new industries and employment opportunities created by the huge investment ahead will also ensure there are lasting economic benefits from clean power throughout the country.

Delivering Clean Power 2030 also paves the way to decarbonising the wider economy by 2050 as we pursue the electrification of heat in buildings, transport, and industry. By 2050, annual electricity demand is likely to at least double. Clean power by 2030 prepares us for the rapid growth in power demand expected over the 2030s and 40s.[4]

Actions we are taking to accelerate delivery

To hold to our path to 2030, we know that the government must take radical action, quickly. This document sets out our first major steps towards clean power, in partnership with the Scottish and Welsh Governments, industry and the public:

Electricity Networks and connections

We need to reform the grid connections process and reduce the queue to connect, working with NESO and Ofgem to provide a framework through which NESO can work with Transmission Owners (TOs) and Distribution Network Operators (DNOs) to prioritise projects needed for 2030, while maintain a robust pipeline beyond 2030. Around twice as much new transmission network infrastructure will be needed in the nation's grid by 2030 as has been built in the past decade[5].

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[2] These voluntary offers of flexibility by energy consumers (whether households or industries) can also be referred to as demand side response (DSR) or demand flexibility.

[3] Undiscounted, 2024 prices. This includes £30bn investment in generation assets, and £10bn investment in transmission network assets. See the Technical Annex for more detail on how this was calculated.

[4] Department for Business, Energy & Industrial Strategy (BEIS) (2022), '*Electricity networks strategic framework, Appendix 1 – Electricity Networks Modelling*' (viewed in December 2024).

[5] National Energy System Operator (NESO) (2024), '*Clean Power 2030*' (viewed in December 2024).

Regulatory reform will ensure Clean Power 2030 is better integrated into planning and decision making, so investment can be made ahead of need and the time taken to build and deliver network projects can be reduced in line with 2030 requirements. This includes working with Ofgem to explore the appropriateness of tightening the incentives and penalties on electricity transmission owners and distribution network operators to drive the acceleration of network delivery. The Scottish and Welsh Governments are considering how their planning and consenting regimes will also integrate with Clean Power 2030.

An improved planning and consenting environment will accelerate the expansion and upgrade of transmission and distribution networks. We will consult on expanding planning consent exemptions to include low-voltage connections and upgrades in England, and engage with MHCLG on opportunities to provide further flexibilities for the consenting of electrical substations. It is essential that we engage effectively and thoroughly with communities that will host new transmission network infrastructure, so they can be a part of the change to our system and benefit from it.

The Scottish Government will shortly consult on the refresh of its Good Practice Principles for community benefits for onshore and offshore net zero energy infrastructure. The government's view is that communities that host clean energy infrastructure should benefit from it. As a first step, we will publish guidance to increase the quantum and consistency of Community Funds and support the launch of industry public communications campaigns to encourage public awareness on the importance of networks infrastructure in supporting net zero.

Planning and consenting

With a prioritised grid queue, we can signal key projects for clean power and speed up planning and consenting processes across Britain. We will ensure communities directly benefit from hosting new clean energy infrastructure. We know that the majority of 2030 clean power projects are already in the pipeline, and so there is therefore a major opportunity in rewiring the planning system and unblocking bottlenecks to ensure projects can receive timely decisions so they can get building.

We will do this first by upgrading the planning system itself, equipping organisations with the flexibility they need to manage the increased caseload it faces. This includes workforce reform and development as well as a commitment to reviewing resourcing within the system.

Next, we will ensure the system can prioritise 2030-critical projects. We will make 2030 a core priority in updated planning policy vehicles and guidance. We have brought onshore wind back in to the Nationally Significant Infrastructure Project (NSIP) regime. We will bring forward a Planning and Infrastructure Bill with measures to streamline the delivery of critical infrastructure in the planning process, and convene community, nature, and industry groups on complex projects to stress-test them prior to application. In line with Lord Banner's recommendations, we will also progress work exploring changes to the legal challenge process for major infrastructure projects.

We will ensure that a reformed planning system enhances the restoration of nature. We will do this by delivering the Marine Recovery Fund for Offshore Wind and are considering strategic mitigation approaches for onshore infrastructure in England. The UK government and the Scottish Government are also working together to establish a similar Marine Recovery Fund for projects in Scotland.

Devolved administrations are taking positive steps towards speeding up energy infrastructure planning and consenting too. In Wales, the Infrastructure (Wales) Act 2024 sets out the new consenting process for significant infrastructure projects, replacing multiple consenting processes in Wales with a single process. In Scotland, work is underway to secure the pipeline of future planners and increase skills and capacity within planning authorities. We are working closely with the Scottish Government on reform to deliver a streamlined and efficient legislative framework for electricity infrastructure consenting.

Renewable and nuclear project delivery

Addressing blockages to networks, connections and planning progress will significantly help us deliver the renewable capacity we need for 2030. But there are specific issues to address.

The Contracts for Difference allocation process needs to meet our 2030 ambitions and put an end to the stop-start failures of recent years. We need high levels of renewables to protect consumers and they need to be secured at the best price. Offshore wind has a particularly important role as the backbone of the clean power system.

Following discussions with industry and subject to further assessment, we are minded to implement a package of targeted reforms. We will consider changes to the information the Secretary of State can use to inform the final budget for fixed-bottom offshore wind, an auction schedule to improve transparency and predictability, and review auction parameters, including our approach to the reference prices used to estimate the budgetary impact of bids. To maximise the competitive process, we are also minded to relax eligibility criteria for fixed-bottom offshore wind projects so projects that have yet to obtain full planning consents can participate. We will consult on these changes ahead of Allocation Round 7.

We will leverage Great British Energy, and wider policy measures to support local and community-led renewable capacity, including for homes, businesses, public buildings and land, and shared spaces. Great British Energy will provide support to deliver the Local Power Plan, putting local authorities and communities at the heart of restructuring our energy economy. It will also align with NESO’s publications and the government’s response to identify locations for new generation projects on private land and undertake development on public land, unlocking scope for generation on government estates.

Solar panels are already an eligible measure in existing programmes like the Warm Homes Local Grant and Warm Homes Social Housing Fund, and we will provide further details on how else solar could be supported in the Warm Homes Plan after the second phase of the Spending Review. We will also assess the potential to drive the construction of solar canopies on outdoor carparks through a call for evidence next year.

We are also committed to nuclear, including the lifetimes of existing nuclear projects where possible, and the development of emerging low carbon and renewable technologies that will play an important role beyond 2030, continuing to recognise that the policy of the Scottish Government is not to support new nuclear developments in Scotland.

Electricity market reform

Reforming the electricity markets will support clean power generation and networks. Reform is vital in ensuring our market arrangements are fit for the 2030s and beyond. We must ensure that the market works in tandem with support schemes to deliver the right investment and operational signals and that any sector-specific barriers to deployment are addressed, to enable the huge volume of deployment that will underpin Clean Power 2030.

A significant increase in short-duration flexibility of 29-35 GW[6] across battery storage, consumer led flexibility and interconnection capacity from 2023 levels will reduce the amount of more costly generation and associated network infrastructure that needs to be built, whilst maintaining security of supply. Reforming the transmission network charging (Transmission Network Use of System (TNUoS) charges) is critical in order to enable the increased deployment of future generation.

The REMA Autumn Update outlines our ambition to conclude the policy development phase of the REMA programme by around mid-2025 and confirms that the timetable for REMA decisions will align with the timetable for the next allocation round (AR7) for the Contracts for Difference (CfD) scheme in order to reduce uncertainty.

Short-duration energy storage and flexibility

As we build an energy system reliant increasingly on variable renewables, improving the flexibility of the wider electricity system is key. A Low Carbon Flexibility Roadmap will be published next year, with new actions to drive clean power flexibility by 2030. We will introduce new market reforms to provide batteries and consumer-led flexibility with appropriate and fair access to, and utilisation within, relevant markets, and we will consult on how grid-scale batteries could be referenced in future planning reforms, and on including grid-scale batteries within the Environmental Permitting Regulations.

We will consider financing options for retrofit works, including batteries, in the Warm Homes Plan in England. We will consult to remove external display requirements for device meters from the Measuring Instrument regulations, and, in Summer 2025, we will publish a consultation on consumer engagement, including on how to help coordinate and amplify accurate messaging on consumer-led flexibility. We will also consider reform on the Maximum Resale Price and will introduce new Guaranteed Standards of Performance relating to smart metering in 2025.

We will respond to recent consultations on Energy Smart Appliance interoperability, a new licensing regime for service providers for consumer-led flexibility and load controllers, and tariff data accessibility. These will be followed up with detailed consultations on draft ‘first phase’ Energy Smart Appliance legislation, establishing minimum cyber security requirements for appliances in scope and a smart mandate for heat pumps; draft consumer-led flexibility service providers and load controller regulations and licence conditions, and measures to improve time of use tariff data accessibility. We will implement Capacity Market policy proposals, including permitted augmentation of storage, adjustments to Extended Performance Testing Requirements and making 3-year Capacity Markets agreements to low carbon technologies requiring no capital expenditure.

Long-duration flexibility

We are projected to need 40-50 GW[7] of dispatchable and long-duration flexible capacity in 2030 to support our power

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[6] See Table 1. This is the difference between the current capacity of batteries, interconnectors, and consumer-led flexibility, and capacities in 2030 under the DESNZ *‘Clean Power Capacity Range’*. Differences in total figures are due to rounding.

[7] The sum of with low carbon dispatchable power, unabated gas, and LDES capacities in Table 1, rounded to the nearest 5GW. Dispatchable technologies are ones which combust fuel to produce electricity and, by varying the rate at which fuel is burned, can respond to meet the needs of the grid with varying levels of flexibility.

system in extended periods of low renewable output. We are determined to drive the development of low carbon long-duration flexibility, which presents a substantial opportunity. We have announced Final Investment Decision for Net Zero Teesside, the world's first at scale gas power plant with carbon capture, and we are also developing a Hydrogen to Power business model which will de-risk investment and bring forward capacity. We also need to scale up deployment of pump storage hydropower and foster further innovation in more nascent long-duration storage technologies such as liquid air energy storage. The cap and floor scheme, which could open in Q2 2025, will support investment in the sector. Unabated gas will continue to play a back-up role throughout the transition to clean power, ensuring security of supply. This means that we will retain sufficient capacity until it can be safely replaced by low carbon technologies.

Supply chains and workforce

Clean power by 2030 is a signal to investors to locate in the UK and build strong domestic supply chains for key aspects of our clean power system. Actions to support and accelerate delivery will give developers greater route-to-market certainty, but we will go further, including with the forthcoming Industrial Strategy, which will include a sector plan for clean energy industries. We will convene a new supply chains and workforce industry forum for key Clean Power 2030 sectors, including trade unions, to develop a deep understanding of system-level supply chain and workforce planning needs for Clean Power 2030 delivery and devise targeted collective actions to ensure they are met. The Clean Industry Bonus will support manufacturing in coastal and energy communities and cleaner, more sustainable supply chains, while increased transparency and predictability in future Contracts for Difference allocation rounds will support investment. The National Wealth Fund will focus at least £5.8 billion of its capital on green hydrogen, carbon capture, ports, gigafactories, and green steel, while Great British Energy will support the growth of clean power supply chains around the UK.

The clean power transition also needs a skilled workforce, with thousands of new jobs throughout low carbon sectors. Details of the Clean Energy Skills Challenge have been published alongside this Plan. The Office for Clean Energy Jobs will work with the sector, trade unions and the devolved governments to support regions transitioning from carbon-intensive industries to clean energy sectors, to ensure jobs are high quality, with fair pay, favourable terms, and good working conditions. This work includes targeted interventions to reskill and upskill workers across the economy, supporting access to training schemes, and promoting the opportunities of clean energy jobs so that a lack of skilled workers does not become a bottleneck in the achievement of our Clean Power ambition.

How we will work, as government and with everyone involved, to deliver

The Clean Power 2030 Unit will look across delivery of the key 2030 projects, working to identify blockages and ensuring that the clean power programme stays on track.

To do this we will draw together a mix of skills and experience from government and the clean power sector, underpinned by an Advisory Commission of leading figures from across industry and academia. The Unit will work closely with those involved in practical delivery, including the devolved governments, to cut through issues quickly and to build a comprehensive view of the power infrastructure currently in development.

This insight, coupled with a strong underlying data capability that will bring together data and insight from across government and the clean energy sector, will help understand what is likely to be delivered, by when, and quickly identify emerging challenges. This will help the Unit take rapid action wherever it is needed to ensure delivery.

This Action Plan is our first major step towards Clean Power by 2030. The coming months and years will see a new programme of activity emerge, relying on the work of a wide range of businesses, many parts of government at central, regional and local level across England and the Devolved governments, the third sector, communities, and individuals.

Why Clean Power by 2030?

Our whole way of life relies on our energy supply. But the world is changing, and the way we have powered our nation for decades, built around oil, gas, and coal is no longer something we can take for granted. Millions of us have experienced hardship in recent years, as the dangers of relying too much on oil and gas, in an increasingly volatile world, have become all too clear.

The solution is clean homegrown power. The answer to some of the biggest challenges we face – building an energy system that is affordable for the long term, keeping our supply secure, and cutting our emissions before it's too late – now all point in one direction: towards the clean power sources that have become the core of modern energy systems.

A clean, affordable, and secure system is a realistic prospect – and we must seize this opportunity. The National Energy System Operator has produced independent advice which indicates what infrastructure we will require to deliver Clean Power 2030.

If we get this right, this is a huge opportunity for our country. We can protect households and businesses from price shocks, we can attract substantial amounts of investment and employment, and we can set the stage for further growth as we decarbonise our heat and transport – while also building a path towards 2050 and beyond.

We start with some sizeable advantages. As a nation we pioneered several of the renewable technologies that have become the low-cost workhorses of a modern energy system. We have an abundance of natural resources, and so the gradual decline of our oil and gas reserves can be more than offset by our substantial wind and solar energy resource.

But to get this right we need to act – and act quickly – because 6 years is a short time in building energy infrastructure. We are not alone in wanting to rebuild our energy system and are competing with other countries for investment and to secure supply chains.

Many of the new investments that will be part of our 2030 power system have already started their journey and a core focus of our work will be ensuring that an ambitious pipeline of new projects with potential to be up and running by 2030 are successfully delivered.

This plan therefore sets out practical actions across every part of the power system, where we are determined to remove the blockages that have, for too long, added cost and delay to the development process. These actions will accelerate delivery in many of the core generation areas – removing barriers, untangling blockages, and accelerating support. Some of our priorities will not come as a surprise: we have to put an end to interminable delays in the system that mean it can take over a decade to develop and build renewables projects. We also need to reform the connections queue process, where the current queue adds up to 739 GW.[8]

However, we are also acting to raise the level of ambition right across the system, as well as taking action to deliver the industrial supply chains, and the skilled workforce, that we need to build a vast amount of new infrastructure.

The energy consumer is at the very heart of Clean Power 2030, because as a government our core aim is making sure everyone has a reliable and affordable energy supply, in a way that protects our environment and quality of life. We also want everyone to have the benefit from the new power sources and technology that can keep bills down for good.

This means a real change to how we deliver as a government. We will now be working with specific projects on the ground to understand their ongoing development in detail, and we'll be ready to do what it takes to keep key investments on track. This also means we'll be working across traditional department lines, and that we'll be ready to adapt and learn as we go, developing new actions wherever we need them to support delivery.

Clean Power 2030 supports the wider missions of this government, to make working people better off by delivering economic growth for every part of our country. Clean power also contributes to improving health outcomes for the British people, including through reducing air pollution.

Clean Power 2030 will set in motion an age of electricity. A time where we have an abundance of clean, homegrown energy, backed by a host of British companies in all four corners of the country. It's about fixing the foundations of our economy so we can protect businesses and families from increased energy bills resulting from volatile global gas markets, give ourselves

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[8] Including Demand. Correct as of end-October 2024. Connections data is published monthly by the Connections Delivery Board.

a secure energy supply for the long term, and create stable and well-paid new jobs and growth in our manufacturing heartlands.

This is the real story of Clean Power 2030; transforming the way this country invests in and builds its future.

	Impact of Clean Power 2030
Consumers	CP2030 will protect and empower consumers by: • Helping to shield consumers from international energy price spikes by reducing our reliance on fossil fuels. • Providing the foundation to build an energy system that can bring down bills for households and businesses for good. • Ensuring communities benefit from hosting new clean energy infrastructure. • Developing more consumer-friendly digital products and services to increase consumer understanding and control over their electricity products, such as apps to manage smart appliances. By increasing the use of digital technologies, consumers can choose to save money on their bills by using appliances when electricity is cheaper or via automated systems managing this on their behalf – for example charging their car overnight and selling excess energy back to the grid, or programming their smart electronic appliances such as dishwashers to complete their cycle within cheaper timeslots. • Increasing consumers' ability to reduce their global footprint by making green spending and lifestyle choices easier/the default. • Increasing consumers' energy independence through the rollout of rooftop solar panels alongside domestic batteries, EV charging, heat pumps, and other green technologies to cut down on the cost of bills and to flatten the peak demand curve. • Reducing our reliance on fossil fuels, which contribute to air pollution - cleaner air will benefit both human health and wildlife.
Business	CP2030 will provide stability for businesses and confidence for investors by: • Accelerating the transition to clean energy sources to create a more stable environment that helps create growth, minimises energy-price-led inflation and also helps shield businesses from energy price spikes. • Giving developers greater route-to-market certainty through a clear national plan for our power system and reforming our planning and grid connections processes, enabling developers to plan and mobilise the supply chains and workforce they need to deliver new infrastructure, unleashing £40 billion of investment per year. • Maximising domestic opportunities for clean energy supply chains, including mobilising investment into the clean power sector and through the upcoming Industrial Strategy where clean energy industries are a priority growth sector. • Stimulating local economies through investment in innovative clean energy projects and accompanying employment opportunities.
Workers	CP2030 will help workers by: • Playing a key part in supporting hundreds of thousands of jobs, as part of the wider transition to net zero • Stimulating skilled new jobs and economic opportunities across the country, including our industrial heartlands. • Boosting awareness of well-paid, high quality jobs in clean energy sectors, in collaboration with the Office for Clean Energy Jobs

Protecting energy consumers for good

The UK's dependence on fossil fuels has left us vulnerable to unstable energy prices, a vulnerability that was exposed by Putin's invasion of Ukraine and saw the electricity price cap increase by over £1,300 in a year, peaking at £2,000[9]. Government spent over £44 billion supporting energy bills between October 2022 and March 2024, the most ever provided to subsidise household bills in UK history[10]. By producing the clean energy we need at home and being more efficient in how we use it, we can boost our energy independence. This transition is the only way to protect businesses and families for good from increased energy bills resulting from volatile global gas markets.

By accelerating the switch to domestic renewable electricity sources and accelerating the application of clean electricity to the wider energy system, we will be able to reduce our reliance on fossils fuels faster. This enhances energy security, making the UK less vulnerable to global market disruptions or geopolitical tensions that affect energy prices.

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[9] Office of Gas and Electricity Markets (Ofgem) (2024), '*Energy price cap (default tariff) policy*' (viewed in December 2024).

[10] National Audit Office (NAO) (2024), '*Report – Value for Money – Energy bills support: an update*' (viewed in December 2024).

Central to delivering decarbonisation in the energy system is ensuring it benefits consumers and businesses.

By building a diverse energy system, we can make the most of our abundant natural resources to protect consumers from future price shocks. However, this mission will not be delivered from Westminster alone – local communities, the clean power sector (comprising industry, academia, and investors) and local government also have a key role to play, and we will empower them to participate in and benefit from decisions on local infrastructure.

We want to ensure that consumers are supported to make choices that benefit them, which will help us deliver on our net zero ambitions.

Market reform and the rollout of flexible technologies will give consumers greater control over their energy bills. For example, consumers might see the impact of Clean Power by installing solar panels which give them greater energy independence or having smart flexible technologies, such as electric vehicles or heat pumps, which enables consumers to take advantage of cheaper tariffs at different times of day.

The government's Warm Homes Plan will provide help for people, including those from fuel poor households, to live in better insulated homes with the ability to take advantage of these new flexible home heating technologies.

Ensuring energy security

When Putin cut off most gas supplies to Europe in 2022, energy prices for families and businesses in Great Britain increased dramatically, even though Russia provided only 4% of our gas imports[11]. Our dependence on globally traded gas for heating and electricity generation was the reason: so long as our energy supply can be weaponised by others, we will remain exposed to global supply shocks and price surges.

In an era of heightened geopolitical risk, switching fossil fuelled generation for homegrown clean energy from renewables and other clean technologies offers us security that fossil fuels simply cannot provide.

We understand that this is not always a like-for-like exchange. As we aim for clean power by 2030, it is crucial we complement renewables with flexible capacity to ensure we can deliver clean power no matter the weather. Historically, unabated fossil fuels have provided this flexibility, but that leaves us exposed to the rollercoaster of fossil fuel prices. This Action Plan sets out a pathway towards deploying low carbon flexible capacity technologies like long-duration electricity storage, power carbon capture, usage and storage (CCUS), and hydrogen to power, working alongside technologies such as nuclear generation, which provide round the clock reliable power.

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[11] BEIS (2022), '*Energy Trends special article – Energy imports from Russia*' (viewed in December 2024).

Our 2030 mission will grow the UK’s overall generation capacity and expand our network infrastructure so that we can safely and securely meet changing demand patterns in 2030 and beyond, driven by consumers’ greener choices through the net zero transition. Taking account of this generational change in the UK’s energy system, we are improving electricity market arrangements to ensure secure supply in a clean system transition, as outlined in further detail in the REMA Autumn Update.

As we rapidly deploy new infrastructure, we will maintain high levels of resilience and security – including to severe weather events which are expected to increase in intensity and frequency as a result of climate change, and in managing threats to our national security, such as cyber threats, as our energy system becomes increasingly interconnected. The government has empowered the independent National Energy System Operator with the responsibility to carry out resilience functions across the electricity and gas systems and we will continue to work with industry, regulators and other stakeholders to improve and maintain the resilience of old, new, and future energy infrastructure.

Our energy system must meet demand while protecting families and businesses from global supply shocks and volatile prices. That is what energy security means to this government, and that is what this Clean Power Action Plan delivers.

Our pathway to 2030

Defining the Clean Power target

Clean Power means that by 2030, Great Britain will generate enough clean power to meet our total annual electricity demand, backed up by unabated gas supply to be used only when essential.

In line with independent advice from the National Energy System Operator (NESO), our clean power target means transitioning to an electricity system with the following characteristics in a typical weather year:

- Clean sources produce at least as much power as Great Britain *consumes* in total, and;
- Clean sources produce at least 95%[12] of Great Britain's *generation*.

We expect delivering a clean power system with these characteristics will make Great Britain a net exporter of electricity and will reduce the carbon intensity of electricity generation from 171gCO_2e/kWh in 2023[13] to well below 50gCO_2e/kWh in 2030, well within the Climate Change Committee's Carbon Budget 6 advice[14]. The figures below visualise this target and set out the current generation mix.

To achieve the mission, we will aim to deliver above this ambition where the system and consumer benefits align so that potential challenges in some areas of clean power delivery can be compensated by deployment elsewhere.

Delivering this target aligns with our ambitious 2030 Nationally Determined Contribution[15] and will help us meet Carbon Budget 6.

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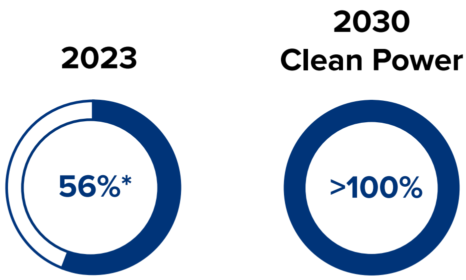
[12] See the technical annex for more detail on the definition of 2030 Clean Power.
[13] DESNZ (2024), '*DUKES*' (viewed in December 2024).
[14] Climate Change Committee (CCC) (2020), '*The Sixth Carbon Budget*' (viewed in December 2024).
[15] BEIS (2022), '*UK's Nationally Determined Contribution*' (viewed in December 2024).

Metric 1a:

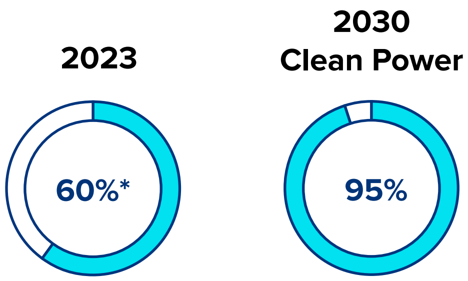
Clean sources produce at least as much power as Great Britain consumes in total.



▼ 44 points below target

Metric 1b:

Clean sources produce at least 95% of Great Britain's generation.



▼ 35 points below target

* This is the closest available official statistic to the clean power 2030 definition at the point of publication. This statistic is for the UK rather than Great Britain and includes gas CHP in the denominator and EfW in both the numerator (the proportion assumed to be from bioenergy) and denominator. Official statistics will be reviewed at a future date to allow us to accurately track delivery.

Metric 2:

Emissions intensity of well below 50gCO2e/kWh by 2030

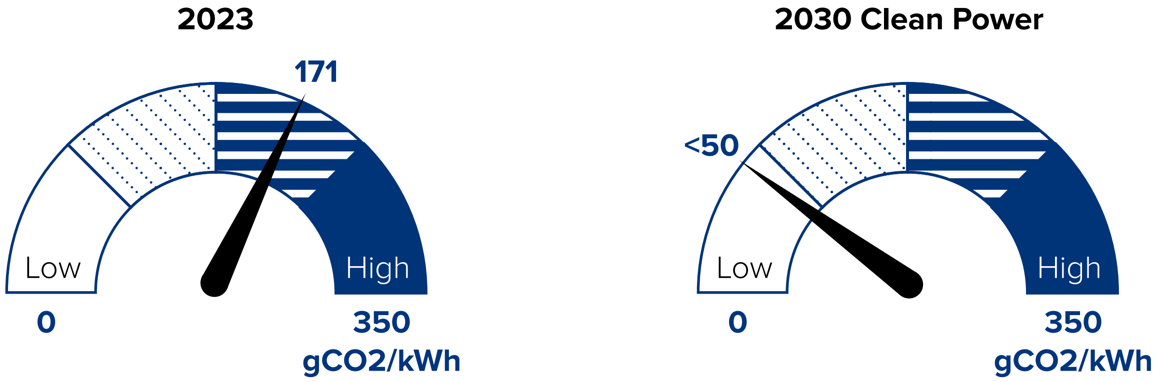
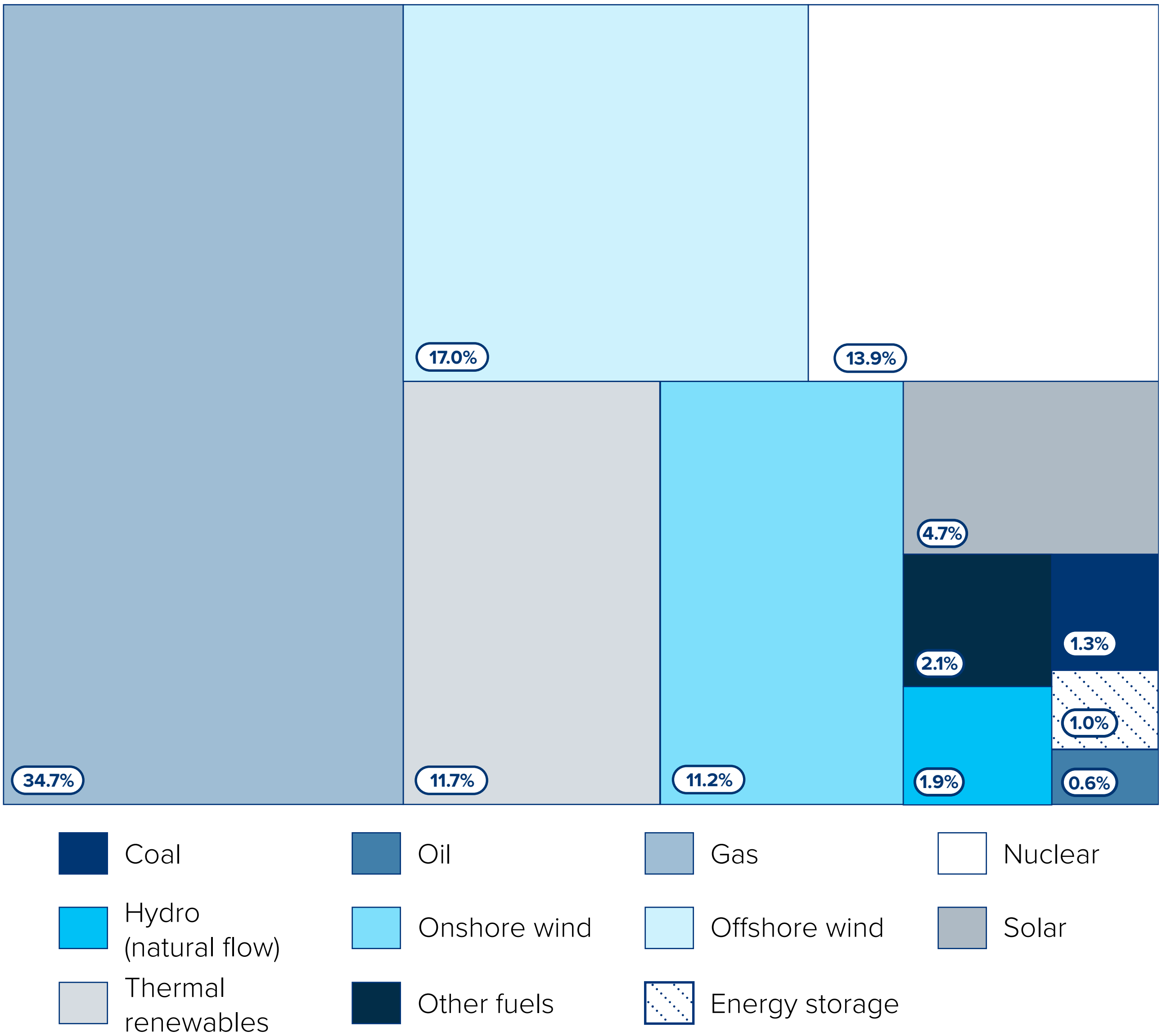


Figure 1: Shares of electricity generated (GWh), 2023



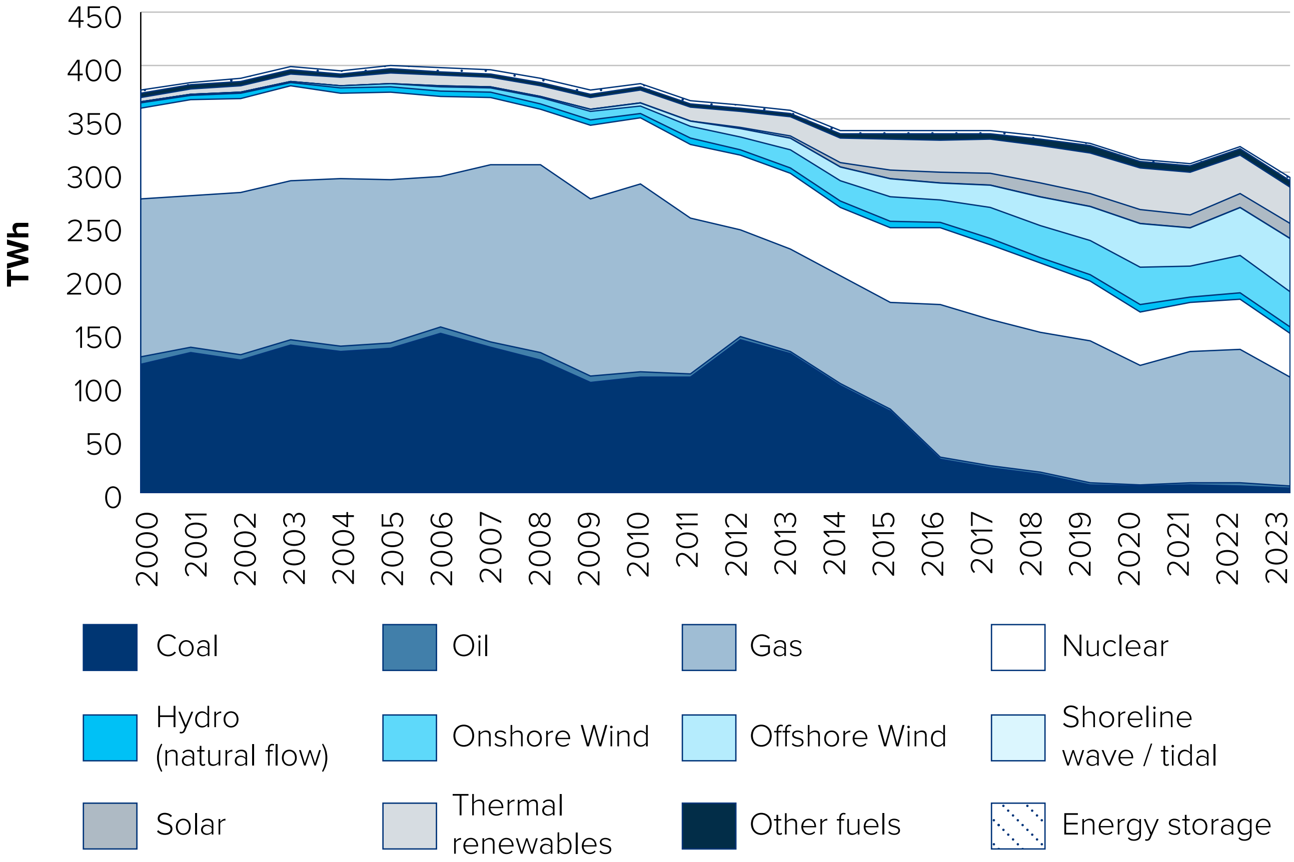
Source: DESNZ (2024), 'DUKES'

Note: The shares of electricity generated are on a UK basis.

What a Clean Power system will look like

Whilst the expansion of renewables in the power system has reduced the share of fossil fuel generation to date – see figure 2 – all routes to a Clean Power system will require mass deployment of offshore wind, onshore wind, and solar[16]. Securing affordable,[17] homegrown renewables means we will be able to run our power system for increasing periods on low carbon generation, with renewables providing the vast majority of generation, and nuclear continuing to deliver a backbone of vital firm low carbon power.

Figure 2: Electricity generation mix (TWh), 2000-2023



Source: DESNZ (2024), 'DUKES'

Note: The generation mix is on a UK basis.

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[16] NESO (2024), '*Clean Power 2030*' (viewed in December 2024).

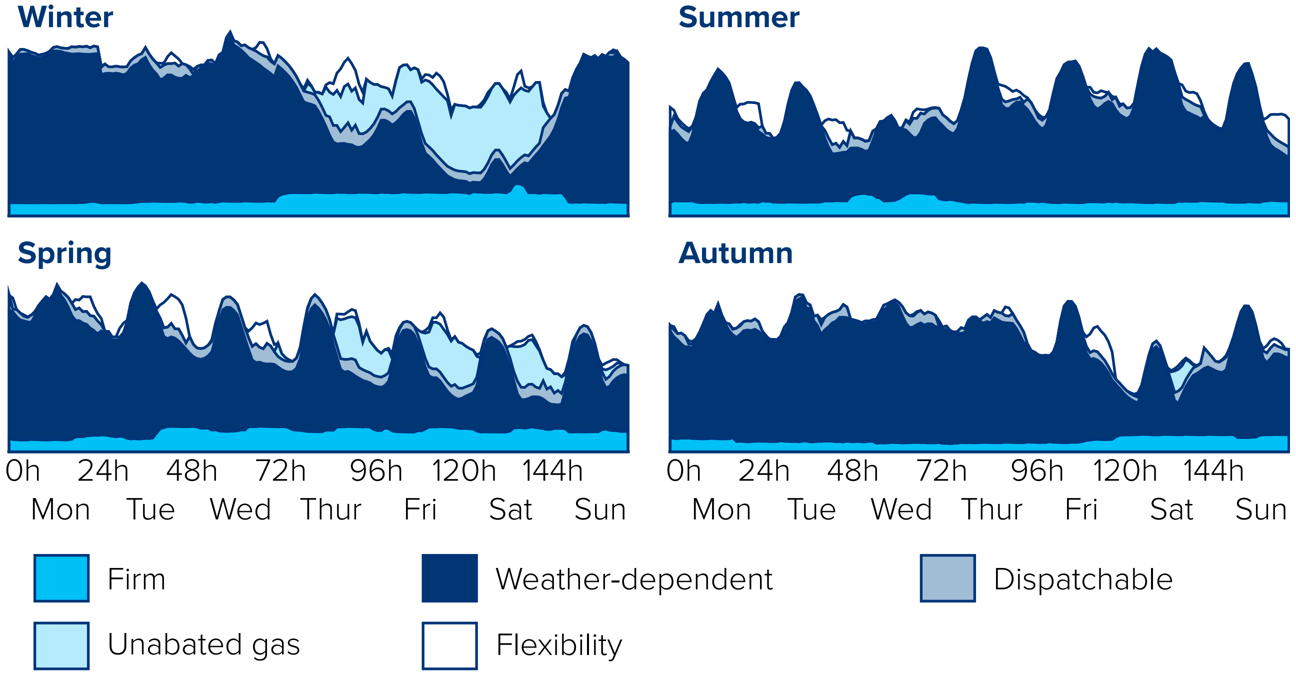
[17] BEIS (2023), '*Electricity Generation Costs 2023*' (viewed in December 2024). The published evidence demonstrates that intermittent renewable electricity sources like offshore wind, onshore wind and solar PV are the cheapest sources of new electricity generation to build and operate.

However, there will be periods over the year, mostly during winter and autumn, where weather conditions and higher electricity demand mean our fleet of renewables and firm generation alone are not able to meet electricity demand. Many of these periods will only be for a few hours. These short periods offer opportunities for flexible, low carbon solutions to meet our needs.

Where renewables alone are unable to meet demand for longer periods, we will enable a suite of technologies to be deployed and maintained to provide longer-duration power capacity. This could be a combination of pumped hydro storage, first-of-a-kind low carbon dispatchable technologies like gas CCUS or hydrogen to power (H2P), or innovative technologies like liquid air energy storage (LAES).

Whilst deploying of longer-duration technologies will help reduce unabated gas generation, we recognise the importance of gas capacity to maintain security of supply. We will see a fundamental shift in the role and frequency of unabated gas generation, moving from generating almost every day of the year, to an important backup to be used only when essential, with generation decreasing as we move towards 2030 – see figures 3-5. This is consistent with NESO's view[18] and aligns with the Climate Change Committee's advice[19] that maintaining gas capacity to use as backup is consistent with a fully decarbonised power system.

Figure 3: Modelled 7-day hourly generation profile in 2030 in the NESO 'Further Flex and Renewables' Scenario (MW)



Notes: Firm includes nuclear, hydro, CHP and waste. **Weather-dependent** includes onshore wind, offshore wind and solar. **Dispatchable** includes biomass, pumped hydro, gas with CCS and hydrogen to power. **Flexibility** includes batteries and residential flexibility. Chart only shows when flexibility is discharging, not charging.

Source: NESO (2024), 'Clean Power 2030'

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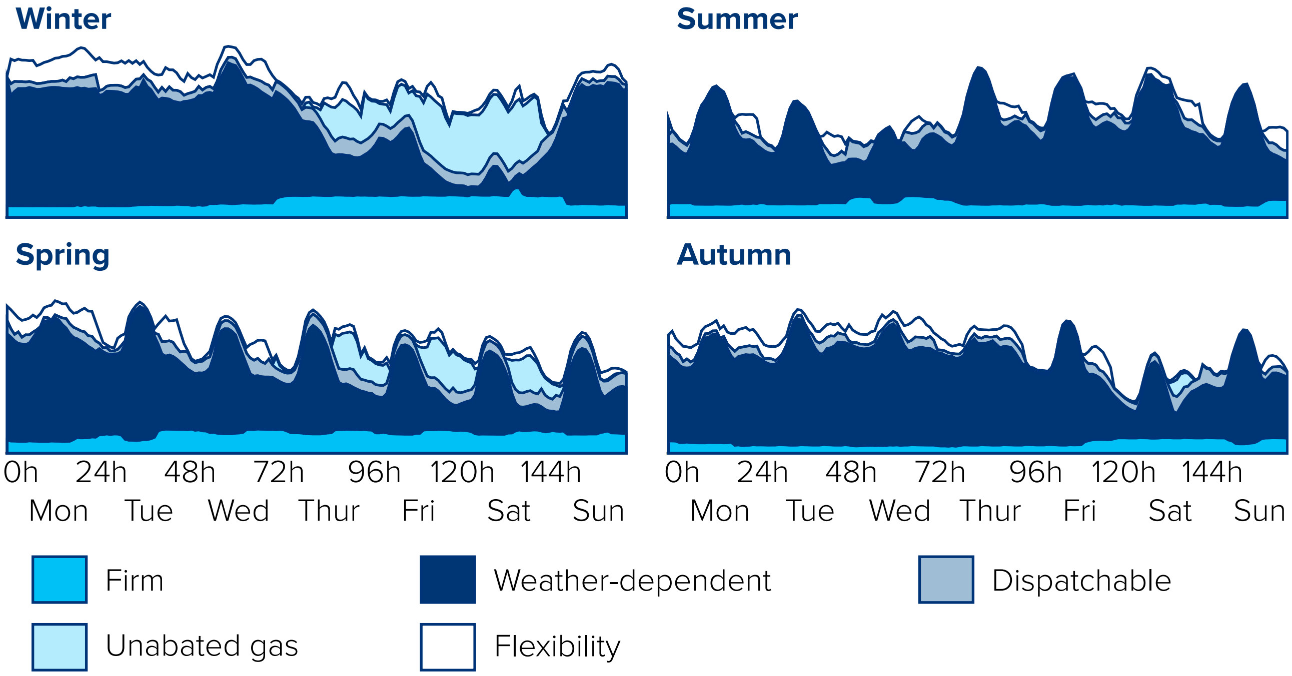
[18] NESO (2024), '*Clean Power 2030*' (viewed in December 2024).
[19] CCC (2023), '*Delivering a reliable decarbonised power system*' (viewed in December 2024).

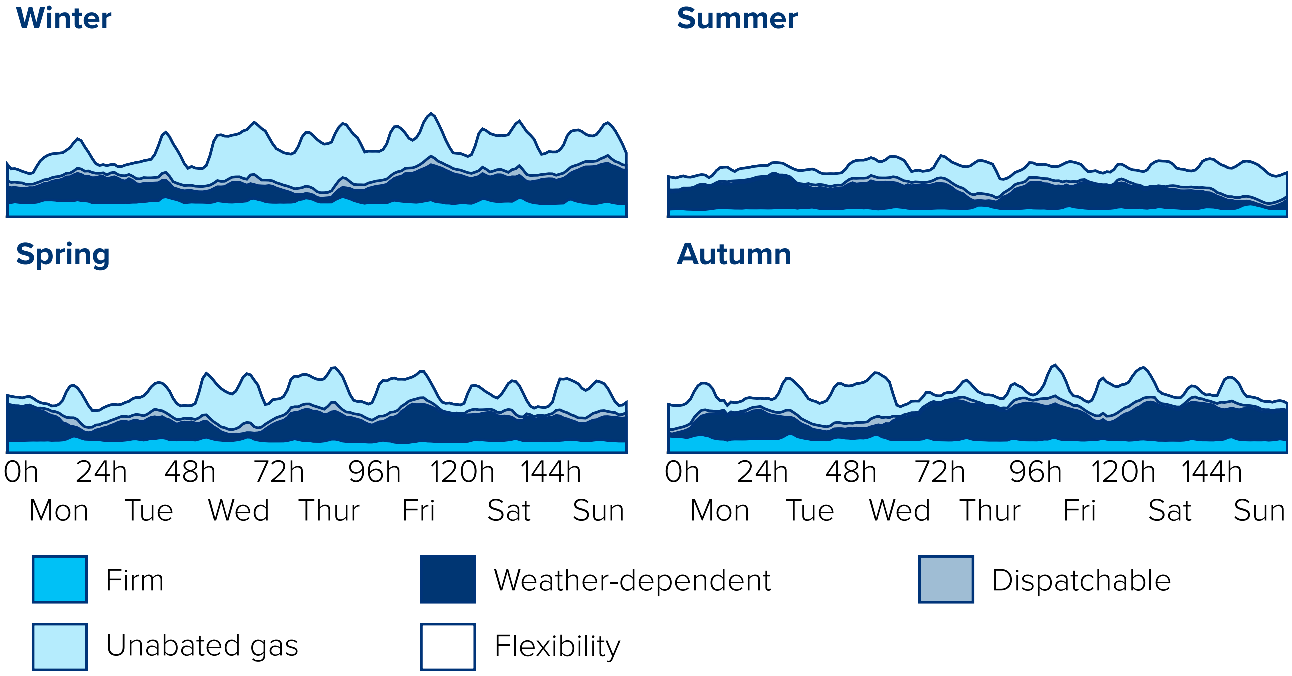
Figure 4: Modelled 7-day hourly generation profile in 2030 in the NESO 'New Dispatch' Scenario (MW)



Notes: Firm includes nuclear, hydro, CHP and waste. **Weather-dependent** includes onshore wind, offshore wind and solar. **Dispatchable** includes biomass, pumped hydro, gas with CCS and hydrogen to power. **Flexibility** includes batteries and residential flexibility. Chart only shows when flexibility is discharging, not charging.

Source: NESO (2024), 'Clean Power 2030'

Figure 5: Historical 7-day hourly generation profile in 2023 (MW)



Notes: Firm includes coal, nuclear, hydro, CHP and waste. **Weather-dependent** includes wind. **Dispatchable** includes biomass, pumped hydro. **Flexibility** is not identified in the historical data. Wind and solar generation are underestimated because they exclude embedded generation and wind farms which do not have operational meters.

Source: NESO (2024), 'Clean Power 2030'

Therefore, the clean power scenarios in Table 1 include technologies that play a range of key roles – variable generation that is renewable, firm generation to meet baseload demand, and dispatchable generation and flexibility for periods of low wind or sun, or higher electricity demand. For each technology, Table 1 shows current installed capacity, alongside, NESO's 'Further Flex and Renewables' scenario, and NESO's 'New Dispatch' scenario.

Using these scenarios, alongside an assessment of maximum feasible deployment based on current knowledge of the project pipeline, we have developed a DESNZ 'Clean Power Capacity Range', which is a range of possible installed capacities for each technology in 2030 – see Table 1. This reflects that there is no singular path to achieving clean power, but instead, that there are a range of scenarios that could get us there. Over time, there will be more clarity on which scenarios are most likely, depending on the outcomes of negotiations and other contract-award processes, and through monitoring delivery of assets with long lead-times, such as the transmission network, offshore wind, and nuclear. This new information will allow the pathway to 2030 to be refined over time, enabled where needed through prioritising connections offers, helping to determine the precise capacity mix required to deliver Clean Power 2030.

Therefore, whilst the 'Clean Power Capacity Range' provides a foundation to guide rapid policy development and focus delivery, the scenarios developed now cannot be exhaustive or definitive, and it is only right that some optionality is retained. In the first instance, this means:

- Government accepts the NESO advice on the infrastructure required for 2030 – decisions are required now to ensure the grid needed for the system in 2030 can be put in place.
- Government sets ranges for deployment of each technology by 2030 and will maintain some optionality until more clarity on which scenario is most likely is available. The 'Clean Power Capacity Range' is provided in Table 1.

There may be technologies not included in these scenarios that could have a role in providing clean power to the system and we will continue to refine our view on these. For example, biomethane is a domestically-produced low carbon gas currently primarily used to decarbonise heating. Biomethane can be used flexibly across many different end-uses – heat, power, industry, transport, agriculture, and hydrogen production – and it may also be able to contribute to low-carbon dispatchable power generation.

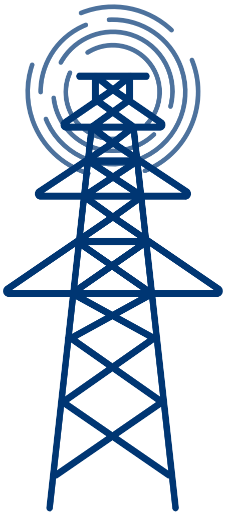


Table 1: Installed capacity in 2030 in the NESO 'Further Flex and Renewables' and 'New Dispatch' scenarios, and the DESNZ 'Clean Power Capacity Range', compared to current installed capacity (GW)

Technology	Current installed capacity[20]	NESO 'Further Flex and Renewables' Scenario	NESO 'New Dispatch' Scenario	DESNZ 'Clean Power Capacity Range'[21]
Variable				
Offshore wind	14.8	51	43	43 – 50
Onshore wind	14.2	27	27	27 – 29
Solar	16.6	47	47	45 – 47
Firm				
Nuclear	5.9	4	4	3 – 4
Dispatchable				
Low Carbon Dispatchable Power[22]	4.3	4	7	2[23] – 7
Unabated gas	35.6	35	35	35[24]
Flexible				
LDES	2.9	8	5	4 – 6
Batteries	4.5	27	23	23 – 27
Interconnectors	9.8	12	12	12 – 14
Consumer-led flexibility[25]	2.5	12	10	10 – 12

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[20] Latest publicly available data for Great Britain at the point of publication. The data source for renewables is DESNZ (2024), '*Energy Trends 6.1*', Q2 2024 data. The data source for nuclear, unabated gas, and LDES is DESNZ (2024), '*DUKES 5.12*', 2023 data. The data source for consumer-led flexibility is NESO (2024), '*Clean Power 2030 Table 2*', 2023 data. The data source for batteries is Modo Energy (2024), '*Indices & Benchmarks*', Q4 2024 data. The data source for interconnectors is Ofgem (2024), '*Interconnectors*', 2024 data. Low carbon dispatchable power includes biomass, power BECCS, gas CCUS and hydrogen to power. The data source for biomass/ power BECCS is NESO (2024), '*Clean Power 2030 Table 2*', 2023 data. Gas CCUS & hydrogen are new technologies so there is no installed capacity at the point of publication.

[21] In addition to the two NESO scenarios, these ranges have been informed by internal modelling and an assessment of maximum feasible deployment based on current knowledge of the project pipeline. Therefore, the range differs from the range of the two NESO scenarios in some instances. However, for solar, there is scope to exceed the 47GW upper limit, subject to system need, noting for example the potential of rooftop solar to boost deployment – see Connections Annex for further details.

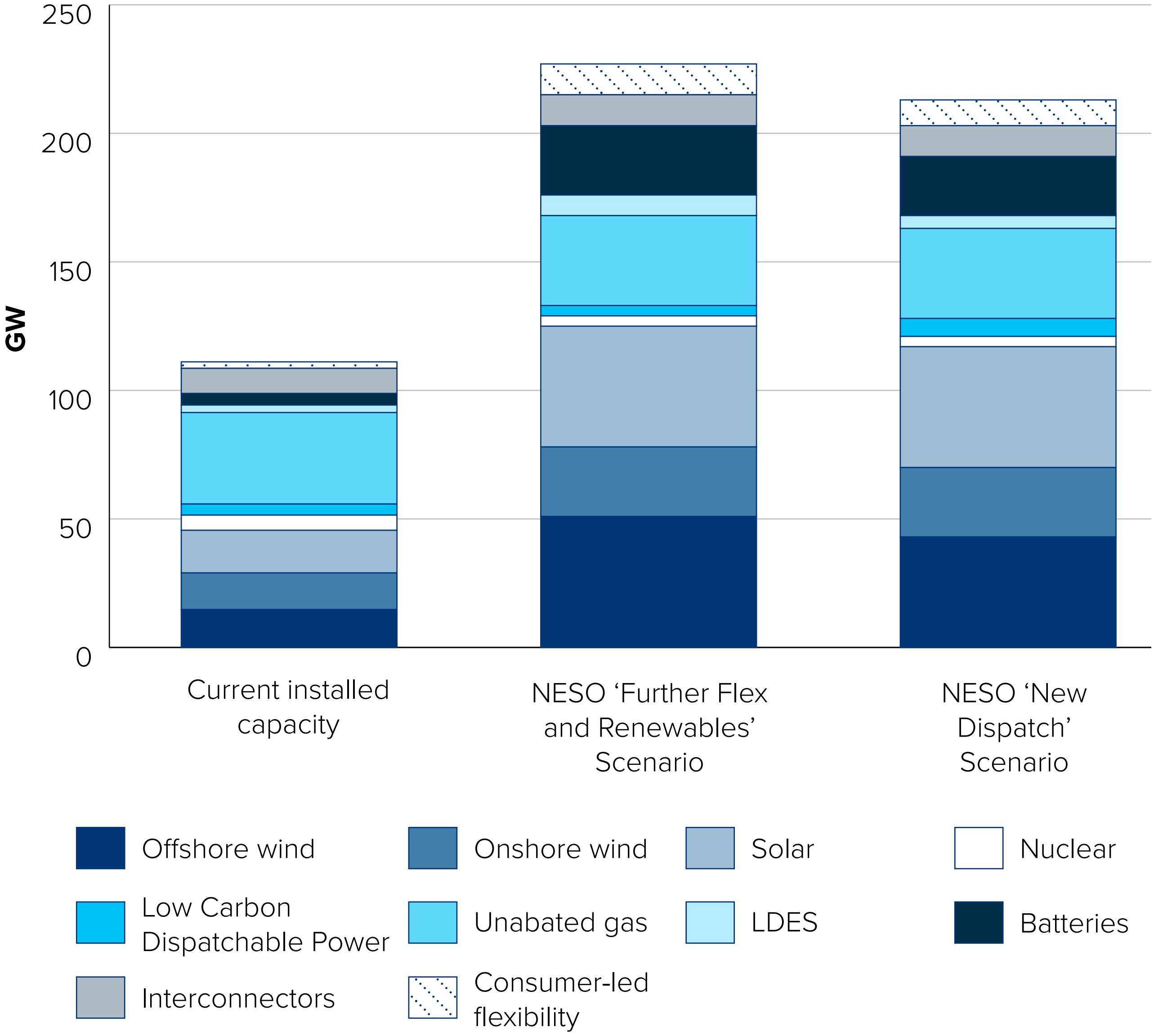
[22] Dispatchable technologies are ones which combust fuel to produce electricity and, by varying the rate at which fuel is burned, can respond to meet the needs of the grid with varying levels of flexibility. This category includes biomass, power BECCS, gas CCUS and hydrogen.

[23] The low end of the range represents the minimum capacity we expect to have in 2030. There is uncertainty on the amount of biomass capacity that will be on the system in 2030 with some existing support arrangements ending from 2027 onwards. HMG is considering the position on potential future support arrangements, but no decisions have yet been taken.

[24] While delivering its Clean Power ambition for 2030, the government's aim is to ensure there will be sufficient flexible capacity on the system to meet security of supply. This includes retaining existing unabated gas capacity.

[25] Excluding storage heaters.

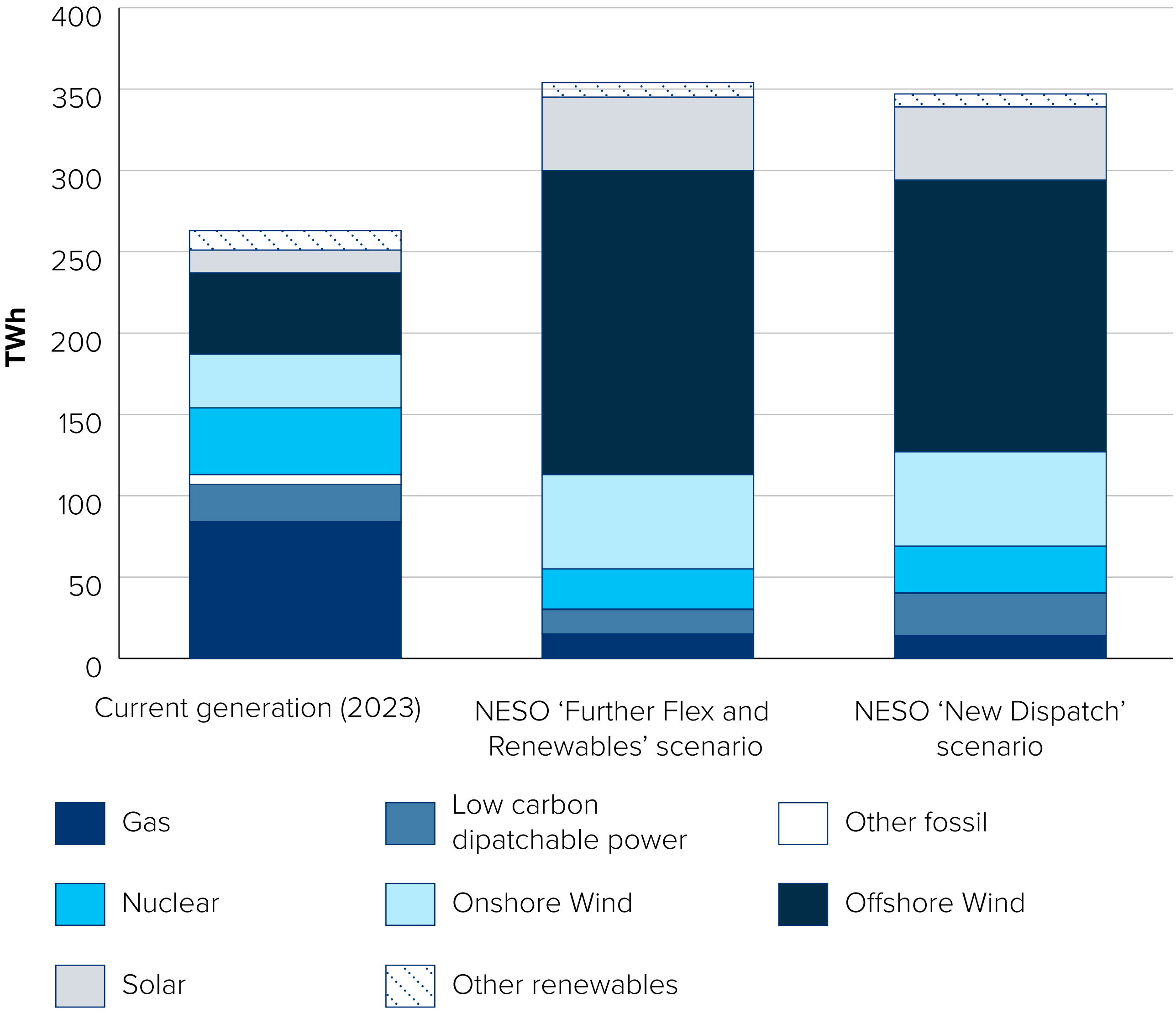
Figure 6: Installed capacity in 2030 in the NESO 'Further Flex and Renewables' and 'New Dispatch' scenarios, compared to current installed capacity (GW)



Note: Numbers for this visual can be found in Table 1

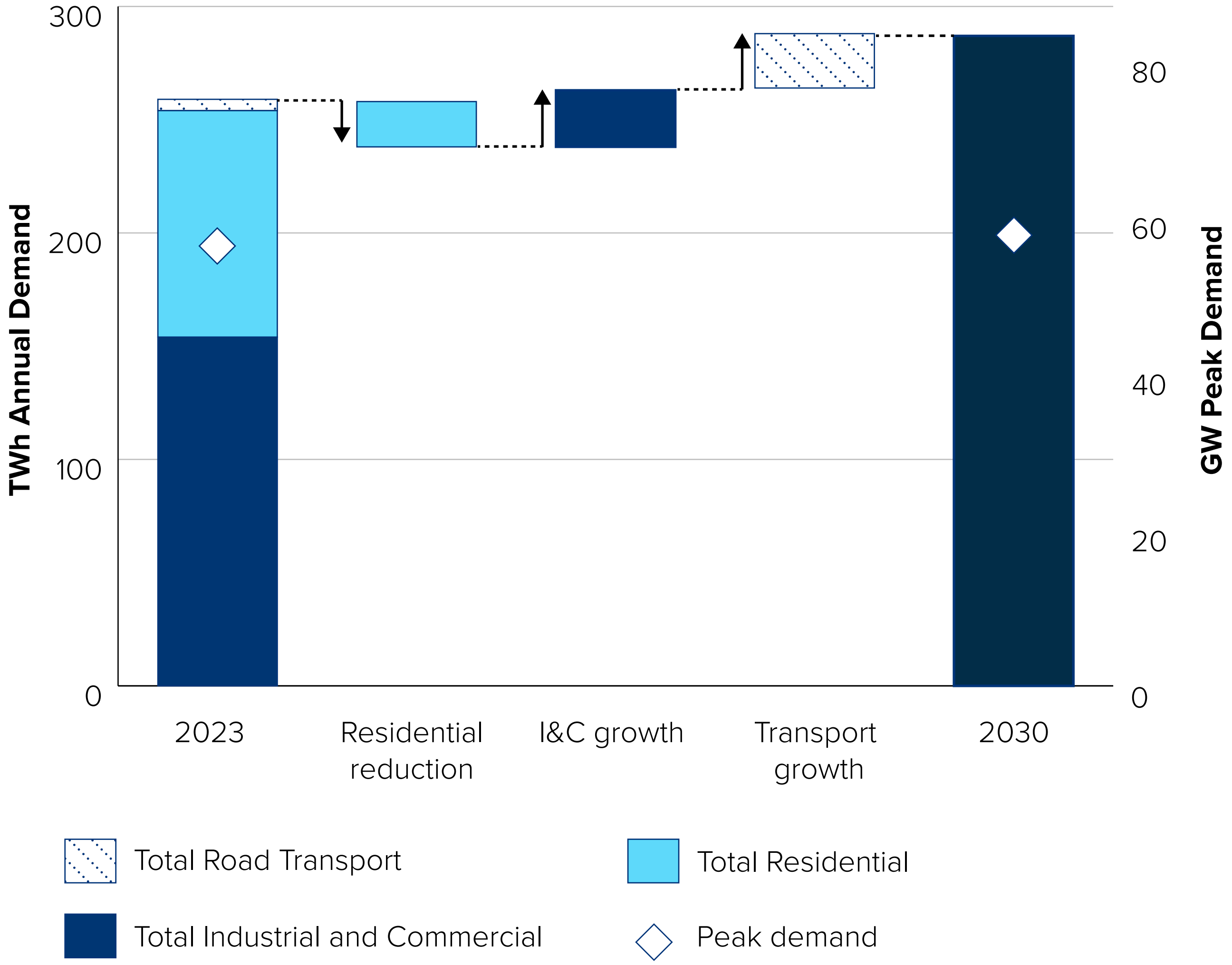
Source: Table 1 and NESO (2024), 'Clean Power 2030'

Figure 7: Generation in 2030 in the NESO 'Further Flex and Renewables' and 'New Dispatch' scenarios, compared to current generation (TWh)



Source: NESO (2024), 'Clean Power 2030'

Figure 8: Changes in consumer electricity demand (TWh annual demand, GW peak demand), 2023- 2030



Note: Peak demand is Average Cold Spell (ACS) peak demand. Peak demand is after smart charging and heat flexibility that occur daily, but does not include V2G and DSR that are less frequently used in the modelling.

Source: NESO (2024), 'Clean Power 2030'

Delivering Clean Power 2030

Delivering capacity that aligns with the 'Clean Power Capacity Range' in Table 1 requires deployment at a very significant scale and pace, which can only be delivered by taking rapid action to unblock delivery challenges. For most technologies, meeting the 'Clean Power Capacity Range' is achievable through delivering and accelerating projects already in the pipeline. Still, these technologies require significant policy action to unblock barriers to ensure timely delivery.

Delivering new capacity for 2030 could be more challenging for some technologies with longer lead-times. Clean Power 2030 capacities are most stretching for hydrogen to power and power bioenergy with carbon capture and storage (BECCS), due to limited availability of transport and storage infrastructure for hydrogen and CO_2 respectively. The amount of overall capacity required also depends heavily on peak demand, which is driven by consumer uptake of technologies such as electric vehicles and heat pumps, usage patterns, and levels of consumer-led flexibility.

To increase our chances of delivery, the ‘Clean Power Capacity Range’ provides a foundation to prioritise the most critical infrastructure to meet Clean Power 2030, which we know will be key to supporting further progress into the 2030s:

- **Connections:** Fundamental reform of the connections process is urgently needed to operationalise Clean Power 2030 and ensure the electricity system meets longer-term strategic needs. Our capacity range provides a framework for NESO to work with Transmission Owners and Distribution Network Operators to prioritise connection offers for strategically aligned projects that can demonstrate they have the means to deliver. To enable NESO to deliver efficient reform, we have set out regional breakdowns of our capacity range for onshore wind, solar, and batteries – providing clarity to developers, investors and network operators on what to connect, where. To continue progressing infrastructure required beyond 2030, our Connections Annex also sets out technology capacity ranges that NESO proposes to use as an indication of what is required on the system by 2035, to guide new connection offers until the Strategic Spatial Energy Plan is published in 2026. This will provide a 10-year horizon for connection agreements. These ranges are mostly derived from NESO’s net zero-aligned Future Energy Scenarios (FES), with a bespoke approach[26] proposed for onshore wind and unabated gas. See the ‘Networks and Connections’ section for more detail.
- **Strategic Spatial Energy Plan:** Our 2030 capacity range is a key input to the development of this Plan, forming its baseline. The SSEP will build from the 2030 capacity range to offer a longer-term spatial plan for the energy system beyond 2030. This will help to ensure strategic coherence between short-term action to deliver 2030 Clean Power and longer-term spatial planning, to enable long-term decarbonisation and energy security.
- **Planning:** Accelerating clean infrastructure projects through the planning system is critical to achieving our goal and unleashing investment to support the Prime Minister’s Growth Mission. Our capacity range will ensure that planners and statutory consultees at the national and local level have a clear sense of which projects to prioritise for consideration and, where appropriate, fast-track through the process to enable decisions on consent to be taken sooner[27]. See the ‘Planning and consenting for new energy infrastructure’ section for more detail.
- **Visibility to industry and investors:** As a challenging goal, delivery of Clean Power 2030 will only be possible if there is a clear understanding across the sector of what needs to be achieved, and if we offer to investors a clear prospectus of the opportunities.

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[26] We are proposing a bespoke approach for onshore wind because the FES projections are based on assumed ONW growth rates in England and Wales which pre-date the decision taken by Secretary of State in July to remove the de-facto onshore wind ban. As a result, we have increased the capacity range for onshore wind to 2035 – see Connections Annex for further detail.

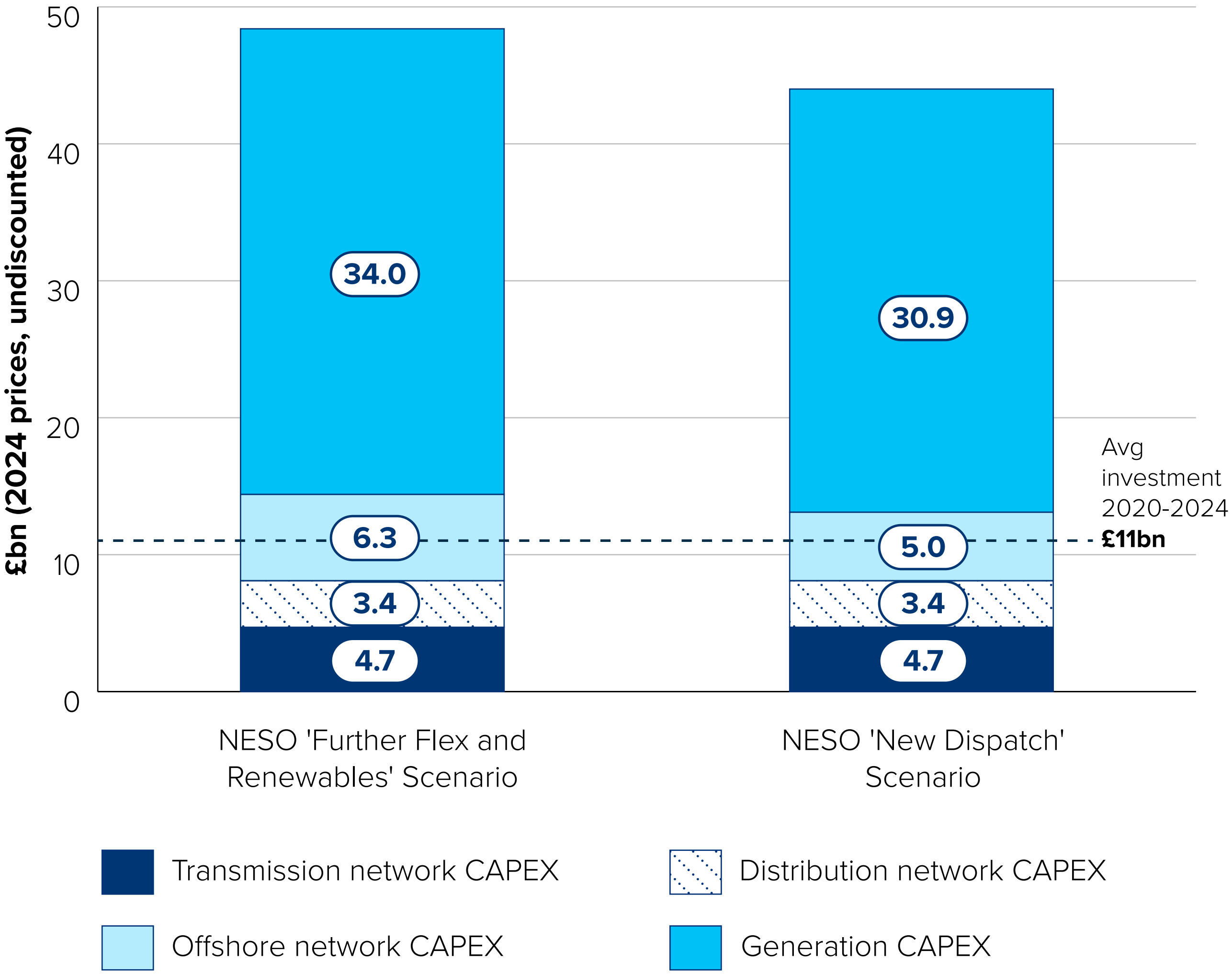
[27] Final decisions on planning consent remain subject to meeting necessary planning and other regulatory approvals.

Cost and consumer impacts of Clean Power 2030

The level of deployment set out in Table 1 will require substantial investment across the country, an estimated **£40 billion**[28] on average per year between 2025-2030, much of which will be private investment.

This broadly aligns with NESO's investment estimate – see figure 9. In addition, by transforming the way we generate electricity, we will build a power system that is not just cleaner, but importantly less reliant on fossil fuels, thereby reducing our exposure to volatile gas prices.

Figure 9: Average annual investment in the NESO 'Further Flex and Renewables' and 'New Dispatch' scenarios, 2025-2030, £ billions, 2024 prices, undiscounted



Source: NESO (2024), 'Clean Power 2030'

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[28] Undiscounted, 2024 prices. This includes £30bn investment in generation assets, and £10bn investment in transmission network assets. See the technical annex for more detail on how this was calculated.

In their advice, NESO set out their analysis of potential impacts of delivering Clean Power on electricity costs in 2030[29]. This indicated it could be delivered with similar costs to today, with scope for lower electricity costs and bills by 2030 as wider changes are taken into account.

This plan proceeds on the basis of the NESO analysis. The precise impact we will see on bills in coming years will depend on a range of factors, including the pathway chosen and other policy choices made going forward as well as the impacts of exogenous factors such as gas prices. As set out above, there are multiple capacity mixes that can achieve Clean Power in 2030. The government will scrutinise every policy choice for the impact it can have in reducing bills facing consumers, as well as value for money and affordability.

The new, more flexible consumer-led energy system will also offer many opportunities to lower the bills customers face. We already see individuals with solar panels and EVs taking advantage of these technologies. The government is determined to ensure it is not just those who are the best informed or better off who have access to these ways to save money. That is why rolling out half-hourly settlement, for example, is so important so that consumers have lower tariffs on offer for consumption at different times of day.

Importantly, Clean Power will protect electricity consumers from volatile gas prices. As the electricity system decarbonises, unabated gas generation is used less often. As a result, there will be an increase in the proportion of generation being paid a contracted price rather than the potentially volatile wholesale price, while the wholesale electricity price itself will also be increasingly decoupled from gas prices. As we rollout renewables, we will see a significant reduction in wholesale prices, the foundation for building an energy system that can bring bills down for good.

During the recent energy crisis, following the invasion of Ukraine, we saw the electricity price cap increase by over £1,300 in a year, peaking at £2,000. To protect businesses and consumers, government put in place energy support schemes at an estimated cost of £44 billion[30]. If a clean power system had been in place at the peak of the gas price crisis, it could have saved significant sums for households, businesses and taxpayers. This is the scale of the prize on offer in terms of stability and energy security.

The role of a clean power system in reaching net zero by 2050

Meeting the Clean Power 2030 goal is key to accelerating to net zero, not only in eliminating emissions that currently come from electricity generation but also via the application of clean power in the buildings, transport and industry sectors. A range of technologies, including electric vehicles and heat pumps, can help us switch away from the use of fossil fuels in these sectors, often improving the efficiency of the energy system in the process.

The shift to a clean power system by 2030 forms the backbone of the transition to net zero, as we move to an economy much more reliant on electricity. By 2050, annual electricity demand is likely to at least double as a result of electrification.[31] Over the period to 2030, most of the emissions reduction from clean power will come directly through displacing fossil fuel electricity generation. By contrast, in the period from 2030 to 2050, the further emissions reductions from

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[29] NESO (2024), ‘*Clean Power 2030*’ (viewed in December 2024).
[30] NAO (2024), ‘*Report – Value for money: Energy bills support: an update*’ (viewed in December 2024).
[31] BEIS (2022), ‘*Electricity networks strategic framework, Appendix 1 – Electricity Networks Modelling*’ (viewed in December 2024).

clean power will come indirectly, through its application to displace fossil fuel use in other sectors, for example in boilers and vehicles.

The Climate Change Committee estimate in the Sixth Carbon Budget report that a clean power system will nearly eliminate the emissions relating to electricity generation by 2050 (currently 12% of total UK greenhouse gas emissions)[32]. In addition, a clean power system will enable transport, buildings and industry sectors to switch from fossil fuels to electricity and contribute 47% of the further emissions reductions required by 2050.[33]

However, although electrification provides the most potential for reaching net zero, it is not the solution for every use of energy across the economy, and will need to be supplemented by targeted deployment of CCUS and hydrogen, alongside action outside the energy system. Delivering Clean Power 2030 is the first part of a longer journey and the challenges for the clean power system will change over time, reflecting the greater long-term emphasis on electrification and the opportunity and necessity to deploy technologies with long lead-times:

- **At least a doubling of demand:** Electrification and other needs for clean power as part of net zero are likely to result in at least a doubling of electricity consumption compared to today, with even larger amounts required if there are significant roles for electricity-intensive decarbonisation routes such as green hydrogen and e-fuels for aviation and maritime. This will require strong growth in power generation from a diverse range of clean sources on a sustained basis through the 2030s and 2040s. There is an essential role for innovation on the path to 2030, to ensure the right technologies are supported to progress through technology readiness levels in the coming years, to enable mass deployment in the decades to come.
- **Nuclear:** Nuclear will play an important role in our future energy system, providing low-carbon, baseload power to the grid. Government will continue to seek to streamline regulatory processes, and foster innovation in nuclear technology, to ensure that nuclear continues to play an important role in the net zero transition after 2030. The budget set out that final decisions on Sizewell C and the Great British Nuclear-led Small Modular Reactor programme will be taken at the Spending Review.
- **An ever-smarter system:** As the extent of electrification of the wider energy system grows, so will the opportunity for a huge amount of short-duration consumer-led flexibility through flexible use of electric heating and smart charging of vehicles – promising wider access to smart tariffs for consumers aiming at lowering their bills, and lower system costs for the nation.
- **More seasonal and spikier demand:** While the within-day picture for electricity demand may be quite smooth in the longer term, electrification of space heating for buildings will lead to demand for electricity that is considerably more seasonal than today, and more changeable due to the requirements for heat on particularly cold days. This suggests a particularly important role for offshore wind in matching demand, as it tends to generate more strongly in the winter than other times of year, as well as low carbon dispatchable power to provide a very long-duration storage solution, including meeting demand during periods that are cold but less windy.

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[32] DESNZ (2024), '*UK territorial greenhouse gas emissions national statistics*' (viewed in December 2024).
[33] CCC (2020), The Sixth Carbon Budget - The UK's path to Net Zero, Figure 2.6 (viewed in December 2024).

- **Reforming our market arrangements:** Our current electricity markets were largely designed for the fossil fuel-based power system of the past. The Review of Electricity Market Arrangements (REMA) Programme is considering the reforms needed to ensure that our market arrangements remain fit for the renewables-dominated power system of the future.

- **Further need to strengthen networks:** Higher, and spikier demand for electricity due to electrification will inevitably require strengthening of electricity networks, particularly at the distribution level. The timing and extent of this will, to some extent, depend on the precise mix of heat decarbonisation solutions deployed.

These are all challenges that we need to plan for now in order that the 2030 Clean Power system is fit for its pivotal role beyond 2030 in reaching net zero. Our actions sit alongside a wider framework being developed to lay the foundation for the longer-term plans for the GB energy system: the Strategic Spatial Energy Plan (SSEP), Centralised Strategic Network Plan (CSNP), and Regional Energy Strategic Plans (RESPs).

Integrating clean power and the natural environment

The world is facing twin climate and nature crises which threaten our global health, wealth and security. These are inextricably linked. The government is committed to accelerating to net zero, to delivering clean power by 2030, and also to restoring nature – for example through its commitment to delivering the Environment Act targets in England and honouring our international commitments under the UNCBD. This will mean halting the decline in species abundance by 2030, and effectively protecting our Marine Protected Areas as part of the global 30 by 30 commitment.

The UK is one of the most nature depleted countries in the world, so it is not enough for us to "protect" or "conserve" the nature we still have left. This is why this Government has committed to restoring nature through such targets, and our related international commitments.

Climate change is itself one of the greatest threats to nature in the years ahead, which is why one of the most important things we can do to protect nature is deliver clean power by 2030 - tackling the UK's dependence on fossil fuels and driving international climate action. Equally, nature is a key ally in helping us tackle the climate crisis, both through mitigation and adaptation.

We should therefore ensure delivery of our climate and nature targets wherever possible, in an integrated and joined up way. This means ensuring habitats like peatlands store rather than emit greenhouse gas emissions; or restoring salt marshes and sea grasses so that they are sequestering carbon as well as protecting our coastal communities from rising sea levels and extreme weather. This means that new energy infrastructure should be built in a way that protects the natural environment by following a “mitigation hierarchy” to do what is possible to avoid damage to nature, and then minimising, restoring and delivering compensation when damage is impossible to avoid.

The real opportunity available to the UK is to deliver clean power by 2030 in a nature positive way, such as rewetting lowland peat soils at the same time as constructing new solar farms or creating new wildlife corridors alongside or underneath linear energy infrastructure.

This approach is not so much about “balancing” energy and the environmental needs; it’s about *integrating* them. It’s about rebuilding our natural infrastructure at the same time as building the new energy infrastructure we need.

Government will launch an engagement exercise in early 2025 to invite communities, civil society and wider stakeholders to submit their ideas on how government can best encourage nature-positive best practice into energy infrastructure planning and development. Feedback from this exercise will allow government to better understand how we can integrate nature restoration through Clean Power 2030.

Supporting businesses and promoting growth

With 90% of global GDP covered by net zero targets[34], clean energy industries represent a significant potential growth area. These industries can generate new jobs through domestic manufacturing and services and preserve our Energy Intensive Industries in a decarbonised economy. Additionally, the only way to guarantee our energy security and protect billpayers permanently is to speed up the transition away from fossil fuels and towards homegrown clean energy.

By accelerating the transition to renewable energy sources, we are creating a more stable environment that is conducive to growth and minimises energy price led inflation. This stability is crucial for businesses, as it helps ensure that energy bills stay low, and allows them to plan and invest with confidence, knowing that they will not be subject to the volatility of fossil fuel prices. If gas price spikes occurred even once every decade, it could cost the UK between 2-3% of GDP annually, adding 13% of GDP to public debt by 2050[35].

Another of the key benefits of Clean Power 2030 and the scale up of clean energy sectors is the creation of new job opportunities in locations across the UK, particularly in coastal regions for offshore wind farms and in regions like the North West of England and North Wales for hydrogen production and carbon capture[36] whilst also supporting industrial jobs.

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[34] Climate Action Tracker (CAT) (2023), '*CAT net zero target evaluations*' (viewed in December 2024).
[35] Office for Budget Responsibility (OBR) (2023), '*Fiscal Risks & Sustainability*' (viewed in December 2024).
[36] CCC (2023), '*A Net Zero Workforce*' (viewed in December 2024).

As we invest in the development of wind, solar, and other renewable energy projects, we will see a surge in demand for skilled workers in these industries and the industries and services that support their deployment. Reskilling our workforce will play a crucial role, with evidence suggesting a high degree of transferability between the UK's oil and gas workforce and the offshore renewables sector[37]. This will not only provide employment opportunities but could also stimulate local economies and drive innovation[38]. Studies have shown that green jobs tend to provide increased productivity and higher wages than non-green jobs, especially for middle and lower skilled workers[39]. A significant proportion of these jobs are expected to be in the energy efficiency and low carbon heating sector[40]. Increased jobs are also expected in low carbon energy, CCUS, hydrogen and electric vehicle manufacturing.

Decarbonising the UK economy could reduce regional inequalities, creating new jobs and supporting existing jobs in industrial heartlands and preventing decline in areas dependent on the oil and gas sector. For example, according to EDF[41], the Hinkley Point C project is helping young people stay and thrive in Somerset. The local area has seen a 25% growth in young people aged 25-39 – 3 times greater than the national average and local areas seeing a growth in the number of medium-sized companies that is ten times higher than anywhere else in the South West[42].

The Scottish Government has invested in a package of skills interventions in the North East of Scotland, supporting the transferability of the workforce across sectors to meet the needs of the net zero transition. This includes an Energy Skills Transition Hub and National Energy Skills Accelerator.

There are also opportunities for the UK to capture more of the value chain for key clean energy industries and the potential to drive inward investment in domestic supply chains. In Spring, the government will publish the new Industrial Strategy, with Clean Energy Industries as a priority growth sector.

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[37] Robert Gordon University (2023) '*Powering up the workforce*' (viewed in December 2024).
[38] Zenghelis et al. (2024), '*Boosting growth and productivity in the United Kingdom through investments in the sustainable economy*' (viewed in December 2024) and CCC (2023), '*A Net Zero Workforce*' (viewed in December 2024).
[39] CCC (2023), '*A Net Zero Workforce*' (viewed in December 2024).
[40] CCC (2023), '*A Net Zero Workforce*' (viewed in December 2024).
[41] EDF (2024), '*Socio-economic Impact Report 2024*' (viewed in December 2024).
[42] EDF (2024), '*Helping Britain achieve net zero*' (viewed in December 2024).

How Clean Power 2030 will transform our energy system

Clean Power 2030 will be a major step towards realising an ambition of a clean, contemporary, digitalised energy system based largely on electricity, to be developed further in later years as part of decarbonising the whole economy. For energy consumers and citizens this will be a transformation in their relationships with energy.

Just as it has in so many other sectors before, such as banking, media, and retail, digitalisation will pave the way for a consumer-led transformation of the energy system, characterised by new business models, firms, and markets. While this will gain momentum in the period to 2030, it will continue to do so far beyond that date, as part of decarbonising the whole economy.

Lessons from other sectors are clear: digitalisation can increase consumer choice, bring down costs for everyone, and lead to the development of more consumer-friendly products and services.

Importantly for the energy system, this digitalisation will simultaneously unlock transformation of the demand side, a critical part of the energy system in the move to clean power and one which has been historically overlooked, failing to serve the best interests of consumers.

The system of the future will give consumers choice over how they engage, ranging from little change to today, through to being able to benefit from bill discounts thanks to smart tariffs. They will be able to engage physically by using appliances when electricity is cheaper or via automated systems managing this on their behalf. These would control how major appliances like car chargers, heat pumps, water heaters, washing machines/dryers, and fridge/freezers use their electricity to take advantage of low prices within the day and integrate the outputs of any residential generation such as rooftop PV, and household energy stores, potentially including the battery in your electric car.

The government is clear that engagement with these systems will be entirely voluntary, led by consumers. Under the previous government, consumers were offered the option to take advantage of different tariffs at different times. The evidence was that consumers were enthusiastic about the possibilities[43]. But this should not be a choice just given to the most informed consumers but to all. That is what the system of the future is about.

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[43] NESO (2023) '*Household engagement with the Demand Flexibility Service 2022/23*'

What Clean Power means for local places

Boosting industry and transforming local economies with clean, homegrown energy

After the grid was first consolidated from 1926-33, energy became a lot cheaper, and this had a beneficial impact on industry, driving down costs[44].

In the same manner but on a much larger and more transformative scale, Clean Power 2030 will catalyse a new era of renewable energy, opening up the possibility for new ventures previously held back by the price of fossil fuels.

It will ensure that the benefits of clean power are spread throughout the country, driving new investment and industry into local places and communities. For example, enabling the development and growth of new energy intensive industries such as data centres across Scotland.

These changes will have a profound impact on people’s livelihoods, as they bring with them new, higher value, future-proof jobs and employment.

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[44] Butler (2001), ‘*The nature of UK electricity transmission and distribution networks in an intermittent renewable and embedded electricity generation future*’ (viewed in December 2024).

Creating a fairer, more equitable energy system

Clean Power 2030 will create the conditions needed to drive investment in, and scale, locally led, owned and managed energy developments. Local leadership will be empowered to play a more active role in delivering the transition – for example, through partnering with and providing support to community energy groups and local and combined authorities, GBE's Local Power Plan will support the rollout of renewable energy projects using established technologies to contribute up to 8GW of clean, homegrown energy.

Communities and the people who live in them and the businesses that serve them, will see clearer links between local projects, and local benefits.

For example, the UK's first hospital-owned solar farm has not only contributed to the daily power needs of Morriston Hospital in Swansea, but also covered 100% of its demand for prolonged periods of time, helping save carbon and bills.

Through its Community and Renewable Energy Scheme, the Scottish Government supports the growth of community energy and helps communities engage in and benefit from the energy transition. To date, the Scheme has advised over 1200 organisations and provided over £67 million in funding to communities throughout Scotland, supporting over 960 projects and the installation of 63 MW of renewable energy.

Building trust, knowledge and confidence to support household technology adoption

Enabling truly local energy led by local citizens, businesses and local leaders will also play a vital role in citizen engagement, with local developments and business models in some cases representing the first real, 'tangible' occasion that local people can learn about and experience renewable energy.

These experiences will help to grow public trust and knowledge. Greater visibility and demystifying of renewable energy at the local level across Great Britain will support electrification right down to the level of the individual household, providing citizens with the confidence to adopt low carbon technologies, keeping us on track for our wider net zero targets beyond 2030.

Removing roadblocks: lowering barriers to investment, development and deployment

Delivering Clean Power 2030 will require reforms to the overarching structures that underpin delivery and operation of the energy system, to ensure they do not act as blockers to deployment of clean power projects.

We need to make sure that consenting regimes work to bring new projects through the system at pace, that the network expands rapidly so that our vast supply of clean electricity can be transported to centres of demand, and that the underpinning supply chain and workforce are available and capable to ensure this transformation is delivered.

We also need to ensure that the market works in tandem with support schemes to deliver the right investment signals, and that any sector-specific barriers to deployment are appropriately addressed, to enable the huge volume of deployment that will underpin Clean Power 2030.

This section of the Action Plan sets out how government will ensure this is delivered, with chapters covering:

- Planning and consenting for new energy infrastructure
- Networks and connections
- Renewable and nuclear project delivery
- Reforms to electricity markets
- Short-duration flexibility
- Long-duration flexibility
- Supply chains and workforce

Planning and consenting

Summary

Our current planning systems across Great Britain are not working at the pace required to meet our target for clean power by 2030. Planning systems are devolved and the regimes vary across Scotland, England and Wales, although similar problems are encountered in each. Lengthy paperwork and often-delayed processes for infrastructure projects hinder our energy security, our economic growth, and fails to deliver for the natural environment. The increased risks to projects associated with delays in planning decisions also increase costs across the system.

Our planning system needs to quickly change to enable government's missions to grow the economy and deliver clean power. Since July, the government has taken decisive steps towards making planning work better for clean power and economic growth. We've lifted the de facto ban on onshore wind in England and have committed to updating our National Policy Statements. We must go further. Processes are not suitable nor are examining authorities well-equipped to deal with the increase in new clean power projects and wider infrastructure that we expect in the coming years to achieve government's missions. There is particular urgency to accelerate the planning process across Great Britain for energy infrastructure since we do not have long for many clean power projects to begin construction if they are to be operational for 2030, especially networks and offshore wind developments.

The urgent need for change means we must undertake a wide-ranging reform programme, encompassing not only deep changes through primary legislation over the course of this Parliament, but to also get moving with operational and regulatory reforms across the system within the next year. Therefore, to enable clean power 2030:

1. **We will equip organisations across the planning system with the tools they need to help deliver Clean Power 2030 and government's wider missions**, including the Planning Inspectorate, statutory consultees, local planning authorities, and government consenting teams. We will enable them to better flex and prioritise their resource so that they can examine mission-critical projects faster. To complement these more immediate changes, we will deliver workforce reform, enhanced training, and reformed career development packages for certain organisations involved in the planning system. We will review resourcing in key organisations to determine whether they are suitable for handling an increased number of projects in the coming years, including the Planning Inspectorate and departmental consenting teams. The Clean Power 2030 Unit will assist planners by convening early engagement between stakeholders for complex applications.
2. **We will update the National Policy Statements for Energy and Planning Policy Guidance in 2025, and we have confirmed changes to our National Planning Policy Framework** to reflect the needs of Clean Power 2030, improving policy certainty for developers and examining authorities.
3. **We will undertake an ambitious programme of legislative reform, including through the Planning and Infrastructure Bill.** Building on the reforms in the Nationally Significant Infrastructure action plan[45], we will introduce legislative changes to update the NSIP planning system in the Planning Act 2008 in England and Wales for all infrastructure projects. We will also reform the legislative framework for electricity infrastructure consenting in Scotland, where there is executive devolution but where legislation under the Electricity Act is reserved for Westminster, to deliver a streamlined and efficient framework that is fit for purpose. We will explore reforming Judicial Review processes following recommendations from Lord Banner's review.
4. **We will ensure that the protection of nature is embedded into the delivery of Clean Power 2030,** including by delivering the Marine Recovery Funds for Offshore Wind, and using development to fund nature recovery where currently both are stalled. The UK government and Scottish Government are exploring a separate Marine Recovery Fund for projects in Scotland

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[45] Department for Levelling Up and Housing Communities (DLUHC) (2023), '*Nationally Significant Infrastructure: action plan for reforms to the planning process*' (viewed in December 2024)

5. **We will ensure communities directly benefit from clean energy infrastructure they host** by building upon existing approaches and encourage consistency in community benefits across technologies.
6. **The Scottish and Welsh Governments have implemented programmes of planning reform which support the delivery of clean power.** We are working closely with both the Scottish and Welsh Governments to accelerate reform further to deliver for 2030.

The challenge

The projects we need for Clean Power 2030 need to begin construction soon. Advice from the NESO indicated that there are enough projects in the pipeline for most technologies, but delivery of the pipeline would require accelerated rates of planning and consenting decisions[46]. Increased pace in the planning system is essential to support effective delivery of the connections queue and wider actions enabling Clean Power 2030. Though construction timelines for clean power technologies vary, it is clear we must act urgently to get them through the planning system, while also delivering positive outcomes for nature and communities.

- Most new transmission network and offshore wind projects will need all permissions for construction by 2026[47] if they are to be operational by 2030 with current construction timelines
- New onshore renewable and battery projects typically have shorter construction timelines, but most large-scale projects would likely still need to receive consent by around 2028[48]
- For much of the firm generation, low carbon-flexibility and unabated gas that we need to underpin a clean power system we have identified the pathways for delivery for 2030 and are working towards accelerating them, but we need to ensure the judicial and wider permitting processes work to reflect the critical importance of these projects.

Our planning reform programme for larger scale energy infrastructure will need to be tightly coordinated. Terrestrial and Marine planning regimes are either fully or executively devolved. The delivery of energy infrastructure in Great Britain is split between interacting systems that differ between nations, with varying roles for central, local, and devolved governments. Some of the planning reforms referenced in this plan relate to consenting in England (and Wales for large NSIPs) while others will affect Scotland given that elements of the legislation governing parts of the Scottish planning and consenting regime are reserved to Westminster. In addition, there are a range of actions also underway in Scotland and Wales.

NESO will be delivering the Strategic Spatial Energy Plan in 2026 to enable long-term planning of the energy system out to delivering Net Zero by 2050. We also need a long-term, holistic approach to managing growing demand for use of the seabed. The Crown Estate's Marine Delivery Routemap will provide an opportunity to positively plan

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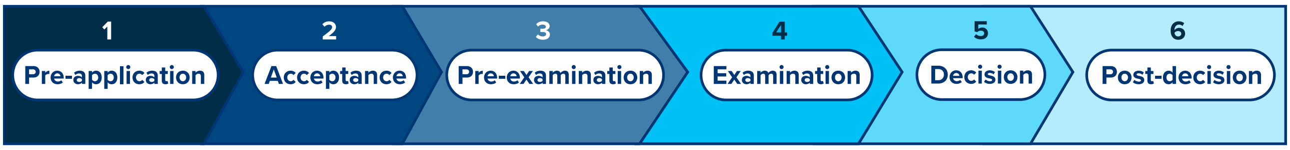
[46] NESO (2024), '*Clean Power 2030*', (viewed in December 2024).
[47] Internal DESNZ estimate informed by stakeholder engagement.
[48] Internal DESNZ estimate informed by stakeholder engagement.

for shared outcomes across different sectors with an agreed set of design parameters that incentivise best environmental practice across the project lifecycle. This will encourage development areas to be brought forward in the right locations that avoid the most vulnerable areas of biodiversity.

For the planning and environmental reform package to facilitate Clean Power 2030, changes will need to be made that cut across many different areas, involving multiple organisations, including developers, supply chains, and investors. The different systems with different requirements and obligations across the planning landscape are complex and were not designed to deliver at the speed and volumes now required of them.

Figure 10: Nationally Signficant Infrastructure Project (NSIP) planning process flowchart



Notes: This flow chart details the process for NSIP energy projects only. Projects which are considered using TCPA follow a slightly different process.

Source: Planning Inspectorate (2024), 'Decision Making Process Guide'

It takes a long time for Nationally Significant Infrastructure Projects (NSIPs) to receive a consenting decision, with ever increasing volumes of information being dealt with at each stage, leading to delays and pressure for all parties. The timespan for Development Consent Orders is intended to be less than two years but can go well beyond this, and the documentation underpinning consents has been getting longer and in too many instances now runs to tens of thousands of pages. Increased litigation has caused delays and introduced additional risk and costs for

developers. A large number of infrastructure projects are expected in the next 3 years[49], and change is needed to meet the urgent need set out in the NESO advice for significant numbers of projects to progress to construction in the next 6-24 months.

For locally-consented energy infrastructure, decisive reform is also urgently needed to deliver clean power by 2030. In England, planning applications with local authorities under the Town and Country Planning Act can sometimes take up to 12 months to receive a decision[50], despite a four-month limit on energy infrastructure projects which require an Environmental Impact Assessment. Currently, the National Planning Policy Framework (NPPF) does not make clear that local planning authorities should consider the benefits associated with renewable energy generation, and proposals' contribution to meeting a net zero future when determining applications for these developments. The Planning Practice Guidance for renewable energy, which adds further detail to the policy contained within the NPPF, contains outdated guidance which requires updating to reflect new policies.

There are also challenges in the planning process for low carbon electricity infrastructure in Scotland, which differs from the systems in England and Wales. These challenges are delaying investment in critical infrastructure and are costly to consumers. Government has run a consultation on proposals for reforming the consenting processes in Scotland under the Electricity Act 1989 and working with the Scottish Government, timely implementation of the results of the consultation process will be essential.

We need to accelerate transformation of the system, building on the work set out in the NSIP Action Plan. In February 2023, the then government published the NSIP Action Plan which outlined five key reform areas to help make the NSIP planning system better, faster, greener, fairer and more resilient. Following on from this, changes to the NSIP system were implemented in Spring 2024 with the introduction of legislative amendments to key infrastructure planning legislation and new infrastructure planning guidance. We recognise previous reforms to the system are yet to be in full effect and will make a positive difference, like the designation of low-carbon nationally significant energy infrastructure projects as 'Critical National Priorities' through the energy National Policy Statements. However, existing reforms still do not match our ambition for Clean Power 2030, and so we must go further – using all tools at our disposal.

Our planning reform programme for energy infrastructure will need to be tightly coordinated. The delivery of energy infrastructure in Great Britain is split between interacting systems that differ between nations, with varying roles for central, local, and devolved governments. For the planning and environmental reform package to facilitate Clean Power 2030, changes will need to be made that cut across many different areas, involving multiple organisations, including developers, supply chains, and investors. The different systems with different requirements and obligations across the planning landscape are complex and were not designed to deliver at the speed and volumes now required of them.

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[49] Prime Minister's Office, 10 Downing Street (2024), '*Plan for Change: Milestones for mission-led government*' (viewed in December 2024).
[50] DESNZ analysis based on the Renewable Energy Planning Database (REPD).

Taking action

We will equip examining authorities with the tools they need to help deliver Clean Power 2030 and government's wider missions

We can unblock bottlenecks by improving resource, particularly shortages of critical specialisms, which are often noted as a main cause of statutory consultees' reasons for planning application deadline extensions[51]. In 2023-24, over 60% of delayed responses to planning applications from the Environment Agency were due to resourcing constraints[52], while Natural England have said the same for over 80% of the time they need to extend a deadline for a planning application[53]. Another statutory consultee, Historic England, have seen a 39% decrease in expenditure on heritage services in Local Planning Authorities in planning policy since 2009/10[54], impacting the delivery of developments. Reform of the planning system includes a need to better employ key skills and resource across a variety of bodies, which can be managed through targeted interventions and streamlining the system. We are expecting an increase in planning applications with the Clean Power 2030 target, providing further challenges than those the planning system is already experiencing. To manage this increase:

- **We will expand cost-recovery mechanisms** across relevant regimes to ensure that all organisations key to consenting have sustainable resourcing models which can match the demand of projects in the system into the future, to help deliver Clean Power 2030 and beyond.
- **We will continue to enhance the support that the Planning Inspectorate and statutory consultees give to developers through the planning process,** particularly at the pre-application stage.
- **We will review resourcing in key organisations to determine whether they are suitable for handling an increased number of projects in the coming years.** To ensure resource is making the most impact, we will drive operational efficiency in statutory consultees, to speed up consultation and examination timelines. Alongside a review of resourcing, we will establish new performance standards for all public-sector organisations, including central government teams, the Planning Inspectorate, statutory advisors, and local planning authorities; in addition to improving guidance and support for the private sector.
- **We plan to reform planning resourcing for the longer term**, including supporting existing strategies such as working with universities and skills providers to strengthen the intake of planners required for all infrastructure building. Additionally, we will look at options for attracting and retaining key specialists, such as through reviewing entry requirements for such roles.

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[51] DESNZ (2023), '*Hydrogen projects: planning barriers and solutions – research findings*' (viewed in December 2024).
[52] Environment Agency (2024), '*Environment Agency's planning consultation response timelines: 2023 to 2024*' (viewed in December 2024).
[53] Natural England (2023), '*Natural England's response times to planning consultations in England*' (viewed in December 2024).
[54] Historic England (2024), '*Proposed reforms to the National Planning Policy Framework and other changes to the planning system: Consultation Response – September 2024*' (viewed in December 2024).

- **We will boost local planning capacity** including wider programmes of support, working with partners across the planning sector to ensure that local planning authorities have the skills they need both now and in the future. The government has announced a £46 million package of investment into the planning system to support capacity and capability including the recruitment and training of graduate and apprentice planners to support the planning system as a whole.

- **We will consider enhancing the quality standards energy NSIP applications must meet in order for their applications to be accepted into the regime and publish best practice** to help prevent resource being used unnecessarily in addressing issues with low quality or incomplete applications. Projects submitted to the Planning Inspectorate should be of a high quality, following best practice and guidance. Through constructive, early engagement with statutory consultees, and timely provision of information and evidence, developers will be able to better meet the high standards expected.

- **The Clean Power 2030 Unit will convene nature, communities and industry groups on complex projects**, in order to encourage and facilitate a high standard for projects, and stress-test them prior to application to identify any problems with input from across the planning system. This could enable an expedited pre-application process and help ease the burden on a system working at capacity.

We will update our national policy vehicles to reflect the needs of Clean Power 2030

Generally, where policy, legislation and guidance leaves room for doubt, examiners and decision-takers may adopt a more cautious approach to consenting and developers will lack clarity on what is required for their application to succeed. This results in added time, process and results in delays, and may open the door for more legal challenges post-decision. To address this, for NSIP policy:

- **We will update National Policy Statements** for energy in England. The Chancellor announced a 12-month review of National Policy Statements (NPSs) in July 2024. We will update our NPSs so that the Planning Inspectorate and other organisations involved in examining projects are given the clarity they need to provide robust advice on infrastructure critical in delivering Clean Power 2030;

- **We intend to take powers through primary legislation to ensure that NPSs are updated every five years through a quicker and easier process, giving increased certainty to developers and communities.**

- **We are reintroducing onshore wind into the NSIP regime at a new threshold of 100 MW and are altering the existing threshold for solar to 100 MW.** This will ensure the planning system is efficient with appropriate routes available that are proportionate to a project's scale, impact and complexity.

For local planning policy in England:

- **We have ended the de facto ban on onshore wind development**, and have now published our consultation response confirming changes to the National Planning Policy Framework (NPPF);

- **We will update the Planning Practice Guidance in 2025 to provide clarity on the application of planning policy** for renewable and low carbon development to support the updates to NPPF in practice. This will help local councils in developing policies for renewable and low carbon energy and identifies the planning considerations associated with a proposal for development.

We will undertake legislative reform

We must reform the planning system, so it works better for energy projects and wider infrastructure for the long term beyond 2030 too. We will need to continue delivering new clean power infrastructure at pace after 2030 to keep up with increasing electricity demand. Government recognises the need to more strategically plan its long-term infrastructure needs and it needs the planning system to be responsive to this.

- **We will bring forward a Planning and Infrastructure Bill with measures to streamline the delivery of critical infrastructure in the planning process.**

The Bill will introduce new measures to prioritise and streamline the delivery process for critical infrastructure through the planning process, including accelerating upgrades to the electricity grid and boosting renewable energy which will benefit local communities. These proposed changes will move us away from a position where vital new infrastructure is being unnecessarily delayed whilst ensuring that it is sustainable, responsible and maintains high environmental and nature standards.

Since our proposed primary legislation is not a quick-fix and will be too late for some projects that are critical for Clean Power 2030:

- **We will review secondary legislation and other legal requirements (like licences) regarding the planning process for energy infrastructure to establish relevant changes to speed up delivery of projects for Clean Power 2030.**

Legal challenges to DCOs can create significant delay to the delivery of NSIPs in England and Wales. Judicial review is a constitutionally important mechanism which allows an individual or organisation to challenge the lawfulness of a DCO decision in court. However, there is a case for reviewing the process to identify ways in which it can be streamlined to ensure it does not unduly slow down vital infrastructure development. Most legal challenges against DCO decisions are unsuccessful, but it can take many years for the courts to reach the decision, and hear further appeals in higher courts, leading to uncertainty and delays. Delays to new infrastructure can increase costs to consumers where constraint payments to operators are required.

- **We will explore reforming the judicial review process for NSIPs following Lord Banner's recent independent report**. We have published a call for evidence on judicial review reform following this report which is due to close at the end of this year. The call for evidence is seeking views on Lord Banner's recommendations and invites suggestions on other options for reform to reduce delays to infrastructure projects in England and Wales. We intend to legislate at the earliest convenience for any desired changes requiring primary legislation following the call for evidence. For example, this could include changing the rules so that claimants in each case only have one attempt to seek permission for judicial review. Any changes that we decide to make will strike the right balance between reducing delays to infrastructure projects and maintaining access to justice in line with our domestic and international legal obligations. In Scotland, the recent consultation on reforms to electricity infrastructure consenting sought views on creating a unified and streamlined system for challenging the decisions of Scottish Ministers, taken under the Electricity Act 1989, through the courts.

We will ensure that the protection of nature is embedded into the delivery of Clean Power 2030

Our existing planning system is built on solid foundational principles. Our policy and legal frameworks were originally developed to ensure the timely delivery of vital new infrastructure and other development, whilst ensuring communities hosting infrastructure are fairly treated and the natural world is protected.

We know that the status quo is not working when it comes to delivering the nature and infrastructure we need. The poor state of our natural environment means that there is often insufficient environmental headroom to allow developments to come forward without significant costly intervention. Applicants can struggle to navigate or satisfy environmental requirements and conditions on habitats, species and protected areas. A lack of clarity for industry from government and statutory consultees, a low-risk appetite from developers, and at times a reluctance from developers to engage with environmental requirements or deliver quality applications can slow down the delivery of much-needed energy infrastructure.

All this can lead to lengthy case-by-case negotiations of mitigation and compensation measures with statutory consultees, and extensions to decision deadlines. Once consent is granted, developers must often meet ‘post-consent conditions’ whereby construction cannot start until the conditions are met. To embed the protection of nature in energy developments, actions will include:

- **We are considering how to use development to fund nature recovery unlocking a win-win outcome for the economy and for nature** – as set out in the King’s Speech, we are working with nature delivery organisations, stakeholders and the sector to consider how we can better support the delivery of housing and infrastructure whilst driving better environmental outcomes;

- **We will undertake measures to reduce pressures on protected sites including through expansion of the Protected Sites Strategies in priority areas in England.** Protected sites face several pressures inhibiting their recovery. This gives rise to development constraints when sites are in unfavourable condition, even if a new development is a small contributor to the overall problem. Reducing pressures on protected sites will help to ease some of the constraints energy developments face when addressing the environmental impacts of their projects;

- **We will publish our roadmap to bring forward Environmental Outcomes Reports** in consultation with devolved government, introducing an outcomes-based approach will provide the certainty developers need to embed environmental considerations into the earliest stages of the project. This will allow stakeholders to focus on delivering for the environment rather than guarding against the risk of legal challenge which will reduce costs and delays from unnecessary work. The roadmap will include our approach to implementation to ensure a smooth transition for stakeholders;

- **We will establish industry-funded Marine Recovery Funds** into which applicants can pay to discharge their compensation obligations, underpinned by libraries of approved strategic compensation measures. The UK government are engaging with the Scottish Government with a view to reaching agreement on the establishment of, and the delegation of appropriate functions to operate and manage, a separate Marine Recovery Fund for projects in Scotland. The Offshore Wind Environmental Improvement Package (OWEIP) as a whole will accelerate and de-risk the consent of offshore wind projects whilst continuing to protect the marine environment;

- **We will consider options for harmonising the offshore wind environmental data and modelling used** for assessing impacts of offshore wind projects on species and habitats to provide consistency in assessments. Standardised methodologies and inputs to models and data standards could be developed allowing developers access to harmonised, coherent public data, reducing disagreements between developers and Statutory Nature Conservation Bodies (SNCBs), and helping to shorten the pre-application timelines for all future projects;
- **We will consult on reforms to the environmental permitting regime to better enable Clean Power 2030**, and ensure that environmental regulators have the powers and evidence to promptly develop the pollution standards required for the permitting of emerging clean power technologies;
- **We will explore strategic approaches to managing environmental pressures around industrial clusters which engages effectively with the planning and permitting systems. This will help to enable cluster decarbonisation within environmental constraints and address emerging issues prior to projects entering the planning system;**
- **We will launch a public engagement exercise in early 2025** to invite stakeholders to submit their ideas on **how government can best encourage nature-positive best practice into energy infrastructure planning and development**. Feedback from this exercise will allow government to better understand how we can integrate nature restoration within Clean Power 2030.

Our reform programme to deliver clean power infrastructure will keep nature at its heart. Whilst we want to accelerate infrastructure delivery, project developers must be clear that government expects them to continue delivering for communities and nature. We are not writing a blank cheque for low quality applications that fail to consider these outcomes.

We will work towards communities benefit from hosting new clean energy infrastructure

To realise our ambitions of becoming a clean energy superpower, some communities will see an increase in the amount of new energy infrastructure being built in their area. We must ensure that we bring all communities with us on this journey to Clean Power 2030. Maintaining public support is vital to the delivery of clean energy ambitions in Great Britain, and those asked to host energy infrastructure should feel tangible benefit from the role their areas play in building a low-cost electricity system[55]. Community benefits are already delivered on a voluntary basis in some sectors across Great Britain (e.g. solar and onshore wind), but this is not consistent across sectors and locations. Government wants to ensure that all communities hosting infrastructure receive high quality benefits in a consistent manner.

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[55] NESO (2024), '*Clean Power 2030*' (viewed in December 2024).

We will ensure that communities directly benefit from clean energy infrastructure they host, and continue to explore how to do so. This will build on existing approaches to community benefits within the onshore wind sector, on which government intends to publish updated guidance for England in due course, and the work that Solar Energy UK have been taking forward to develop industry-led guidance for solar energy projects. In the interim, the government plans to publish new guidance on voluntary community funds so that communities benefit in a fairer, more ambitious and consistent way from new onshore electricity transmission infrastructure.

Planning reform in Scotland

Scotland is taking further action to improve the resourcing of the planning system. The Scottish Government's consultation on Investing in Planning set out of proposals aimed at increasing the capacity of the planning system in Scotland – the Scottish Government is now progressing a range of actions following the consultation. which set out a range of proposals aimed at increasing the capacity of the planning system in Scotland. Following the consultation we are now progressing a range of actions

The UK and the Scottish Government share the view that the consenting regime for larger scale electricity infrastructure in Scotland is not fit for purpose. Delays are caused by inefficient and outdated features of the existing legislative framework. The UK government, with the support of the Scottish Government, agree that the most pragmatic route to speeding up the deployment of low carbon electricity infrastructure is to reform the existing legislative framework. To address this:

We will seek powers to reform the current legislative framework for electricity infrastructure consenting in Scotland, with changes deployed by the Scottish Government. The Electricity Act 1989 could, for example, be amended to modernise and remove inefficiencies, whilst giving communities and statutory consultees meaningful opportunities to influence applications for consents.

The UK and Scottish Governments have worked together closely on reforms to electricity infrastructure consenting in Scotland referenced above. The recent consultation gathered evidence on a package of proposals which would help to streamline the existing outdated system in Scotland, which will encourage investment and acceleration towards our 2030 ambitions.

Additionally, with specific regard to consenting for offshore electricity infrastructure, the Scottish Government has been actively engaged with the UK government in the development and implementation of the reforms being delivered via the Offshore Wind Environmental Improvement Package under the Energy Act 2023, which will enable more efficient regulation of adverse environmental impacts arising from Scottish offshore wind developments. The Scottish Government also continues to pursue a continuous improvement approach to Scottish consenting processes through its Consenting Streamlining Unit, implementing more streamlined procedures where beneficial.

Planning reform in Wales

The Welsh Government has recently taken action to accelerate their infrastructure planning decisions. Immediate action has including enabling Planning and Environmental Decisions Wales (PEDW) to take decision on energy projects up to 50 MW, and prioritising applications for Developments of National Significance which have the greatest public benefits.

Longer term, the Infrastructure (Wales) Act sets out the new consenting process for significant infrastructure projects in Wales both on land and in the territorial sea[56]. This replaces multiple existing consenting processes with a single process. It will provide confidence and certainty in the decision-making process which is underpinned by clear policy that strikes the right balance between the need for infrastructure projects to help combat climate change whilst respecting our natural environment.

They have produced a consultation paper on development of a resilient and high performing planning service, including proposals for funding, performance monitoring, and increasing staffing skills and resilience[57].

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[56] Welsh Government (2024), '*Implementing the Infrastructure (Wales) Act 2024*' (viewed in December 2024).
[57] Welsh Government (2024), '*Promoting a resilient and high performing planning service*' (viewed in December 2024).

Electricity Networks and connections

Summary

Our grid infrastructure needs strengthening. Failure to do so risks holding back our energy security, economic growth and other important infrastructure with lengthy delays. Across many walks of life, people see grid infrastructure as a massive impediment to their plans.

In truth, Great Britain's electricity network must undergo unprecedented expansion, as the economy electrifies, to deliver decarbonisation, energy affordability and energy security, and support economic growth. To connect new generation and meet future demand, around twice as much new transmission network infrastructure will be needed in Great Britain by 2030 as has been delivered in the past decade[58]. In addition to relevant cross-cutting actions on planning, supply chains, and skills we will take action to deliver the network we need at the right time:

Fundamentally reforming the connections process, working with NESO, Ofgem, TOs and DNOs to prioritise viable projects that align with the Clean Power 2030 Action Plan. Without these critical reforms, the queue will not align with our strategic needs and the projects we need will be delayed.

Regulatory reform to ensure that the Clean Power 2030 target is better integrated into planning and investment decision making, enabling investment in networks ahead of need. This includes working with Ofgem to explore the appropriateness of tightening the incentives and penalties to drive the acceleration of network build-out delivery.

Improving networks planning and consenting to provide the levers to accelerate the expansion and upgrades required across our transmission and distribution network to ensure energy infrastructure can support the delivery of the 2030 target.

Engaging with communities to enable them to benefit from living near new transmission network infrastructure.

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[58] NESO (2024), '*Clean Power 2030*' (viewed in December 2024).

The challenge

Urgent action is required to ensure that the grid we need is in place for the connection of low-carbon generation and electrification of sectors such as transport, heating, and industry. Network build must be accelerated to address annual constraint costs, which are projected to increase without action from the already high level of around £2 billion per year in 2022[59] to around £8 billion per year[60] (or £80 per household per year) in the late 2020s[61], in a scenario where delays to network build persist. This cannot be allowed to happen.

Network constraints occur when the electricity system is unable to transmit power to electricity users because the maximum capacity of the circuit is reached. Constraint costs arise when NESO has to manage this problem by paying generators to reduce (turn-down) their electricity output in areas that are congested and switch on (turn-up) in locations closer to electricity users.

Work is required to significantly reduce the end-to-end delivery time for new transmission infrastructure. In the independent 2023 Report[62] by Nick Winser (Advisory Commissioner to the Clean Power 2030 Mission), he set out recommendations to halve timelines from 14 to 7 years, starting with strategic spatial planning of energy projects which would allow the network to be planned holistically ahead of need. Winser was clear that ambitious interventions were needed across every stage of the delivery process and government is working with delivery partners to drive the necessary change, including Ofgem, NESO and the network companies, who play a crucial role in delivery of new infrastructure on the ground.

To deliver a decarbonised power system by 2030, we will need to build on Winser's recommendations, going further and faster where necessary, to ensure the network we need is in place in time. NESO's Clean Power 2030 advice[63] confirms that all 80 transmission projects they identified as required to achieve clean power by 2030, including both upgrades to existing infrastructure and new transmission lines, are already in existing strategic network plans[64]. Of these, there are three with delivery dates post 2030, which we know need to be accelerated. Delivery of the full list of projects to such a short timeline is an unprecedented challenge. Government and the Clean Power Advisory Commission will work closely with partners to monitor delivery of individual projects and identify targeted interventions to accelerate delayed projects where necessary, including through prioritisation in the consenting process. Wherever renewables can connect to the distribution network, this should be encouraged for reasons of speed and efficiency.

The distribution network is also in need of reform and, whilst it is less constrained than transmission level, large amounts of distribution-connected renewable

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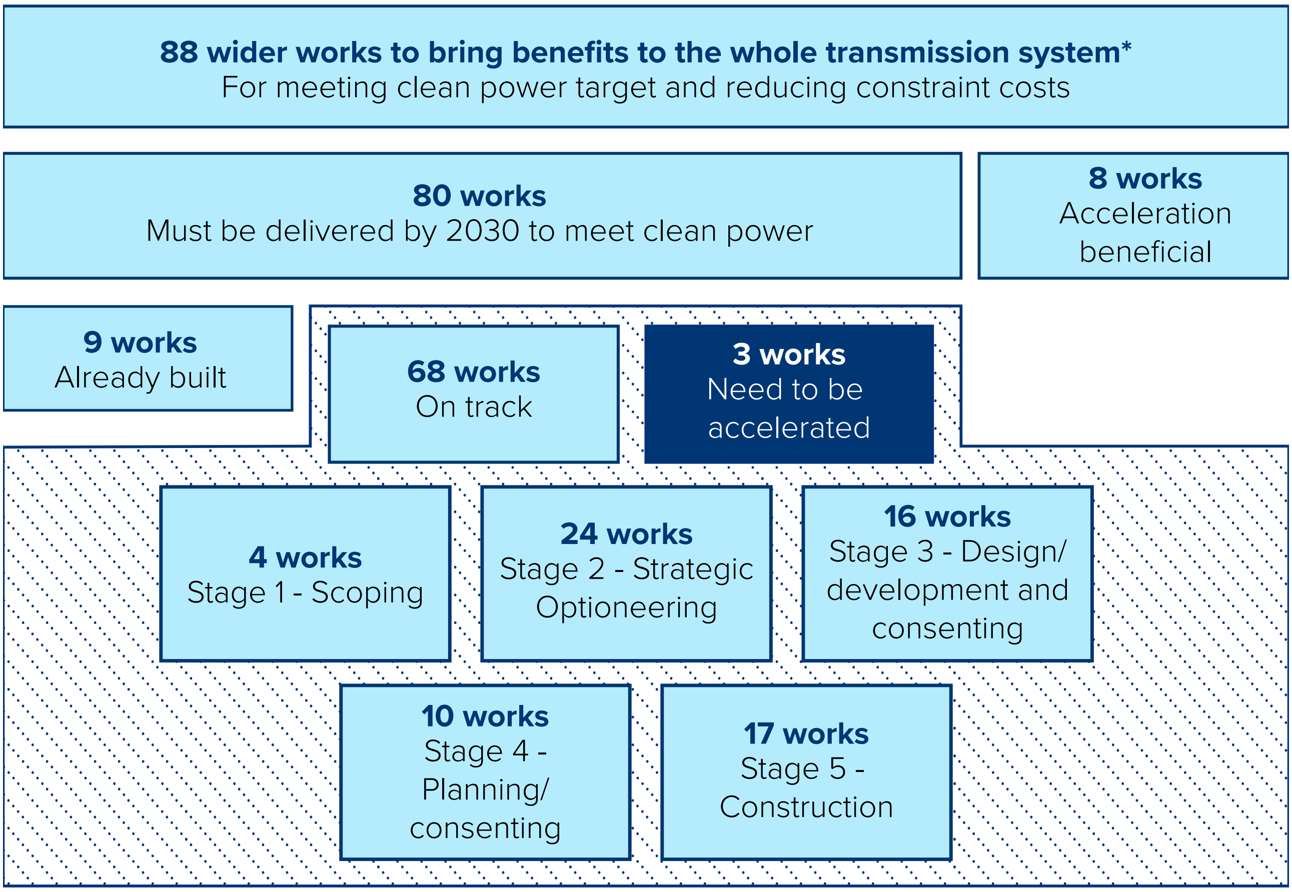
[59] National Grid ESO (2022), '*Monthly Balancing Services Summary*' (viewed in December 2024).
[60] Undiscounted, 2022/23 prices.
[61] DESNZ (2023), '*Community benefits for electricity transmission network infrastructure: government response*' (viewed in December 2024).
[62] DESNZ (2023), '*Independent report: Accelerating electricity transmission network deployment: Electricity Networks Commissioner's recommendations*' (viewed in December 2024).
[63] NESO (2024), '*Clean Power 2030*' (viewed in December 2024).
[64] NESO (2024), '*Clean Power 2030*' (viewed in December 2024).

generation and storage will need to be accelerated to achieve the 2030 target. Significant reinforcement and build out of the distribution network will also be required to support the electrification of sectors projected for the decades ahead, as well as to accommodate new demand in some locations for growing infrastructure and industrial uses, such as data centres and transport hubs.

In addition to those actions set out in this chapter, delivery of network infrastructure will rely on actions outlined elsewhere in this Action Plan, notably the interventions being developed by the Office for Clean Energy Jobs to secure a workforce with the right skills to deliver Clean Power, resourcing and reforming planning and consenting for energy infrastructure, and supply chain interventions.

Figure 11: Transmission network project maturity and delivery timeline



Source: NESO (2024), 'Clean Power 2030'

* These are wider transmission network reinforcements – they may not include all works, for example, works driven by connection enabling works, operability etc.

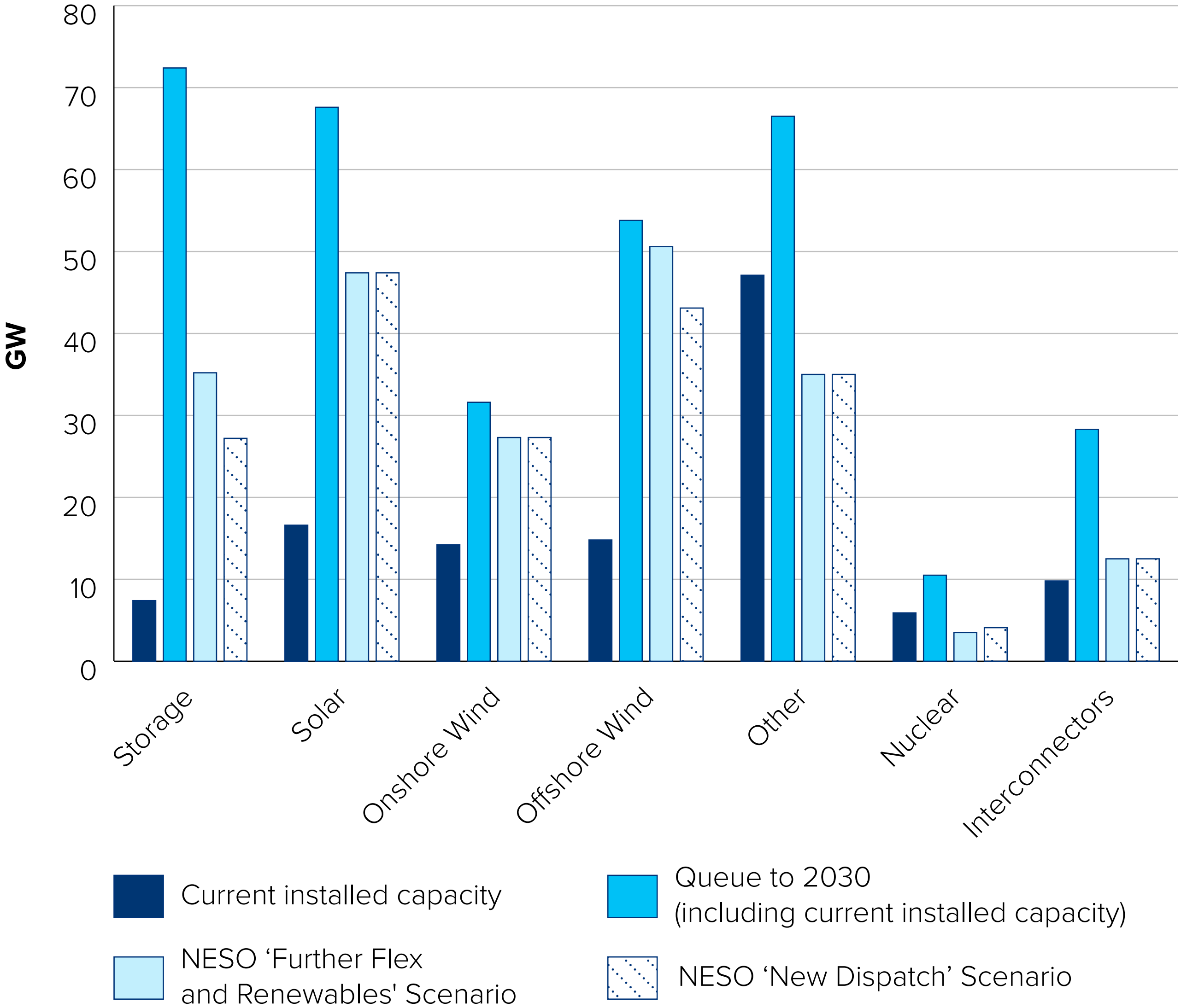
Taking action

Connections reform

Over the last five years, the grid connection queue has grown tenfold, and now contains an equivalent capacity of 739 GW[65]. Many of these projects are speculative or do not have the necessary funding or planning permission to progress, causing unacceptable connection delays for viable projects behind them. Fundamental reform of the connections process is critical and urgent – without it, the projects we need for Clean Power will not be able to connect on time.

We also need to accelerate towards net zero and ensure timely connections for demand including an increasing volume of low carbon technologies such as EV charge points and heat pumps, as we electrify the wider economy.

Figure 12: Current connections queue compared to current installed capacity and NESO 'Further Flex and Renewables' and 'New Dispatch' scenarios (GW)



Note: Other includes biomass, unabated gas, coal, oil and other fuels for current installed capacity. 2030 capacity figures refer to unabated gas only.

Source: Table 1 & DESNZ (2024), 'DUKES' & NESO (2024), 'Clean Power 2030'

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[65] Including Demand. Correct as of end-October 2024. Connections data is published monthly by the Connections Delivery Board.

The queue is currently managed on a 'first come, first served' basis which does not consider the required 'mix' of energy projects (e.g. solar, wind) or where this mix is best located. As such, we do not have the levers to ensure an optimised future energy system across all regions of Britain that responds to local energy planning as well as national needs.

To meet our 2030 ambition, we must act now to rationalise the queue and accelerate the projects that are critical to our goal. This means going beyond previous plans to remove slow-moving or stalled projects from the queue and prioritise based on readiness alone. These actions are still needed but to achieve Clean Power 2030, technological and locational factors need to be considered in the connection process so the right projects can connect in the right place at the right time.[66] This Action Plan can now provide the basis to do this.

By removing unviable projects, re-ordering the queue, and accelerating connection timescales for the projects we need most, connection reform is expected to unlock £billions of much-needed investment in renewable generation[67] and electrification of the wider economy – investment that has been held back for too long.

A strategically aligned connections process will also bring inherent efficiencies in network design, planning, and build, and provide long-term confidence not only for investors in renewable energy, but also for all demand sectors that will depend on clean energy for electrification (from data centres – including those vital for supporting AI (Artificial Intelligence) – and gigafactories, to EVs and heat pumps), as well as related supply chains and the jobs these will create.

Government, Ofgem, NESO and network companies have been working at pace[68] to strengthen existing 'first ready, first connected' proposals and NESO has now consulted on[69] the detailed methodologies that will enable it to filter the queue and prioritise connections using strategic plans, starting with capacity ranges for generation technologies required for clean power by 2030 that are laid out in this Action Plan. Government will:

- Work with NESO and Ofgem to **change the grid connections process** to operationalise the Action Plan, by providing a framework through which NESO can work with Transmission and Distribution Operators to prioritise aligned projects, resulting in updated offers being issued before the end of 2025. Further detail on this is set out in the connections reform annex of this publication. We will introduce legislation, when parliamentary time allows, to ensure connection reform aligns with strategic energy and network plans and supports delivery of clean power by 2030.
- Subject to Ofgem's approval, additional flexibilities will be included in the reformed connection process to manage project attrition and over- or under-supply. For example, projects that go beyond the 2030 pathway for a technology but are aligned to the relevant 2035 pathway will still be eligible to connect before 2030 where there is spare capacity, after all 2030 pathway projects have been assessed. NESO will also be able to make substitutions of the same technology

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[66] See the connections reform annex for further detail on regional breakdowns of technology capacities.

[67] DESNZ & Ofgem (2023), '*Connections action plan: speeding up connections to the electricity network across Great Britain*' (viewed in December 2024)

[68] DESNZ & Ofgem (2024), '*Open letter from DESNZ and Ofgem: Aligning grid connections with strategic plans*' (viewed in December 2024).

[69] NESO (2024), '*Connections reform consultation*' (viewed in December 2024).

between zones to manage over- and under-supply, where this does not cause material network constraints.

To avoid impacting projects whose development is already well advanced, NESO has proposed that any project that has been awarded a Contract for Difference or Capacity Market contract, an Interconnector or Offshore Hybrid Asset Cap and Floor agreement, Merchant Interconnector approval, or has secured planning permission as a Nationally Significant Infrastructure Project or via relevant Town and Country Planning Acts (including through devolved governments' planning regimes), will be included in the new reformed connections queue provided they have also met the Gate 2 Readiness Criteria.[70] Government will also use the publication of the SSEP in 2026 to examine the mix of technologies and consider whether capacity reserved for undersupplied technologies should be released for other technologies.

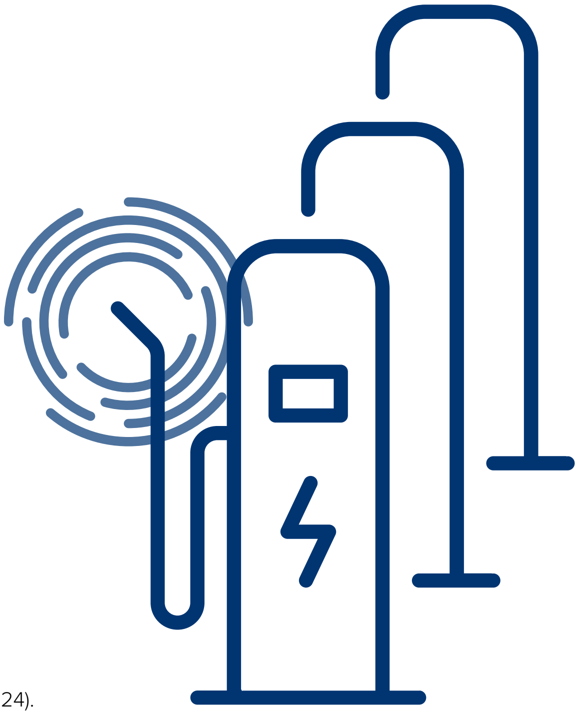
All parties involved must work at pace to secure swift and positive resolution of the reform process and explore all opportunities for faster implementation so that customers can received updated connection offers as soon as possible in 2025. In line with updating connection offers, the Transmission Owners will review and where necessary revise enabling and local works to comply with the requirements of the Security and Quality of Supply Standard. NESO also plays a role in ensuring overall compliance of the network with these standards.

Regulatory reform

Through its Accelerated Strategic Transmission Investment (ASTI) framework, Ofgem has prioritised the timely delivery of 26 large-scale strategically important transmission projects for delivery ahead of, or by, 2030. Of these, NESO have indicated that 21 need to be delivered by 2030 to deliver the Clean Power Plan. Delivery incentives apply to all 26 ASTI projects and Ofgem is building on this approach in future price controls for networks, which will be adaptive to efficiently fund additional build requirements. Timely delivery of these key projects remains very challenging and delivery incentives may need to be stronger to encourage ambition by the Transmission Owners.

To address these challenges, government will:

- Amend the Strategy and Policy Statement (which sets out government's strategic priorities that Ofgem must have regard to) to **ensure 2030 clean power and broader decarbonisation goals are sufficiently weighted in decision making** to approve strategic investments by network companies at an earlier stage.
- Work with Ofgem to explore the appropriateness of **tightening incentives and penalties for Transmission Owners and Distribution Network Operators** for delivery of strategically important network infrastructure. We will also work with Ofgem to ensure all incentives and penalties are robustly enforced.



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[70] NESO (2024), '*Open letter on connections reform*' (viewed in December 2024).

Networks planning, land rights and consenting

Accelerating transmission and distribution network build required for 2030 is heavily dependent on the capacity of the planning system and wider reforms to planning and environmental requirements for all new energy infrastructure. This includes better resourcing of the planning system, reforms to consenting for energy projects in Scotland, and prioritisation of electricity networks projects in the consenting processes in England and Wales. Further details on these measures can be found in the Planning and Consenting for New Energy Infrastructure chapter.

At the distribution network level, current land rights processes in England and Wales can take between 2 to 4 years, which can lead to unnecessary delays[71]. A call for evidence undertaken by the previous government found that both network operators and landowners believe reform to these processes are necessary[72]. To address this, government will consult and engage in 2025 on proposals including:

- **Expanding planning consent exemptions** to include low voltage connections and upgrades, including upgrading single phase to three phase overhead lines (with voltage remaining the same) by amending the Section 37 regulations as they apply in England and Wales.
- **Opportunities to provide further flexibilities on the consenting of electricity substations.**

The National Policy Statement for Electricity Networks Infrastructure (NPS-EN5) sets out the government's position on undergrounding, which is that there is a starting presumption for overhead lines for large network projects. The exception to this is in nationally designated landscapes, where undergrounding is the starting presumption. This position takes into account factors including cost and environmental impacts, and the government's view is that this sets an appropriate balance between overhead lines and undergrounding.

Community engagement

To bring communities with us, we will need to better engage and provide assurance to communities and ensure they benefit from living near new onshore energy infrastructure. This government believes that it is a vital principle that communities that host clean energy infrastructure should benefit from it.

To recognise the vital role of communities living near new onshore transmission network infrastructure, government will deliver a strong package of community benefits. We will:

- **Publish voluntary guidance** to increase the quantum and consistency of Community Funds for transmission networks. This guidance will detail the recommended level of benefit, scope, eligibility, delivery costs, and the role of communities and developers.

To improve understanding of the need for new transmission infrastructure and better set the context for discussions with communities on new projects, the government will:

- Support the launch of a **public communications campaign** developed by industry with government support, to encourage public awareness on the importance of networks infrastructure in supporting net zero. This will be launched in early 2025.

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[71] Energy Networks Association (ENA) (2023), '*Common sense plan for planning*' (viewed in December 2024).
[72] DESNZ (2024), '*Land rights and consents for electricity network infrastructure: summary of responses*' (viewed in December 2024).

These actions, alongside ongoing work of the government and our delivery partners, including Ofgem, NESO, and the Transmission Owners, will further accelerate networks projects that are critical to achieve 2030 Clean Power and reduce constraints on the network. They will ensure that communities benefit from hosting network infrastructure, reform the grid connections process to ensure timely connection for generation that is ready and is required for Clean Power 2030, and ensure that the network is ready for increasing electricity demand and continued development of low carbon generation post-2030.

Great British Energy

Setting up Great British Energy is one of government's first steps for change, putting the UK on the path to become a clean energy superpower. Great British Energy will be 100% owned by the British people, for the British people.

Our new publicly-owned energy company is designed to drive clean energy deployment to boost energy independence, create jobs, and ensure UK taxpayers, billpayers and communities reap the benefits of clean, home-grown energy. Great British Energy's project development and local power functions will help support the Clean Power 2030 mission, including through the development of up to 8 GW of local and community energy projects. We will continue to see its impact after 2030, ensuring we can meet future demand as we further decarbonise the economy out to 2050.

Great British Energy will benefit all four nations, and we are working hard to ensure its functions can complement the green energy initiatives across Scotland, Wales and Northern Ireland, creating jobs and building supply chains across the UK, while respecting the devolution settlements. Achieving our shared net zero targets, having greater control over our own energy resources, and increasing our energy independence are challenges for the whole of the UK, and this is an excellent opportunity to learn from each other's expertise and experience.

We are making rapid progress in establishing Great British Energy. In July, we published Great British Energy's Founding Statement, which set out its five functions: project investment and ownership; project development; supply chains; the Local Power Plan; and Great British Nuclear. We also announced Juergen Maier as the start-up Chair, alongside GBE's first major partnership with The Crown Estate. Since then, Great British Energy has announced its Aberdeen headquarters and made key policy decisions, including plans to collaborate with the National Wealth Fund to accelerate investments. And finally, we have secured £125 million in funding for 2025/26 so that GBE can start its important work to drive forward clean energy deployment.

This is just the start. Great British Energy will be capitalised with £8.3 billion over the current Parliament. Through its five functions, the publicly-owned company will help to create a better investment offer for privately-owned energy companies and international investors who will continue to play a significant role in our transition to an affordable, decarbonised power sector.

Renewable and nuclear project delivery

Summary

Electricity generated by renewables and nuclear power will be the backbone of a clean electricity system by 2030. Actions set out in other chapters, to lower barriers to planning and environmental consent, electricity network connection, and access to necessary supply chains and workforce will go a long way to increasing deployment of renewable technologies. However, even with success in these areas, there are outstanding and specific barriers that we face to deploy the renewables needed for a clean power system in 2030. There are also hurdles facing our nuclear fleet and the scaling up of emerging renewable technologies.

To lower and remove these, we will:

Improve the way Contracts for Difference are allocated, particularly for Allocation Round 7 (AR7), to support clean power delivery and ensure it can procure the capacities needed to hit the target.

Coordinate the interaction between wind turbines and civil aviation and defence infrastructure, working to find mitigation solutions and unlock deployment of planned offshore and onshore wind projects.

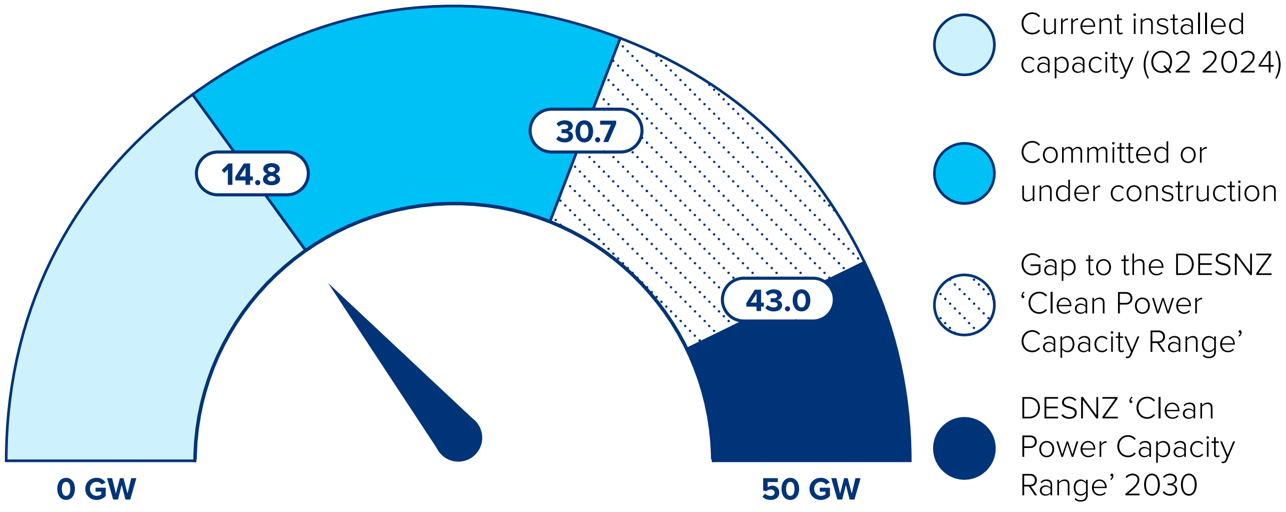
Leverage Great British Energy and deploy further policy measures to increase the rollout of local and community generation, including for homes, businesses, public buildings and land, and shared spaces.

Manage assets reaching the end of existing government support terms to minimise any capacity that may be lost before 2030, including through supporting repowering through the Contracts for Difference scheme.

Work with EDF to support the delivery of Hinkley Point C and support the development and technology readiness of emerging clean technologies that will play an important role beyond 2030.

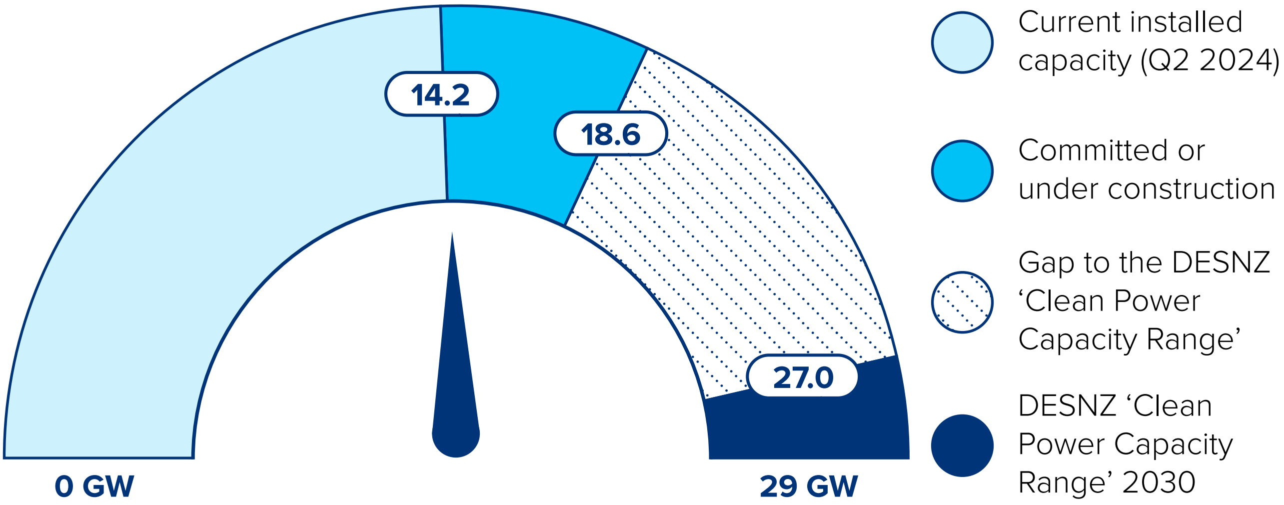
Offshore Wind

Current installed capacity compared to the DESNZ 'Clean Power Capacity Range' in 2030 (GW)



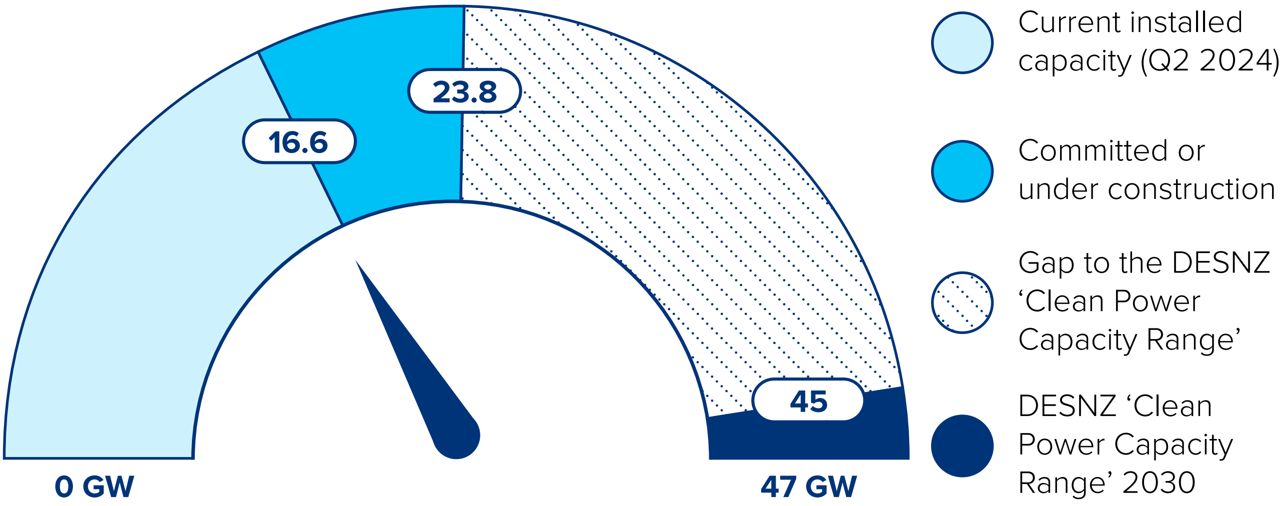
Onshore Wind

Current installed capacity compared to the DESNZ 'Clean Power Capacity Range' in 2030 (GW)



Solar

Current installed capacity compared to the DESNZ 'Clean Power Capacity Range' in 2030 (GW)



Source(s): Table 1, Low Carbon Contracts Company (LCCC) (2024), '*CfD register*' (viewed in November 2024).

Notes: Committed / under construction is defined as projects that have secured a Contract for Difference (CfD) but not yet become fully operational. For onshore wind and solar PV, 'merchant' (non-CfD) capacity that has not yet deployed has not been counted. Any pre-2030 asset retirements are not considered in these estimates.

The challenge

Renewable technologies will form the foundation of our clean power system, and we need to see very significant deployment to make this a reality. Meeting the renewable capacities set out in the DESNZ 'Clean Power Capacity Range' is achievable, but will require deployment at a sharply accelerated scale and pace. This can only be delivered by unblocking delivery challenges throughout the development lifecycle.

Accelerating delivery is exceptionally critical for **offshore wind**, where lead times for projects are often more than a decade[73]. This means that all that can be deployed by 2030 has either already been consented or is in the development and consenting process. Procurement and final investment decisions of these projects will need to be in place over the next 1-3 years.

There is greater potential to bring new **onshore wind** and **solar** projects forward and deliver additional capacity beyond what is already planned by 2030, due to shorter lead times[74]. But again, many 2030 projects are likely to already be in various stages of development, and final investment decisions on these projects will still need to be made well before our 2030 target.

Actions in this chapter, alongside cross-cutting enablers set out in other chapters, will support the delivery of renewable generation projects by de-risking the existing pipeline, accelerating new projects through the pipeline, and maximising the potential of existing capacity as assets approach end-of-life.

Nuclear power will also play a key role in achieving Clean Power 2030 and beyond by providing low-carbon, baseload generation on the system.

Taking action

Improving the way that Contracts for Difference are allocated to support 2030

The Contracts for Difference (CfD) scheme is the government's flagship policy for incentivising new low carbon electricity generating projects in Great Britain. The CfD and its predecessor investment contracts have seen around 9 GW of renewables start generating under them already, with a further 26 GW contracted to become operational by 2030[75].

Though the CfD has delivered substantial volumes of renewable capacity over the last decade, AR5 was a round that failed to deliver any offshore wind, which was a massive setback for industry and meant consumers were left more exposed to fossil fuel markets. We need consistency of success and scaling up to protect customers and meet Clean Power 2030. There is currently around 31 GW of either constructed or contracted offshore wind capacity. This will need to rise to 43-50 GW in 2030. The government will therefore seek to secure at least 12 GW across the next two to three allocation rounds – AR7, AR8 and, depending on the speed at which projects deploy, AR9.

This government has shown its ability to get the offshore wind sector back on its feet. While AR5 secured 0 GW of offshore wind, AR6 supported over 5 GW, at a price that was cheaper to build and operate than new fossil fuels. The government will ensure it secures the right volumes of offshore wind at a competitive price.

It is also the case that industry has long been calling for CfD reform to remove some of the uncertainty and give greater line of sight to support industrial strategy. That is why the government is developing

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[73] DESNZ (2023), '*Seizing Our Opportunities: Independent Report of the Offshore Wind Champion*' (viewed in November 2024).
[74] DESNZ (2023), '*Electricity generation costs 2023*' (viewed in December 2024).
[75] LCCC (2024), '*CfD Register*' (viewed in December 2024).

targeted reforms to the CfD mechanism to ensure it is able to support the volume of new capacity – in particular, fixed-bottom offshore wind – needed to deliver the renewable contribution to the Clean Power 2030 target whilst continuing to minimise the costs of doing so to consumers. Subject to further assessment, including of the merits, feasibility and any further consultation where relevant, for AR7, the government is currently minded to implement:

- **A relaxation of CfD eligibility criteria for fixed-bottom offshore wind projects** to permit projects that have not yet obtained full planning consents to participate in near-term allocation rounds. This would award CfDs at an earlier stage in the offshore wind development cycle compared to the current model. Coupled with wider reforms, this could improve competition and enable earlier supply chain engagement.

- **Changes to what information the Secretary of State uses to inform the final budget for fixed-bottom offshore wind**, to avoid a repeat of AR5 and cost effectively maximise the volume of capacity that could be contracted from each round. This includes providing greater visibility over sealed bid information for the Secretary of State ahead of finalising the budget, so that there can be more certainty on how much capacity a given CfD budget will procure.

- **An auction schedule**, including capacity ambitions for upcoming allocation rounds, to improve transparency and predictability in the timing and scale of ambition for the CfD.

- **A review of auction parameters**, including our approach to Reference Prices (estimates of the average GB market price for electricity) used to estimate the budgetary impact of projects bidding into allocation rounds. The government recognises industry concerns and feedback about Reference Prices and the implications for CfD budgets and is seeking to ensure these concerns are balanced with our strong ambitions for the power sector for 2030 and beyond.

Alongside increased certainty around the auction and the potential capacity it can secure, **the government is also considering changes to CfD contract terms that would give longer market certainty once contracts are awarded,** including consideration of the merits of increasing the current 15-year CfD term to reduce overall project costs. The department intends to consult on this in early 2025, and to move ahead, would need evidence that this was in the interests of consumers.

Given the level of investment required, the government recognises the need to ensure that reforms provide stability and confidence to the sector, including the supply chain, and are delivered in a timely way. The government will consult on reforms in early 2025 ahead of the next allocation round, with a view to implementing any changes in time for Allocation Round 7 to open in summer 2025.

In addition to these proposals, there are wider measures that contribute further to ensuring the CfD mechanism is fit for purpose, including the Clean Industry Bonus (see the 'Supply chains and workforce' chapter) and reforms to the network charging regime in time for future CfD allocation rounds (see the 'Reforms to electricity markets' chapter).

Coordinating the interaction between wind turbines and civil aviation and defence infrastructure

Wind turbine generation must be done in a way that does not interfere with aviation and defence surveillance systems. At present, requirements are placed on proposed onshore and offshore wind projects that are impacting upwards of 20 GW[76] of capacity. The identification and implementation of interim and enduring solutions to this long-standing problem is therefore critical for Clean Power 2030.

The government has been working with the Offshore Wind Industry Council via a Joint Taskforce to drive collaborative agreements, seeking to find solution(s) so that offshore wind and military radar infrastructure can coexist now and in the future. The Onshore Wind Industry Taskforce has established its working group on aviation and defence to review the same issues.

Military radar

The Ministry of Defence (MoD) has launched Programme Njord, which will work with colleagues from DESNZ, The Crown Estate, Crown Estate Scotland, the devolved governments and the Offshore Wind Industry Council to identify, procure and implement a mitigation to resolve this problem for military radar.

The full costs of the long-term radar mitigation solutions identified by Programme Njord will be funded via an alternative route, delivered by government, and the funding requirement is therefore removed from **offshore wind** developers.

For **onshore wind** development which impacts military aviation, DESNZ and MoD are working at pace to seek an acceptable mitigation.

Civil radar

- DESNZ and the Department for Transport are working with the Civil Aviation Authority and the aviation industry to **agree a transparent and fair process to resolving objections**.
- The Onshore Wind Industry Taskforce is exploring the best specific approach, and will set out further detail to mitigate civil radar objections in the upcoming Taskforce Policy Statement.

Eskdalemuir

The Eskdalemuir Seismic Array is a facility in southern Scotland monitoring global nuclear activity. Wind turbines produce seismic ground vibrations which can compromise the Array. To safeguard the Array, MoD manages a finite seismic noise capacity to prevent compromising the detection capabilities of the Array. Scottish Government, MoD and DESNZ are collaborating to implement an updated approach to managing onshore developments around the Array.

- **MoD are consulting on their approach to safeguarding the Array, and following further work being undertaken by MoD the Scottish Government will consult on its development management guidance for new onshore wind projects in the Eskdalemuir consultation zone**. This will include a proposal on how onshore wind can be maximised within the array's consultation zone.
- The Onshore Wind Industry Taskforce will continue to examine these issues and will report by Spring 2025, covering a range of issues from supply chains and skills, to aviation and defence.

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[76] Internal estimate based on stakeholder engagement.

Great British Energy Project Development

Developers are facing high risks, rising costs, and lengthy delays to energy projects developed in the UK, slowing down our rate of deployment. Alongside process change, the UK needs significant delivery acceleration in order to meet Clean Power 2030. GBE will accelerate the delivery of onshore and offshore clean energy projects by leading or co-leading (alongside public and private sector partners) projects through the pre-development phase and, in some cases, construction and operation – getting shovels into the ground quicker and improving UK energy security through publicly-owned energy projects.

- On private land, **GBE will align with NESO's publications and the government's response to identify locations for new generation projects** where additional capacity is needed to support the UK's spatial and wider energy system needs. GBE will work in partnership with the private sector to deliver these opportunities and provide a service that is additional to the market, maximising geographical opportunities and speeding up deployment of clean energy.
- **GBE will also undertake development on public land**, unlocking additional scope for generation capacity on government-owned estates to support decarbonisation, including in partnership with the private sector. GBE will seek to work with government to access the land and actively partner with government landowners who will host generation assets and provide power directly to public buildings, in addition to connecting into the grid.

Developing on both public and private land will support large-scale generation capacity in key strategic areas of the UK, improving system efficiency and accelerating the overall rate of deployment.

Unlocking local and community energy

Much of the generation capacity that will be deployed by 2030 is likely to come from large-scale, commercial energy infrastructure. However, local and community renewable energy will also play a vital role in delivering our ambitions, contributing to the capacity mix on an aggregate basis, delivering significant local benefits and reducing network system losses by bringing generation supply closer to electricity demand. Local and community power generation can contribute significantly to the prosperity of local places, driving down electricity bills, encouraging people to engage with the green economy, providing energy resilience, and promoting skilled jobs.

- That is why one of GBE's five functions will **provide support to deliver the Local Power Plan, putting local authorities and communities at the heart of restructuring our energy economy**. GBE will partner with, and provide funding and support to Local Authorities, Mayoral Combined Authorities, Community Energy Groups and others, as well as working with and through the devolved governments, to roll out local and community energy projects (mainly onshore wind and solar) to develop up to 8 GW of clean power in England, Scotland, Wales and Northern Ireland in support of the Clean Power 2030 Mission.

Alongside the work of GBE, government is also taking specific actions to remove barriers to, and further the deployment of, local energy. These will support deployment across local settings:

In homes and local businesses:

There is great potential for rooftop solar installation across the UK's warehouse and industrial sectors. Research commissioned by UK Warehousing Association (UKWA) indicates that the UK's 20% largest warehouses alone can provide 75 million square metres of roof space, and all warehousing roof space has the potential to support up to 15 GW of rooftop solar capacity[77].

- The Solar Taskforce has examined government and industry actions that can unlock this potential through its rooftop subgroup and will publish the Solar Roadmap in Spring 2025.

New standards will be introduced next year which will amend the energy efficiency standards in the Building Regulations in England. This will ensure all new homes and buildings in England are zero-carbon ready, meaning they will become zero-carbon when the electricity grid decarbonises without the need for any retrofit work. The Future Homes and Buildings Standards consultation was published in December 2023 and closed in March 2024. It set out detailed technical proposals for what future standards could entail, including proposals relating to solar panels.

- **We are reviewing proposals and feedback from the consultation and will publish the government response in due course.**

As part of the government's Warm Homes Plan, we are considering the role that finance may play in supporting homeowners with the upfront costs of energy efficiency improvements, solar panels, and installing low carbon heating.

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[77] UK Warehousing Association (UKWA) / Delta Energy & Environment (2022), '*Investment case for rooftop solar power in warehousing*' (viewed in December 2024).

- Solar can be a cost-effective way to lower energy bills for fuel poor households, especially when paired with the adoption of a heat pumps, and **is an eligible measure in existing programmes like the Warm Homes Local Grant and Warm Homes Social Housing Fund. We will provide further details on how else solar could be supported in the Warm Homes Plan after the second phase of the Spending Review.**

In shared spaces:

Outdoor carparks provide potential to deploy solar canopies providing clean electricity, potential for electric vehicle charging and shelter for cars. Following the implementation of a new permitted development right to allow for the installation of solar canopies in non-domestic off-street carparks in England, it is now easier and quicker to deploy this technology.

- **The government will assess the potential to drive the construction of solar canopies on outdoor carparks over a certain size through a call for evidence next year.**

Finally, the National Wealth Fund's local authority advisory and lending function has a £4 billion capitalisation. It offers: commercial and financial advisory services to help local authorities undertake ambitious projects with confidence; and, lending on flexible terms at a market leading rate to local authorities who are developing projects, including in the clean energy sector.

Managing assets reaching the end of existing support

The UK-wide Renewables Obligation (RO) scheme was introduced in 2002 for GB (2005 for Northern Ireland) and it currently supports around 30% of the UK's electricity supply[78]. It is made up of three separate but complementary obligations covering England and Wales, and Scotland and Northern Ireland, and it closed to most new entrants in 2017. The Scottish Government runs the Renewables Obligation Scotland Scheme and we are working with them as we look forward to the next stages of the RO.

From 2027 onwards a large volume of renewable assets will stop receiving RO support. In total, across the GB RO schemes, around 1,000 active RO generators at approximately 9 GW of capacity will be reaching the end of subsidy by December 2030[79]. If these assets retire early, the renewable deployment required to achieve Clean Power 2030 targets and CB6 would have to increase to replace this lost renewable generation.

- We have surveyed existing RO generators to gather site-specific evidence on future plans and **are conducting further analysis to inform possible policy options to manage this risk**.
- We have already made a decision to **enable access to the CfD for repowered onshore wind from Allocation Round 7**[80] to ensure there is a route to continued generation for projects that require significant capital investment to continue operations.
- We are also implementing wider measures that will support the repowering and life extension of renewable assets, including through planning policy and through Ofgem's work on Offshore Transmission Owner (OFTO) asset life extensions.

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[78] Ofgem (2024), '*Renewables Obligation (RO) Annual Report 2022-23 - (Scheme Year 21)*' (viewed in December 2024).
[79] Ofgem (2024), '*The Renewables and CHP Register*' (viewed in December 2024).
[80] DESNZ (2024), '*Consultation outcome: Proposed amendments to Contracts for Difference for Allocation Round 7 and future rounds*' (viewed in December 2024).

Biomass: existing low-carbon firm & flexible generation

Sustainably sourced biomass can be used as a low carbon fuel for renewable electricity generation[81] and so could play an important role in Clean Power 2030 by providing flexible or firm generation. Last year, biogenic sources of electricity, including conventional biomass, anaerobic digestion and biogenic energy from waste provided nearly 34TWh (equivalent to 25% of all UK renewable electricity and 12% of overall electricity generation)[82].

Support arrangements for a variety of large and small-scale biomass generators (including biogas technologies) conclude by 2030, or earlier. The previous government consulted on future support for large-scale biomass[83]. The current government is considering whether there is a strong value-for-money case to provide future support for these generators. Any future support would need to have greater protection for consumers and would be subject to robust sustainability criteria. No decisions have yet been taken; however, we plan to respond to the consultation shortly.

Large scale biomass plants also have the potential to transition to power BECCS. This carbon capture technology can combine the conversion of sustainable biomass, biogas and biogenic wastes into electricity while capturing a high percentage of the CO_2 emissions contained in that biomass in long-term storage in geological sequestration. Large scale power BECCS has the potential to support low carbon electricity and deliver negative emissions, helping to balance residual emissions from hard-to-abate sectors.

Nuclear and emerging technologies

Nuclear

Nuclear will play a key role in achieving Clean Power 2030 in the United Kingdom and our long-term net zero objectives by providing firm, low carbon baseload power at scale to generate alongside intermittent renewable generation – see Table 2.

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[81] DESNZ (2023), '*Biomass Strategy*' (viewed in December 2024).
[82] DESNZ (2024), '*DUKES*' (viewed in December 2024).
[83] DESNZ (2024), '*Transitional support mechanism for large-scale biomass electricity generators*' (viewed in December 2024).

Table 2: Nuclear reactors that will impact installed capacity in 2030

Nuclear Power Station	Type of reactor(s)	Capacity	Status
Heysham 1	Advanced gas-cooled reactor	1.1 GW	Online – currently expected to come offline in 2027
Hartlepool	Advanced gas-cooled reactor	1.2 GW	Online – currently expected to come offline in 2027
Heysham 2	Advanced gas-cooled reactor	1.2 GW	Online – currently expected to come offline in 2030
Torness	Advanced gas-cooled reactor	1.2 GW	Online – currently expected to come offline in 2030
Sizewell B	Pressurised water reactor	1.2 GW	Online – currently expected to come offline in 2035
Hinkley Point C	European pressurised reactor	3.2 GW	Construction – expected to come online between 2029 and 2031

To help deliver Clean Power 2030, government will work with EDF to support the delivery of Hinkley Point C, with Unit 1 scheduled for completion between 2029 and 2031, enabling consumers to benefit from the project's generation as soon as possible. EDF have also confirmed they will be further extending the lives of the four generating Advanced Gas-cooled Reactor (AGR) stations, following inspections and regulatory approvals. This means that two of the AGR fleet, Heysham 2 and Torness, are expected to be generating and providing clean power until 2030.

The impact of these activities could be significant in helping ensure a reliable supply of low-carbon electricity, reducing greenhouse gas emissions, and supporting the overall decarbonisation of the power sector. However, there are uncertainties associated with having Hinkley Point C online by the end of the decade, given delays in the past few years.

As set out in the Budget, the government is also progressing the post-2030 generation interventions, with final decisions on Sizewell C and the Great British Nuclear-led Small Modular Reactor programme to be taken at the Spending Review. The government will continue to seek to streamline regulatory processes, and foster innovation in nuclear technology, to ensure that new nuclear continues to play an important role in the net zero transition after 2030. We also acknowledge the policy of the Scottish Government is not to support new nuclear developments in Scotland.

Emerging renewable technologies

Whilst emerging renewable technologies, like floating offshore wind and tidal stream, are expected to play a limited role in the 2030 energy mix, our ability to deploy them at scale could be important to the UK's achievement of longer-term decarbonisation objectives. For example, floating offshore wind could unlock the ability to take advantage of the strong winds at deeper water depths, providing additional capacity as our seabed becomes increasingly constrained. Emerging technologies could also provide broader system benefits, including by enabling renewables deployment in a wide range of locations or power generation that is uncorrelated with other energy sources, such as tidal stream.

In addition, early investment in the deployment of emerging technologies like floating offshore wind could provide wider economic benefits and export opportunities for the UK.[84] The Supply Chains and Workforce chapter sets out further detail on how government is realising these benefits, such as through the Floating Offshore Wind Manufacturing Investment Scheme.

The UK already has the world's largest pipeline of floating offshore wind projects based on confirmed seabed exclusivity, including around 25 GW already in development in Scotland. The Crown Estate has made available seabed capable of supporting up to a further 4.5 GW in the Celtic Sea, and the partnership announced between GBE and The Crown Estate will bring forward new offshore wind developments.

The government will continue to work with the industry to identify ways to support the development of innovative new renewable generation technologies to ensure that they can play the necessary role in the UK's long term energy mix. The government response to the consultation on amendments to the Contracts for Difference scheme announced that floating offshore wind projects successful in future allocation rounds would be granted the ability to build out in up to three phases, providing developers more flexibility in the construction phase and reducing project risk[85]. The National Wealth Fund will also continue to explore opportunities to finance nascent renewable generation projects, seeking to mobilise private capital into them and enable final investment decisions to be reached.

Next steps

We expect the actions set out above, delivered alongside cross-cutting enabling actions in other chapters, will set the framework for the delivery of renewable and nuclear deployment needed to meet the 2030 clean power capacity range. But there will be further action required to get these projects over the line, and the Clean Power 2030 Unit will continue to work across government, the devolved administrations and industry to ensure the implementation of enabling actions.

This includes through the ongoing work of the Offshore Wind Industry Council, the Solar Taskforce and the Onshore Wind Industry Taskforce, and through addressing delivery risks for renewable projects as they emerge (see the below case study as an example).

In the devolved nations, work is also underway to deliver this GB-wide target, with actions such as the Scottish Government's forthcoming Solar Vision, whose commitments will enable greater deployment of solar in Scotland.

Key upcoming milestones:

- The Solar Roadmap and the Onshore Wind Industry Taskforce report will both be published by Spring 2025.
- Consultation on relevant reforms to the Contracts for Difference scheme will be issued in early 2025.
- The consultation response on the Future Homes and Buildings Standards will be published in due course.

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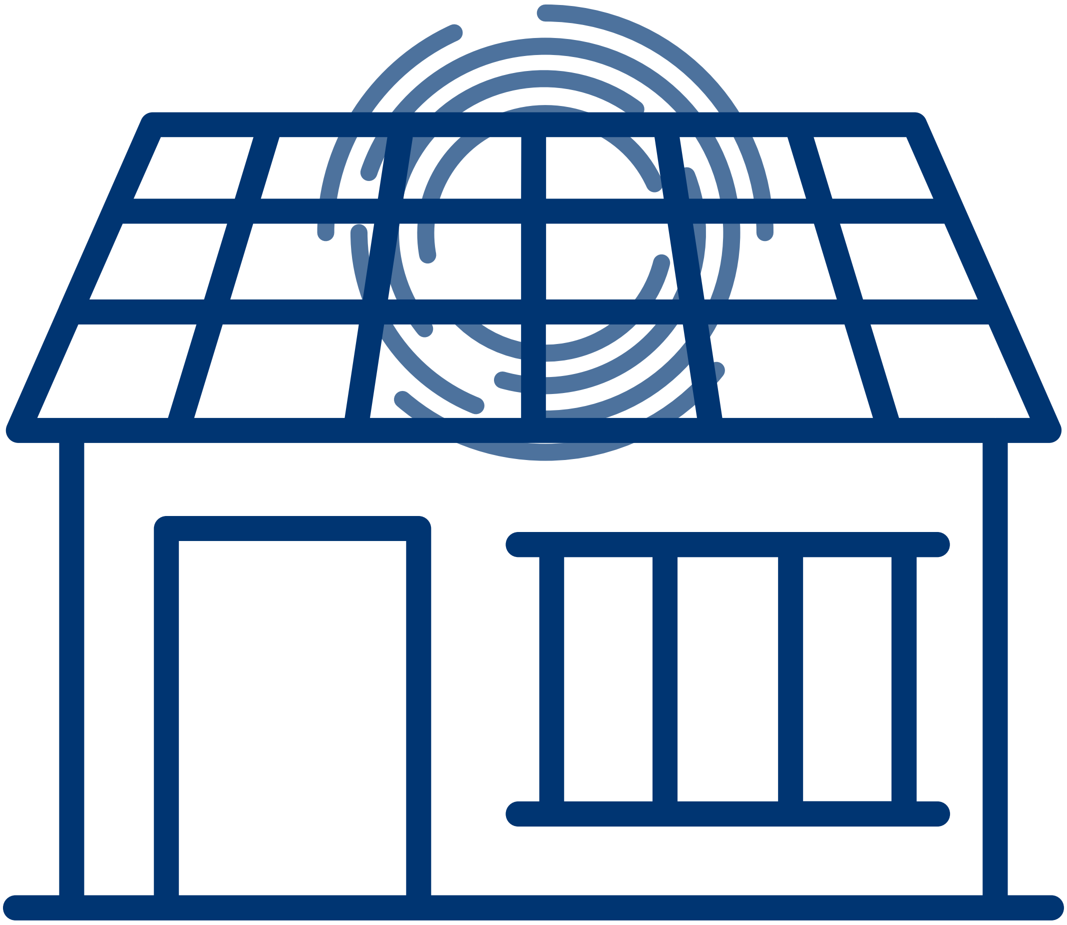
[84] The Crown Estate (TCE) (2024), '*Supply chain for Celtic Sea floating wind farms could power 5,000 new jobs and a £1.4bn boost for the economy*' (viewed in December 2024).
[85] DESNZ (2024), '*Contracts for Difference for Low Carbon Electricity Generation, Government response to the consultation on policy considerations for future rounds of the Contracts for Difference scheme*' (viewed in December 2024).

- Further details on the Warm Homes Plan will be announced after the second phase of the Spending Review.
- A call for evidence on the potential to drive solar canopies on carparks over a certain size will be issued next year.
- The consultation response on proposed transitional support for large-scale biomass will be published in due course.



Case Study: Management of emerging risks for project delivery – wake effects

Wake effects occur when wind turbines disrupt airflow to other turbines and reduce the energy production of those projects.

New projects with larger and/or a greater number of turbines have an even greater propensity to cause wake effects on existing downstream operational projects. Historically, this has been resolved outside the planning system, but a precedent was set with a wake condition in the 2023 Awel y Mor Development Consent Order, which said "No part of any wind turbine generator shall be erected as part of the authorised development until an assessment of any wake effects and subsequent design provisions to mitigate any such identified effects as far as possible has been submitted"[86].

As we radically accelerate the deployment of offshore wind in the UK to meet our 2030 target, we understand the uncertainty that this emerging issue has introduced both on operational windfarms and those in development, including the approximately 10 GW of pre-2030 offshore wind capacity currently in the planning system.

The Clean Power 2030 Unit would look to convene expert opinions from planners, engineers, academics, project delivery, data scientists and policy to understand the levers we can pull in this space, working with stakeholders like The Crown Estate, Crown Estate Scotland, the Planning Inspectorate, ORE Catapult and industry to gather the data and build an evidence base, looking for comparison mitigations with international partners and other industries.

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[86] Statutory Instrument (2023), '*Infrastructure Planning: The Awel y Môr Offshore Wind Farm Order 2023*' (viewed in December 2024).

Reforming our electricity markets

Summary

Delivering Clean Power by 2030 requires an ambitious and actively planned approach from both government and business. Action is needed to shape and enable effective markets. This approach is central to the development and operation of the 2030 system and will only grow in importance as the system becomes more distributed and flexible in 2030 and beyond. To be successful in delivering clean power by 2030, we need to:

- **Support investor certainty** by ensuring wholesale market reforms, as being developed under the Review of Electricity Market Arrangements (REMA) programme, are delivered quickly and progress towards delivery is communicated clearly. We will do this by:
  - Publishing a REMA update alongside this 2030 Action Plan to provide further clarity on how our future electricity market might be designed;

  - Committing to a decision across the REMA programme by around mid-2025 and in time for the next CfD allocation round (AR7); and
  - Supporting interim measures from NESO and Ofgem, in the balancing market and on TNUoS respectively, whilst the REMA programme is completed.
- **Reform the Capacity Market** to provide clear and viable routes to decarbonisation for unabated gas, enable low-carbon flexible capacity, including consumer-led flexibility to increase its contribution to security of supply, and incentivise investment into existing capacity.
- **Accelerate reforms** to **balancing markets**, maintain **system operability** and reforms to **network charging** to ensure that the electricity system can be operated securely and cost effectively.
- **Unlock the full potential of consumer-led flexibility** through timely delivery of Market-wide Half Hourly Settlement in the retail market

The measures set out in this chapter seek to bring forward investment in low-carbon generation and flexibility while driving efficiencies in market operation. The proposals below address the more immediate challenges in our electricity system and will work alongside our ongoing efforts to drive the rollout of low-carbon generation and transition away from unabated gas generation while maintaining security of supply.

The challenge

While the state must play a role as system architect, markets are, and will, remain central to the development, delivery, and operation of the power system. It is widely accepted that the set-up of our electricity market with associated regulation and incentives needs to adapt to the future shape of our renewables-dominated power system. This need to adapt is recognised in the range of reform programmes and measures being undertaken by government, including REMA, which is considering the enduring market arrangements which are needed for the 2030s and beyond.

The delivery of clean power by 2030 needs to proceed at pace whilst we ensure that electricity markets are redesigned for the long term. Given the impact that market reforms will have on the long-term future of our energy system, it is crucial the potential reforms are properly and robustly considered. We recognise that in order to invest and build at the scale and speed necessary to deliver our 2030 target, the government must provide investors with greater clarity on short term risks, and long-term outcomes from policy and market changes. Therefore, this chapter sets out a clear way forward and timeline on this programme of work, together with the accompanying REMA update published alongside this plan.

Taking action

We have identified four key areas which require action and a clear direction of travel, to enable the delivery and maintenance of a clean power system by 2030. Some of these actions require additional policy development, while other areas require the acceleration of existing reforms to resolve existing challenges in the market. These actions are:

- Setting a clear direction of travel for wholesale market reform
- Reforming the Capacity Market
- Accelerating reforms to balancing markets, maintaining system operability and reforms to network charging
- Reforming the retail market to deliver better for consumers

Setting a clear direction of travel for wholesale market reform

Government seeks to reduce the uncertainties arising from policy and regulatory change as much as possible, to minimise the extent of policy and regulatory risks, which can be a significant barrier to investment. We have considered a wide range of options for wholesale market reform. Alongside this Action Plan, the government has published an Autumn Update on REMA providing greater clarity on the status of the different longer-term options for market reform. It is clear that “no change” is not an option in any scenario.

We have narrowed down policy development to improve locational and operational signals to two sets of options: zonal pricing (where the single electricity wholesale market is split into several zones) and retaining national pricing alongside a range of reforms to its existing arrangements. Whilst no decision has yet been taken between zonal pricing or reformed national pricing, and both options are under equal consideration, significant progress on narrowing down the options has been made, with policy development continuing at pace.

We are continuing to conduct further analysis and are aiming to conclude the policy development phase of the REMA programme across all policy areas by mid-2025. We will ensure that these REMA timelines align with the timetable for the next CfD allocation round (AR7). We plan, therefore, to announce the final decisions on REMA and the timetable for their implementation, particularly in relation to wholesale market reform and any transitional or legacy arrangements, before the AR7 auctions open, giving investors clarity for prospective bids. We will aim to provide ongoing clarity to industry, where possible, throughout the decision and transition periods.

We recognise that significant market reform creates uncertainty for investors and market participants. Government recognises the potential implication for cost of capital of transferring locational risk to generators. We will take these factors into account in our Cost-Benefit Analysis and in final decisions on whether to introduce zonal pricing or reformed national pricing. However, no change is not a viable option given the significant changes in the generation mix that will take place. In the REMA publication we provide an update on policy development for legacy and transitional arrangements. This includes:

- Confirming our commitment to **treat agreements under the next CfD allocation round in the same way as existing CfD agreements**, in relation to any legacy or transitional arrangements.
- Setting out our expectation that **if zonal pricing was to be introduced, existing and AR7 CfD contracts would be amended to use a local zonal reference price**, insulating these agreements from zonal price risk.

Reforming the Capacity Market: Short-term changes to ensure security of supply and support the transition to Clean Power 2030

As Great Britain's primary mechanism for ensuring security of supply, we are proposing a suite of near-term reforms to the Capacity Market that will contribute to both Clean Power 2030 and Great Britain's electricity security. These changes are critical to ensure continued investment in and the commercial viability of assets critical to security of supply.

The Capacity Market is a well-established, technology-neutral scheme in which existing and new-build electricity capacity (in the form of generation, interconnectors, consumer-led flexibility and other technologies) receive revenue (£/MW) based on capacity. Participants secure agreements through auctions which require them to make capacity available at times of system stress.

The nature of risks relating to electricity security faced by the system are changing. As the amount of renewable generation increases, reform is needed in order to meet peak demand in an increasingly electrified economy or demand over periods of low renewable output. Flexible technologies can, and will, play a critical role in enabling the safe transition away from gas to clean power and the Capacity Market will adapt to this new landscape. Government is taking steps now to reform the Capacity Market to provide clear and viable routes to decarbonisation for unabated gas, enable low-carbon flexible capacity to increase its contribution to security of supply, and incentivise investment into existing capacity to ensure security during the transition to Clean Power[87,88].

Measures aimed at supporting the decarbonisation of existing and new unabated gas assets include:

- Consulting on an exit pathway for unabated gas plants with multi-year agreements to leave the Capacity Market without penalty and transfer to a Dispatchable Power Agreement, facilitating conversion to power CCUS once the technology is available.
- Calling for evidence on *additional* pathways that could be implemented in the future to enable decarbonisation of unabated gas, such as conversion to Hydrogen to Power.
- Placing an obligation on power plants. This includes all substantially refurbishing power plants and new combustion power plants participating in the 2026 Capacity Market auction to declare that they will comply with new Decarbonisation Readiness legislation recently introduced alongside these proposed changes to the Capacity Market. This legislation will require new build and substantially refurbishing unabated gas and other combustion power plants in England to be built in such a way that they can readily convert to hydrogen-firing or by retrofitting carbon-capture technology within the plant's lifetime[89].

In parallel, the government is actively developing proposals to improve our understanding of the system's capacity and to ensure electricity security during the transition to Clean Power by:

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[87] DESNZ (2024), '*Consultation: Capacity Market: proposals to maintain security of supply and enable flexible capacity to decarbonise*' (viewed in December 2024).

[88] DESNZ (2024), '*Call for Evidence: Capacity Market: call for evidence on proposals to maintain security of supply and enable flexible capacity to decarbonise*' (viewed in December 2024).

[89] Draft Statutory Instrument (2024), '*The Environmental Permitting (Electricity Generating Stations) (Amendment) Regulations 2024*' - provisionally expected to come into force from 28 February 2026 (viewed in December 2024).

- Exploring future options for developing NESO's modelling of longer-term capacity needs, including indicative future capacity targets eight years ahead depending on responses to the call of evidence published in October. As the grid decarbonises, it is particularly important to ensure we have as much clarity regarding future capacity needs as possible.
- Making it easier for refurbishing plants to access multi-year Capacity Market agreements, providing greater revenue certainty and encouraging the type of investment that ageing plants need to extend their operating life.

The government recently published a policy update on the Capacity Market Phase 2 policies.[90] The government intends to introduce these proposals ahead of next year's Capacity Market prequalification window. This includes:

- Enabling low-carbon technologies to access 3- year agreements with no capex thresholds, facilitating CM access and supporting investment in low carbon, low capex technologies, and
- Introducing a new 9-year capex threshold for low carbon projects, so that new and refurbished projects with costs which fall between the existing 3-year and 15-year threshold are not prevented from coming forward in the Capacity Market.

Consumer-led flexibility involves voluntary actions taken freely and directly by energy consumers to shift their electricity use. This enables consumers to be rewarded with cheaper electricity by flexibly adjusting their usage to times of lower demand on the grid. The government is reducing administrative barriers to consumer-driven flexibility. Building on feedback already received from industry the government will publish a package of proposed changes to the Capacity Market shortly, that aims to improve the contribution that consumer-driven flexibility can make to our electricity security. This will seek views on how to better value, integrate and incorporate consumer-led flexibility within the Capacity Market.

Maintaining operability and managing constraints

Rapid progress will need to be made to ensure that the electricity system can be operated securely and cost effectively using zero carbon ancillary services. In the nearer term, this will include overcoming barriers to more advanced IT and digitalisation, including integrating new technology into NESO's control room. Additional changes to the wider market are needed to help ensure decarbonised system operability, including constraint management. These changes will help to ensure continued investment in renewables and reduce costs.

NESO will continue developing short and medium-term balancing service markets, in order to help deliver a cost-efficient system: NESO's Roadmap[91] outlines measures to enhance utilisation of batteries in providing flexibility services and introduce new stability and voltage markets to increase accessibility to low-carbon technologies. Further detail on measures to enhance the efficiency of batteries are outlined in the Short-duration Flexibility chapter.

NESO are also leading on a **Constraints Collaboration Project** with industry, to develop options for improved constraint management. The project aims to reduce these costs to consumers by implementing market-based constraint management measures. Initial assessments indicate potential savings of up to 6% of thermal

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[90] DESNZ (2024), '*Capacity Market: Policy Update – 2023 Phase 2 Consultation*' (viewed in December 2024).
[91] NESO (2024), '*NESO Roadmap*' (viewed in December 2024).

constraint costs per annum compared to the current balancing mechanism[92].

This includes the potential for constraint management markets and the use of technical solutions such as the use of storage to increase the flow of electricity over constraints. The outcomes of this project should be available by early 2025. We will consider the outcomes of this project as part of the ongoing REMA programme.

There are several policy initiatives planned to maintain system operability through low-carbon flexible assets as the proportion of variable renewable generation grows:

- **An electricity system operability strategy for 2030.** This will provide clarity on how NESO will maintain system operability in a way that is consistent with Clean Power 2030, at best value to the consumer. The strategy will be published by NESO and we will work with NESO, Ofgem and stakeholders to develop a coherent and robust strategy, to be published in Spring 2025.
- **NESO have agreed to improve forecasting of medium to long-term operability needs**, including by location where relevant. This will help give investors and developers the level of certainty that they need for the future demand of these services to invest in low-carbon ancillary service capability.
- **Improved greenhouse gas emissions reporting on NESO operability activity across all electricity markets**. This will provide transparency on the greenhouse gas intensity of each ancillary service that is used to maintain operability, enabling the tracking of progress in the decarbonisation of these crucial services on which operability depends. These measures will help to reach Clean Power 2030 and will work in conjunction with a longer-term strategy to resolve operability challenges.

Ensuring the continued investment in renewables:

The system is experiencing rising Transmission Network Use of System (TNUoS) Charges, creating a need for reforms to the network charging regime. TNUoS charges recover the cost of building and maintaining the transmission network in England, Wales, Scotland, both onshore and offshore. They feature a price signal designed to reflect the costs that demand consumers and generators impose on the transmission system by connecting in different locations. The NESO's 10-year projection shows a trend of significant increases to TNUoS charges for Scottish generators, and a significant decrease to those in England and Wales. We also recognise that some of the highest charges are at the very end of the network resulting in some of the most productive wind assets facing the highest charges. We understand from some stakeholders that there is a need to address the volatility and long-term uncertainty arising from TNUoS charges. In particular, the increasing size of charges and the relationship with CfD marginal clearing strike prices can have an impact on investment.

Ofgem have proposed a temporary cap and floor to alleviate these concerns. In an open letter[93] Ofgem encouraged NESO to develop a temporary cap-and-floor solution in response to projected increasing costs and volatility of TNUoS to drive investment in renewables. We expect that this update will provide generators with greater certainty ahead of future allocation rounds including providing certainty on direction

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[92] NESO (2024), '*Constraints Collaboration Project – Final Report*' (viewed in December 2024).

[93] Ofgem published an open letter to industry on 30th September 2024 proposing a cap-and-floor solution to the increasing cost and volatility of Transmission Network Use of System charges.

of travel ahead of AR7. We will continue to work with Ofgem and NESO as this modification progresses.

All the above proposals are at different stages of development; subject to the outcome of recent consultations and calls for evidence. The Clean Power 2030 Unit will work closely with NESO and Ofgem to ensure the timely delivery of these reforms. The earliest implementation for changes to network charges would be for the 2026 auction prequalification window.

Following this shorter-term reform, under the lead REMA design options, Ofgem would introduce enduring reforms to network charges to ensure that they send a stable, cost-reflective, and effective locational signal. These options are being developed and assessed through Ofgem's strategic review of transmission charging. We continue to work with Ofgem in this space and they seek to conclude policy thinking in line with REMA timeframes.

Unlocking the potential of the retail energy market

The future retail market will play a vital role in enabling consumer-led flexibility, outlined in greater detail in the short-duration flex chapter. The market needs the right price signals which accurately reflect the value of actions to the wider system, and which incentivise suppliers and consumers to engage in such consumer-led flexibility. Additionally, smart technologies will be needed to enable consumers to engage with new products and services, allowing them to benefit.

Market-wide Half-Hourly Settlement is a key enabler for the retail market, making its timely delivery critical for the 2030 target. This industry-led transformation programme, overseen by Ofgem, will change the landscape of the retail market. Consumers will be able to take advantage of this system to get lower bills.

In addition, the smart meter rollout is critical for unlocking innovative approaches to managing consumer demand and will enable the successful delivery of Market-wide Half-Hourly Settlement. Improved price signals will align retail market incentives with a decarbonised energy system and demonstrate the value of consumer-led flexibility. The short-duration flexibility chapter contains actions to remove barriers to smart meter adoption.

Consumer protections must enable trust in the market. In the future, smarter technologies, tariffs, and services should empower consumers to take advantage of lower price periods. We will progress work in this area so that all consumers can benefit, regardless of their level of engagement, energy needs, or income.

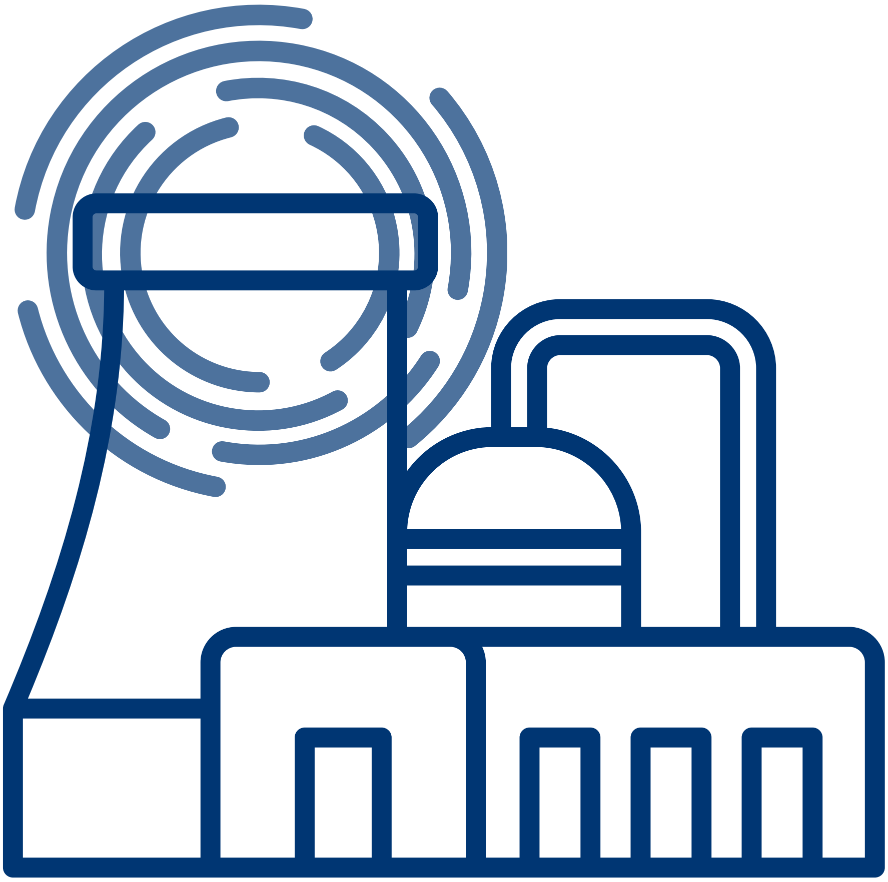
In coordination with Ofgem, we will ensure that consumer protections are designed in such a way that they protect consumers, whilst still enabling consumers to access the benefits that innovation can bring. This includes strengthening the regulator to ensure it can hold companies to account for wrongdoing, a consultation on regulation of Third Party Intermediaries, and a commitment to improving compensation as showcased in Ofgem's consumer confidence programme.

Government is committed to retaining the default tariff cap, and will work closely with Ofgem to ensure that the future price protection framework enables consumers to get the most out of a smarter and more flexible market, whilst also ensuring that those who are unable to use energy more flexibly are not unfairly penalised.

Next steps

We expect these actions, delivered alongside cross-cutting enabling actions in other chapters, to drive decarbonisation by enhancing investor confidence, spurring investment in clean technologies, and fostering a more adaptable and efficient energy system essential for meeting the 2030 target. The Clean Power 2030 Unit will work across government and industry to ensure we advance policy development on wholesale market reform. This includes the ongoing work of the REMA and Retail teams.

- **The REMA Autumn Update** provides further clarity for stakeholders – particularly investors – on REMA's progress, timelines, and the policy options still being considered.
- We will seek to conclude the policy development phase of the REMA programme by mid-2025. We will ensure that REMA timelines will align with the timetable for AR7 in order to provide investors the maximum clarity for prospective bids.
- On **CfD reform** and **Capacity Market reform**, we will ensure the timely delivery of reforms needed to enable 2030 Clean Power, whilst continuing to progress the longer-term reforms being considered under REMA.



Short-duration flexibility

Summary

Since Winter 2022, under the previous government, the National Energy System Operator has offered to consumers the option for them to take advantage of different tariffs at different times. This was a departure from a monolithic system where most consumers have received a single price, whatever time they used various appliances. There was a positive response from consumers to this voluntary offer.

A significant increase in short-duration flexibility of 29-35 GW across battery storage, consumer-led flexibility and interconnection capacity from 2023 levels is possible and can play a role in achieving clean power in 2030.

The opportunity is huge, as battery storage and consumer-led flexibility are scalable and could be relatively quick to deploy. Their deployment could not only cut bills for consumers but minimise the amount of more costly generation and associated network infrastructure that needs to be built, whilst maintaining security of supply.

Key actions set out in this Chapter to address some of the biggest challenges include:

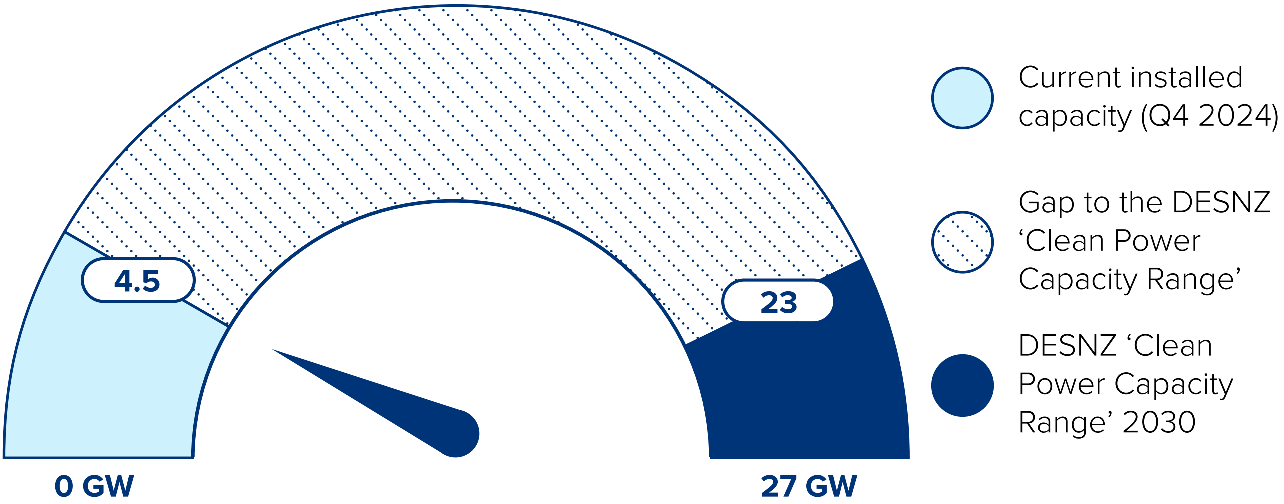
- **Publication of a Low Carbon Flexibility Roadmap in 2025** to consolidate existing and further new actions to drive both short and long-duration flexibility for clean power in 2030 and net zero by 2050;
- Incremental **market reforms to provide batteries and consumer-led flexibility** with appropriate and fair access to, and utilisation within, relevant markets, to assist investment decisions;
- **Enhanced management** of the portfolio of disparate programmes, projects and activities that contribute to the delivery of consumer-led flexibility, including review of the Market-wide Half-hourly Settlement (MHHS) Programme's delivery model to ensure implementation.

Challenges and Actions

We have divided these challenges and actions into four subsections: battery storage; consumer-led flexibility; common enablers for both technologies; and electricity interconnection.

Battery Storage

Current installed capacity compared to the DESNZ 'Clean Power Capacity Range' in 2030 (GW)



Source: Table 1

Grid scale[94] and small-scale[95] batteries can offer short-duration flexibility (currently typically a maximum of two hours' continuous supply of electricity without recharge). Long-duration electricity storage (currently defined as at least 6 hours of continuous supply of electricity), is considered in the long-duration flexibility chapter of this Action Plan.

Batteries can be used to store electricity when it is plentiful and low cost, such as during low demand periods when wind and solar output is high, for use when electricity generation is less plentiful or during times of peak electricity demand. Batteries can reduce the amount of generation and associated network that needs to be built to meet peak demand, helping Britain reach clean power in a cost-effective way and reducing delivery risk associated with other types of energy infrastructure.

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[94] Utility-grade batteries providing services to a region or the whole of GB.

[95] Those providing services to a household or business and sitting behind the meter for the premises.

Currently, there is 4.5 GW of battery storage capacity in Great Britain[96], the majority of which is grid-scale. Based on NESO and DESNZ battery storage growth scenarios for 2030, we expect 23-27 GW of battery storage to be needed by 2030 to support clean power, a very significant level of increase. The government expects the majority of this increase to come from grid-scale batteries, with small-scale batteries also making a contribution.

While there are many common enablers for both consumer-led flexibility and battery storage which are addressed later in this chapter, there are also specific actions necessary for battery storage to deliver on its potential for supporting clean power. In addition, DESNZ is considering the role heat batteries can play in decarbonising homes and hopes to be in a position to feed this work into the low carbon flexibility roadmap in summer 2025. Among the specific actions required for batteries, improving the time it takes for mature grid-scale batteries to obtain grid connections and planning decisions are the most significant actions in order to deliver the huge increase in grid-scale battery capacity. The table below sets out these hurdles and corresponding actions needed to address them, as well as specific hurdles and actions applying to small-scale batteries.

Table 3: Battery-specific hurdles and actions

Area	Hurdle	Action
Grid scale batteries	**(a) Grid connections** While there are many projects with grid agreements, these and other grid connection agreements are not ordered by project maturity or strategic need leading to long waits for a grid connection.	**NESO** have agreed to work with **Ofgem** and **network companies** to ensure that grid connection reforms and acceleration of grid infrastructure development timelines result in a sufficient capacity (in line with the 2030 clean power capacity range) of mature, grid-scale battery projects to connect and operate by 2030.
	(b) Planning Grid-scale batteries take a long time to gain planning approval and are not currently referenced in the national planning policy framework.	**DESNZ** will work with **MHCLG** to consider how grid-scale batteries, and their importance for clean power in 2030 and net zero, could be referenced in future planning reforms.
	(c) Health and safety Grid scale batteries are currently covered by a robust health and safety framework. This needs to be maintained as batteries deploy.	**Defra** will consult on including grid-scale batteries within the Environmental Permitting Regulations by June 2025.
Small scale batteries	**(a) Affordability** The upfront costs of home batteries can be high for consumers, particularly those on low incomes.	**DESNZ** will consider the financing options for retrofit works, including batteries, in the Warm Homes Plan.

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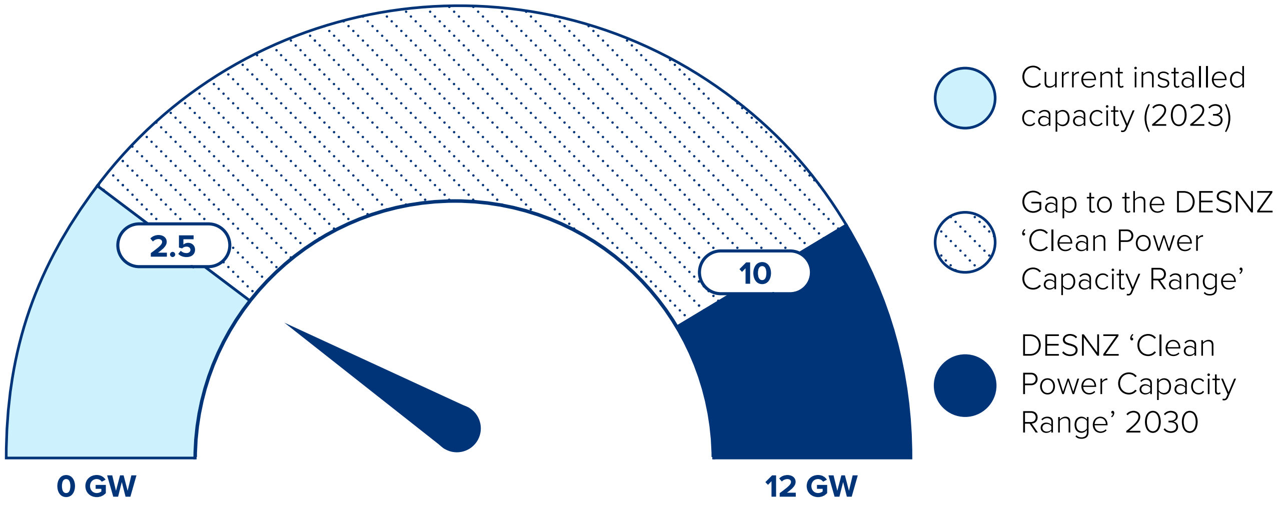
[96] Modo Energy (2024), '*Indices & Benchmarks*' (viewed in December 2024).

Area	Hurdle	Action
	(b) Final consumption levies Home batteries and EV batteries providing vehicle-to-grid services are asymmetrically charged with respect to final consumption levies. This means that levies are charged on import but not refunded on export, creating a disincentive to providing flexibility.	**DESNZ** and **Ofgem** will review the options available to remove final consumption levies for home batteries and vehicle-to-grid EV batteries and set out next steps in a 2025 Clean Power Flexibility Roadmap.

Consumer-led flexibility

Current installed capacity compared to the DESNZ 'Clean Power Capacity Range' in 2030 (GW)



Source: Table 1

Consumer-led flexibility involves voluntary actions taken freely by energy consumers – or on their behalf by Demand Side Response Service Providers (DSRSPs) with consumers' consent – to shift some of their electricity use when they choose to be rewarded for this flexibility while still having their energy needs met[97]. The financial benefits of flexibility on offer to consumers reflect the benefits to the wider electricity system (which in turn benefits all consumers).

A consumer could choose, for example, to receive cheaper electricity bills or other benefits in return for enabling a service provider to vary the electricity use of an

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[97] These voluntary offers of flexibility by energy consumers (whether households or industries) can also be referred to as demand side response (DSR) or demand flexibility.

Energy Smart Appliance (ESA) such as their electric vehicle (EV) smart charge point or their smart heat pump while still meeting the consumer's needs (e.g. a charged EV by the morning or household temperature remaining within defined bounds).

All consumers will enjoy benefits from nation-wide consumer-led flexibility, as it will lower prices for peak hours by flattening the price curve.

Consumer-led flexibility also reduces Britain's aggregate electricity use at peak demand periods, thereby minimising the amount of generation and associated network that needs to be built to meet peak demand. It can therefore help Britain to reach clean power in a cost-effective way with reduced large infrastructure delivery risk. Ofgem monitors consumers' approach to flexibility and its role includes ensuring that sufficient consumer protection is in place for this growing sector.

In 2023, following a scheme put in place by the National Energy System Operator, there was 2.5 GW of consumer-led flexibility utilised in Great Britain (not including electric storage heater flexibility), with 0.8 GW from smart heat pumps and flexible district heating, 0.5 GW from EV smart charging, 0.4 GW from other smart appliances and 0.8 GW from non-domestic consumer-led flexibility. Non-domestic consumer-led flexibility has fallen over time, reducing from 1.7 GW in 2021 to 1.2 GW in 2022 and then to 0.8 GW in 2023[98,99].

Up to now, only those consumers who were the best informed took up the flexibility on offer. With market-wide half-hourly settlement there is considerable potential for growth led by consumers.

Based on NESO and DESNZ scenarios for 2030, excluding electric storage heaters, we expect 10-12 GW of consumer-led flexibility capacity is possible by 2030 to support clean power. Government expects EV smart charging to be a key driver of consumer-led flexibility capacity growth.

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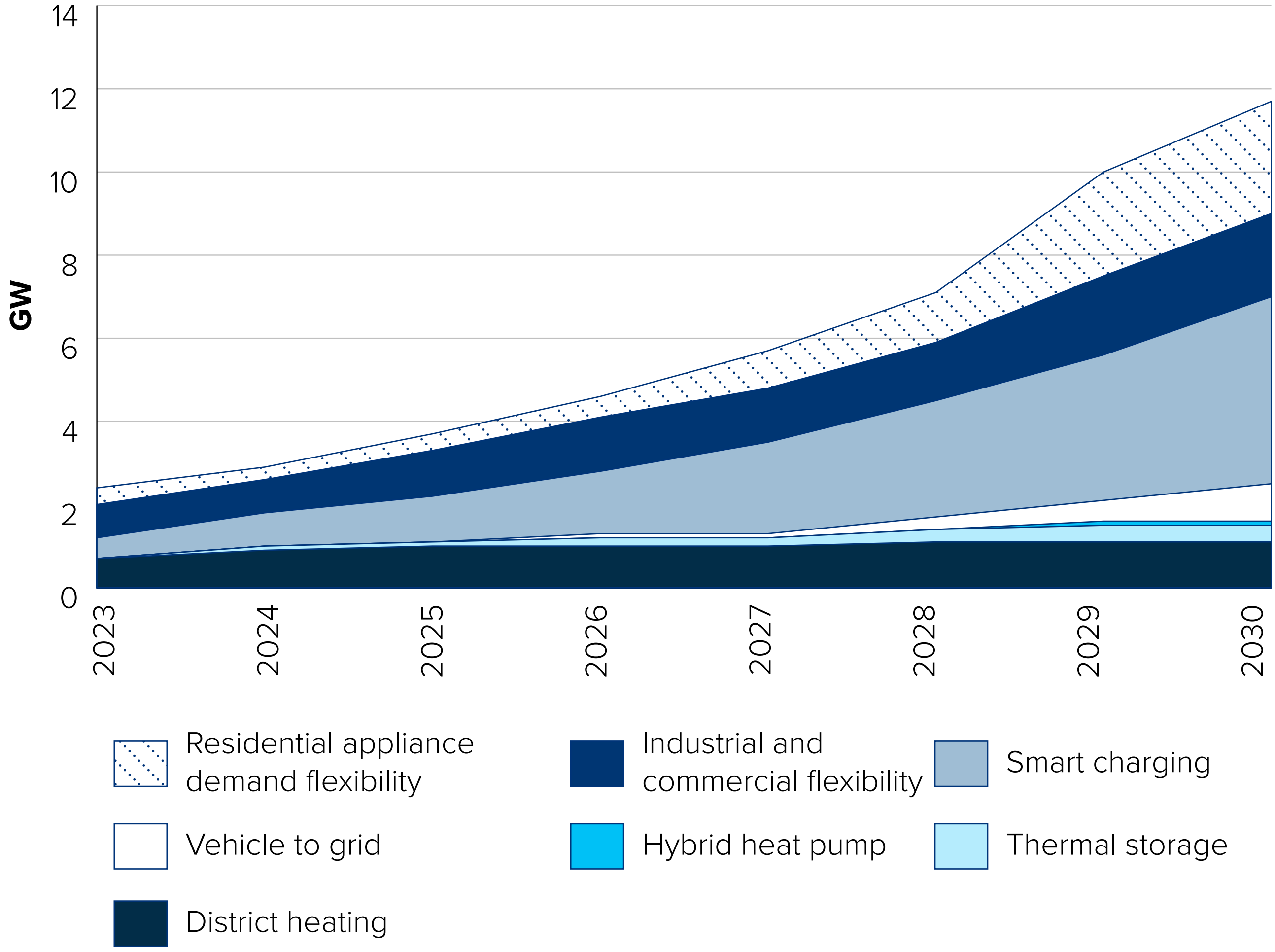
[98] NESO (2024), '*Future Energy Scenarios 2024*' (viewed in December 2024).

[99] 4.8 GW is also assumed flexibility from storage heaters in 2023. The electric storage heaters providing current flexibility have in most cases been in place for a long time, and this capacity is expected to fall over time. It will be important that when consumers replace storage heaters that they adopt new and efficient forms of low carbon heating such as heat pumps.

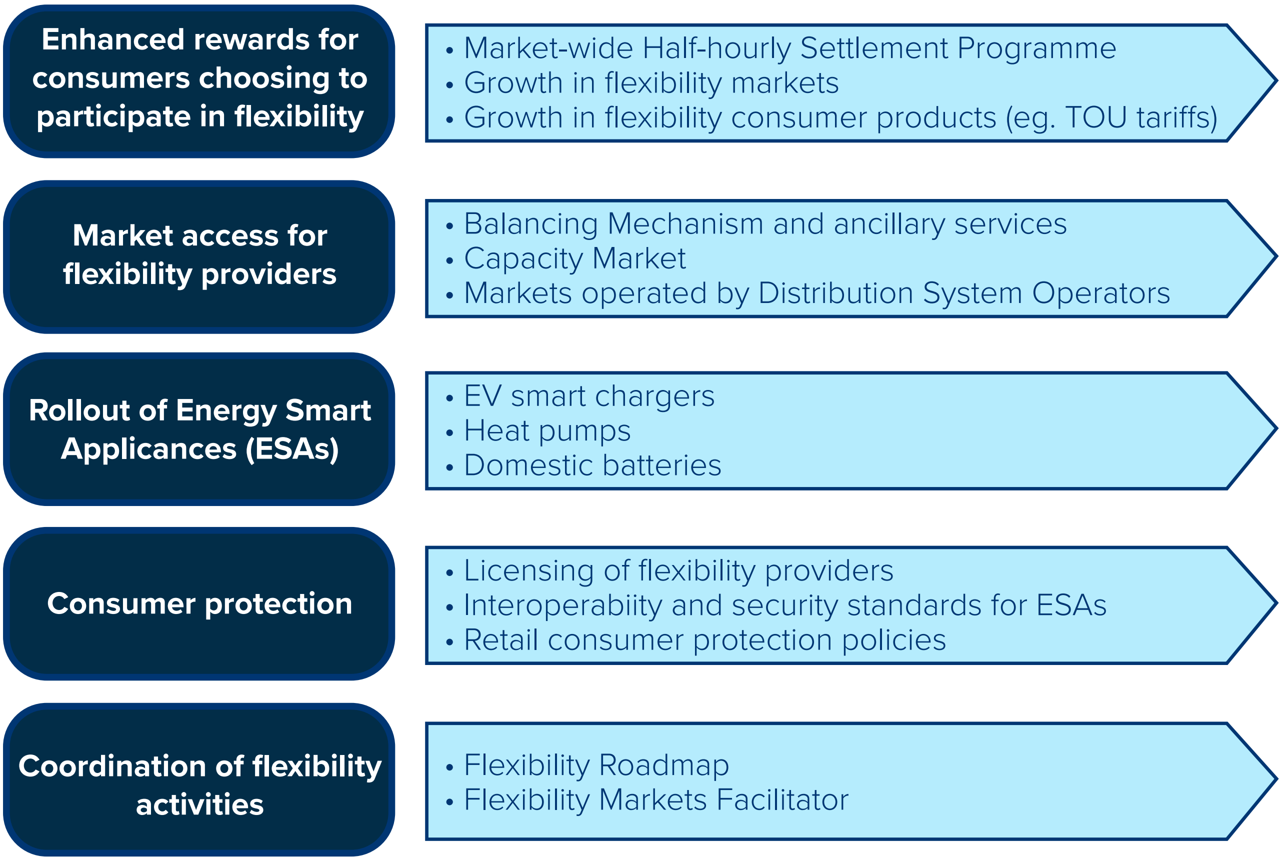
Figure 13: Consumer-led flexibility at peak (GW), 2023-2030



Note: Data excludes storage heaters that shift around 4 GW. NESO refers to consumer-led flexibility as demand flexibility.

Source: NESO (2024), 'Clean Power 2030'

Ensuring that all consumers have the potential benefit of this flexibility requires the delivery of a large number of different policies, projects and programmes across many different organisations, summarised at a high level in the diagram below.



Enhanced rewards for consumers choosing to participate in flexibility

- Market-wide Half-hourly Settlement Programme
- Growth in flexibility markets
- Growth in flexibility consumer products (eg. TOU tariffs)

Market access for flexibility providers

- Balancing Mechanism and ancillary services
- Capacity Market
- Markets operated by Distribution System Operators

Rollout of Energy Smart Applicances (ESAs)

- EV smart chargers
- Heat pumps
- Domestic batteries

Consumer protection

- Licensing of flexibility providers
- Interoperabiity and security standards for ESAs
- Retail consumer protection policies

Coordination of flexibility activities

- Flexibility Roadmap
- Flexibility Markets Facilitator

While there are many common enablers for both consumer-led flexibility and battery storage, there are also specific actions necessary to further increase the scale of choice and opportunity for consumer-led flexibility and enhanced energy bill savings. Some areas requiring a step change are presented in the table overleaf, where the hurdle they present to consumer-led flexibility capacity is set out. For context, the wider government net zero programmes supporting the electrification of transport and heating will also be fundamental to the amount of consumer-led flexibility that becomes available by 2030.

Table 4: Consumer-led flexibility-specific hurdles and enablers

Area	Hurdle	Action
Market-wide half-hourly settlement	Swift introduction of market-wide half-hourly settlement is vital for incentivising all energy suppliers to reward consumers for being flexible, but the programme has faced delays.	**Ofgem** as programme sponsor will review the market-wide half-hourly settlement programme delivery model by the end of FY24/25, including to ensure that industry parties have credible plans to complete market-wide half-hourly settlement in a timely way and maximise the amount of half-hourly consumption data available.
Smart Secure Electricity Systems	Trust in consumer-led flexibility is essential to uptake, requiring interoperability of ESAs (e.g. to support choice and competition in service provision for consumer-led flexibility), effective regulation of DSRSP engagement with consumers, and safeguards against cyber-security and grid stability risks.	**DESNZ** will publish in Spring 2025 a government response to the 2024 package of Smart Secure Electricity Systems Programme consultations on ESAs interoperability, a new licensing regime for service providers for consumer-led flexibility and load controllers, and tariff data accessibility. This will be followed up with detailed consultations on draft "first phase" ESA legislation establishing minimum cyber-security requirements for appliances in scope and a smart mandate for heat pumps; draft DSRSP and load controller regulation and licence conditions; and measures to improve time of use tariff data accessibility.
Delivery Coordination for consumer-led flexibility	Successful delivery of consumer-led flexibility requires coordination across a large number of policies, projects and programmes spanning government departments, Ofgem, NESO and industry. More strategic coordination and portfolio management is required.	The Clean Power 2030 Unit will work with policy teams to review necessary organisational requirements to effectively plan and track delivery data for consumer-led flexibility across all relevant organisations, and address obstacles, on an ongoing basis.

Area	Hurdle	Action
Metering	**Smart meters** Consumers looking to participate in consumer-led flexibility need to be able to quickly obtain a smart meter.	**DESNZ** is working with Ofgem to introduce new Guaranteed Standards of Performance relating to smart metering in 2025. These may include standards relating to the timely installation and maintenance of smart meters, compensating consumers where they are not met.
	Device meters Current device metering regulation requires meters to have external displays, which adds to manufacturing costs of smart appliances.	**DBT** will continue stakeholder engagement on allowing for remote display options in the Measuring Instruments Regulations, for meters used for trade, and plan to consult on options to amend the existing requirements during the first quarter of 2025.
Consumer engagement	Consumer-led flexibility is a voluntary activity, and it is crucial that consumers are well informed of what it involves and how to participate, which evidence shows is not always currently the case.	**DESNZ** will, in Summer 2025, publish a consultation on consumer engagement, including on the potential to better coordinate and amplify accurate messaging on consumer-led flexibility.
Large non-domestic consumer-led flexibility DSR	Consumer-led flexibility capacity from large non-domestic energy consumers has fallen from 1.7 GW in 2021, to 1.2 GW in 2022 and then to 0.8 GW in 2023[100].	**DESNZ, NESO** and **Ofgem** will set out specific actions for supporting an increase in large non-domestic consumer-led flexibility in a Low Carbon Flexibility Roadmap in 2025, following industry engagement.
EV smart charging	**Increasing access to EV private charging** Landlords can increase the costs of charging EVs for tenants who need to access a communal smart charger, making EV smart charging unduly expensive for some.	**Ofgem** will consider reform on the Maximum Resale Price, seek views on what needs to change to address identified issues and update the current requirements, as required, setting out progress and next steps in the 2025 Flexibility Roadmap.

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[100] Figures illustrate the loss of incentive, including the Triad changes during this period, not the decline in actual DSR capacity.

Area	Hurdle	Action
	Increasing access to smart public charging. Charging of electric vehicles in public on-street locations has the potential to deliver short-duration flexibility. However, charge point operators are only just beginning to provide flexible tariffs to their customers.	**DESNZ** together with **DfT** will explore with industry options to accelerate deployment of smart charging at public charge points and set out progress and next steps in the 2025 Flexibility Roadmap.

Common enablers for consumer-led flexibility and battery storage

Some of the greatest hurdles faced by consumer-led flexibility and batteries are common to both, in particular around market access. Unlike low carbon generation and other forms of low carbon energy storage, battery and consumer-led flexibility projects are wholly dependent on forecast market revenues for investment decisions. Therefore, confidence that there will be appropriate access to, and utilisation within, relevant markets is crucial for scaling up battery storage and consumer-led flexibility for Clean Power 2030.

The table below sets out more detail on this and other common hurdles, and corresponding actions for addressing them and turning them into enablers for battery storage and consumer-led flexibility. Additional work that has the potential to improve market opportunities for consumer-led flexibility and batteries, including wider change to GB market arrangements that could send sharper price signals, is discussed in the 'Reforming our electricity markets' chapter of this action plan.

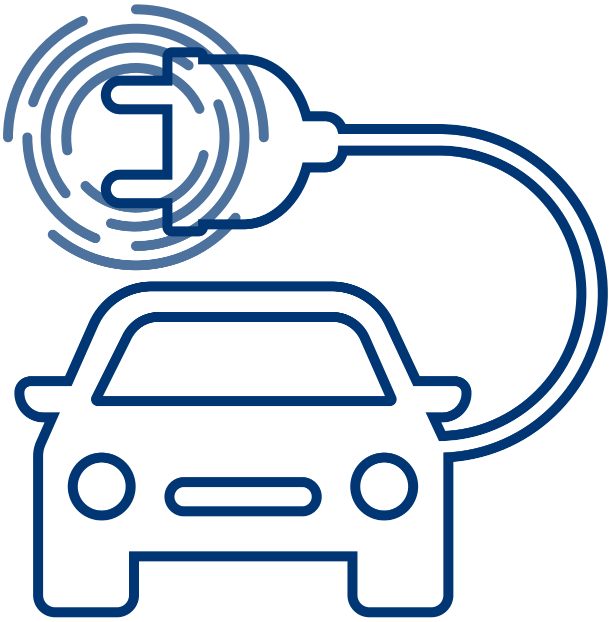


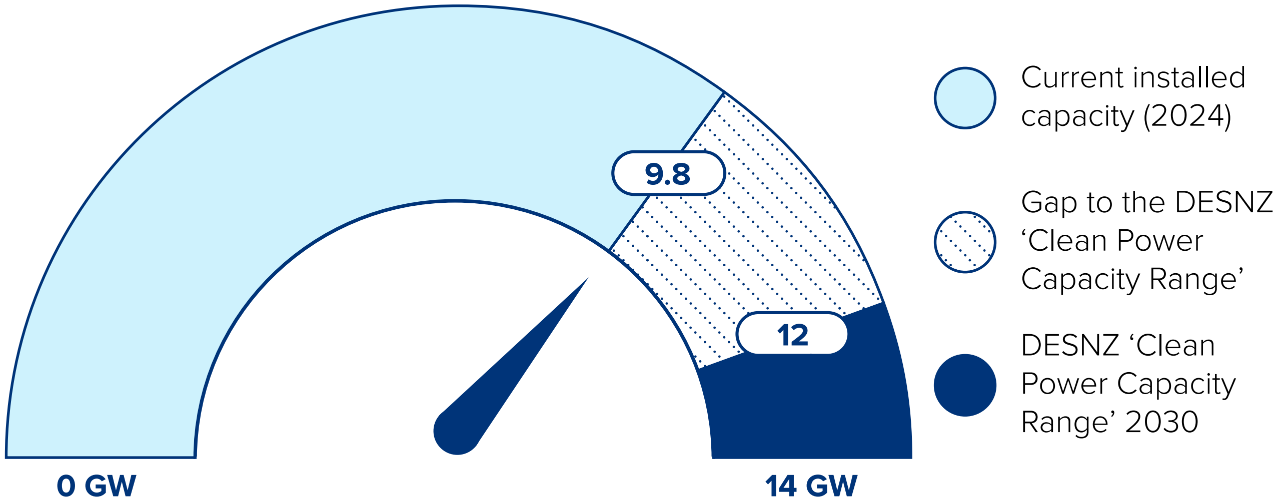
Table 5: Consumer-led flexibility and battery storage common enabler hurdles and actions

Area	Hurdle	Action
Market Access	Access to some energy markets (e.g. the Balancing Mechanism, other NESO/DSO markets and the Capacity Market) is currently challenging for some kinds of short-duration flexibility. Issues include: • Overly stringent market entry requirements for flexibility; • The System Operator's ability to use all low carbon flexible assets (such as batteries and consumer-led flexibility) effectively and incorporate them fully into the economic dispatch process has been hindered due to legacy systems, manifesting in "skip rates"; and • Barriers to the stacking of revenues by flexibility assets across different markets.	**NESO** have agreed to set out, for inclusion in the Low Carbon Flexibility Roadmap, progress on and further actions to support providing flexibility assets with appropriate and fair access to the markets it manages, including: • removing unnecessary or overly restrictive rules or participation requirements to the greatest extent possible, allowing access to more types of flexibility assets; • providing increased transparency as well as improvement to the systems NESO uses to dispatch flexibility, with evidence of reductions in flexibility asset skip rates; • further facilitating revenue stacking across different markets; and • an assessment of the potential to create additional measures to enable a wide range of flexibility providers to offer services to meet system needs (including constraint management). **DESNZ** will, ahead of the 2025 Capacity Market prequalification period in summer 2025, implement the Capacity Market policy proposals as outlined in its July 2024 and October 2024 responses to the 2023 Phase 2 Capacity Market consultation. These include permitted augmentation of storage, adjustments to Extended Performance Testing Requirements and making available 3-year Capacity Market agreements for low carbon technologies whose CAPEX is £0/kW. In addition, DESNZ plans to publish shortly a Consultation and Call for Evidence to invite stakeholder views on how to better reflect the diversity of consumer-led flexibility technologies and their treatment and handling within the Capacity Market.

Area	Hurdle	Action
Flexibility Roadmap	Great Britain lacks an up-to-date framework for prioritising and managing the delivery of ongoing actions across government, NESO, Ofgem and industry. This will be crucial for maximising the potential of flexibility for Clean Power 2030 and net zero by 2050.	**DESNZ** will publish with **Ofgem** and **NESO** a joint Low Carbon Flexibility Roadmap in 2025. The Flexibility Roadmap will set out clear short and long-duration flexibility milestones and measures required for both clean power in 2030 and net zero by 2050, building on those within this Action Plan. The Roadmap will also provide a framework for planning and tracking the delivery of these key flexibility measures. As part of this, DESNZ, working with Ofgem and NESO where appropriate, will review current measures to assess where further changes or new policies are needed to support Clean Power 2030 and net zero by 2050.
Digital-isation	There is insufficient visibility of – or sharing of data on – distributed energy including local generation and flexible assets on the grid, hampering the integration of these assets and potential for their utilisation within flexibility markets.	**DESNZ** and **Ofgem** will work with **NESO** to set out measures in the Low Carbon Flexibility Roadmap in 2025 to enable greater visibility of distributed energy assets to unlock further flexibility and assist with network planning.
Innovation support	Further innovation is needed to accelerate the deployment of short-duration flexibility for 2030, for example to reduce the costs of bidirectional chargers for vehicle-to-grid and develop consumer-led flexibility interoperability standards.	Further innovation across **DESNZ** will ensure the flexibility innovation needed to facilitate clean power 2030 and net zero.

Electricity interconnection

Current installed capacity compared to the DESNZ 'Clean Power Capacity Range' in 2030 (GW)



Source: Table 1

Electricity interconnectors connect the transmission systems of two countries, enabling us to import and export electricity. At the end of 2023, Great Britain had 9.8 GW of interconnector capacity across 9 interconnectors, with a further 2 interconnectors (1.9 GW of capacity) in construction[101]. Based on both government and NESO modelling of clean power trajectories, we expect 12-14 GW of interconnector capacity by 2030 to deliver clean power. Interconnectors can bring a wide range of system and consumer benefits. Electricity interconnectors support security of supply by enabling access to more diverse generation over a wider geographic area. They also provide system flexibility by helping the system rapidly respond to changes in supply and demand. This means that, when we generate more electricity than we need, a strong interconnector system will allow us to export the excess electricity, thus contributing towards the clean energy superpower role of the United Kingdom.

Finally, interconnectors contribute to European-wide decarbonisation, as they can allow for more efficient use of intermittent renewables between connected countries.

The table overleaf sets out the key hurdles to maximising the growth of electricity interconnection by 2030. There may be additional, project specific hurdles that DESNZ will work with developers to action, as appropriate. Additionally, the Supply Chain and Workforce section of this document details how the UK will use our established manufacturing capacity to support the delivery of Clean Power 2030.

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[101] Ofgem (2024), '*Interconnectors*' (viewed in December 2024).

Table 6: Electricity interconnection hurdles and actions

Area	Hurdle	Action
Grid connections and planning	The grid connection and planning processes mean that interconnectors awarded cap and floor agreements by Ofgem in the third cap and floor window / Offshore Hybrid Asset pilot a) might have been awarded a connection agreement for later than 2030, or b) might not be operational by 2030.	**NESO** and **Ofgem** will ensure that the grid connection reforms support the interconnection capacity required to meet the 2030 clean power capacity ranges, and **MHCLG** will consider how planning reforms can support this capacity for the 2030 clean power capacity ranges.
HVDC supply chains	The supply chains for HVDC cables are tight and present risks to interconnector projects with cap and floor agreements from the third cap and floor window / Offshore Hybrid Asset pilot not being operational by 2030.	**DESNZ** is exploring a range of options to mitigate supply chain challenges including measures to develop the domestic supply chain.

Next steps

The implementation of the actions in this chapter should make a strong impact in helping to achieve the benefits for consumers made possible by clean power in 2030, particularly by rapidly improving market access and utilisation for battery storage, increasing opportunities for consumer-led flexibility, implementing market-wide half-hourly settlement, and significantly reducing grid connection and planning timelines for grid-scale batteries and interconnectors.

The government will continue to work with Ofgem, NESO and industry to review the need for further actions and we will include these new actions within the Low Carbon Flexibility Roadmap that we will publish in 2025. Success will involve evidence that investments and operational assets are ramping up short-duration flexibility capacity in line with the capacity ranges for Clean Power 2030 that are set out in this Action Plan. The Clean Power 2030 Unit will be closely monitoring this.

Delivery of this short-duration capacity for clean power in 2030 will also significantly help with meeting carbon budget and net zero requirements[102], enabling the power sector to accommodate the significant increase in future electricity demand that will result from the electrification of other sectors such as transport, heat and some parts of industry.

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[102] BEIS (2021), '*Smart Systems and Flexibility Plan*' (viewed in December 2024).

Long-duration flexibility

Summary

Long-duration flexible technologies can add significant value to the system and can provide a secure supply of electricity during extended periods of low renewables output. There are a number of innovative low carbon technologies such as power carbon capture, usage and storage (CCUS), hydrogen to power (H2P) and forms of long-duration electricity storage (LDES), capable of replicating the role of unabated gas. We estimate between 40-50 GW[103] of dispatchable and long-duration flexible capacity could be needed by 2030. Whilst we will continue to rely on unabated gas to ensure security of supply, we will drive the deployment of these low carbon technologies, cementing our position as a world leader at the cutting edge of the clean energy revolution.

The following interventions will support the deployment of long-duration flexible technologies in driving towards Clean Power 2030:

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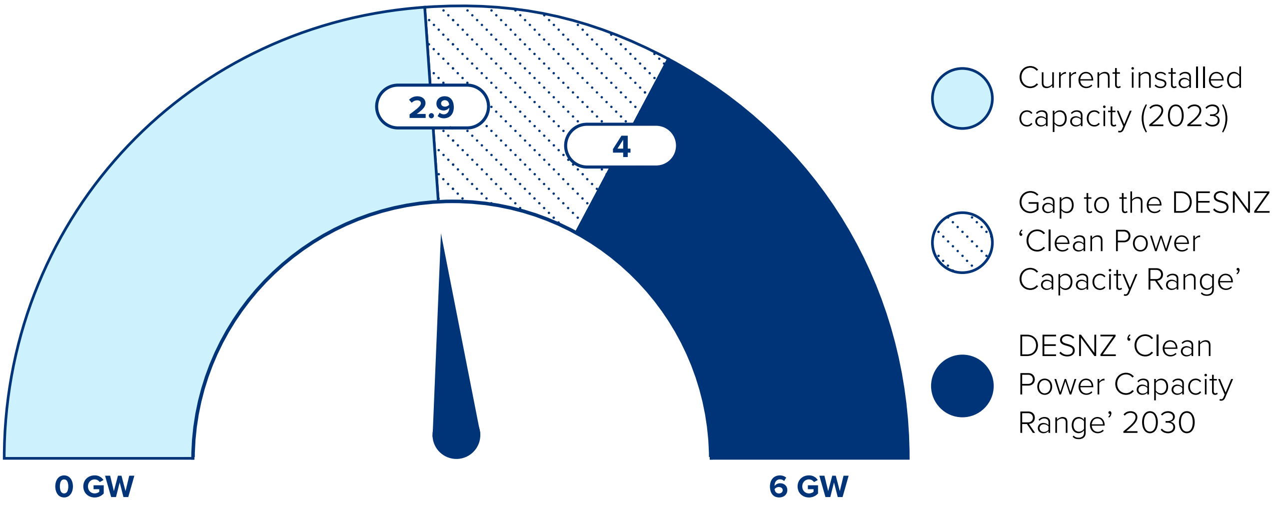
[103] The sum of low carbon dispatchable power, unabated gas, and LDES capacities in Table 1, rounded to the nearest 5 GW. Dispatchable technologies are ones which combust fuel to produce electricity and, by varying the rate at which fuel is burned, can respond to meet the needs of the grid with varying levels of flexibility.

- **We have announced a groundbreaking deal with Net Zero Teesside**, our first power CCUS project – delivering secure, low carbon power from 2028.
- **We are developing a hydrogen to power business model**[104] to de-risk investment and bring forward hydrogen to power capacity at an accelerated rate. We intend to provide further market engagement on the design of the business model in Spring 2025.
- **Ofgem will introduce the cap and floor scheme** to support investment in long-duration electricity storage, aiming to open the scheme to applications in Q2 2025.

Long-duration electricity storage

Current installed capacity compared to the DESNZ 'Clean Power Capacity Range' in 2030 (GW)



Source: Table 1

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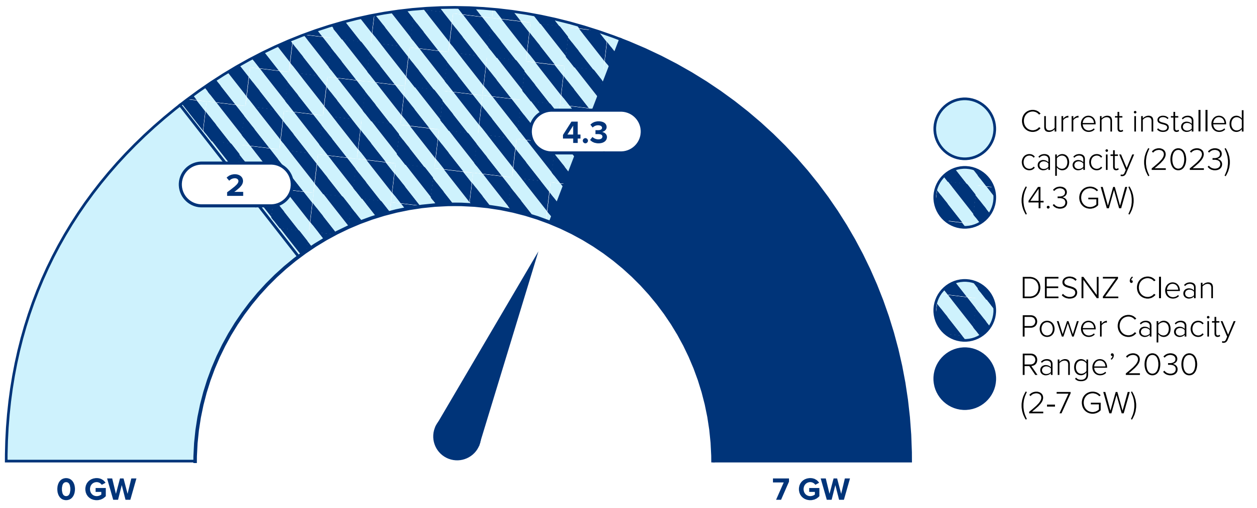
[104] DESNZ (2024), '*Hydrogen to power: market intervention need and design*' (viewed in December 2024).

Low Carbon Dispatchable Power

Current installed capacity compared to the DESNZ 'Clean Power Capacity Range' in 2030 (GW)



Source: Table 1

Note: Low carbon dispatchable power includes biomass, power BECCS, gas CCUS and hydrogen to power. Dispatchable technologies are ones which combust fuel to produce electricity and, by varying the rate at which fuel is burned, can respond to meet the needs of the grid with varying levels of flexibility.

The challenge

Long-duration flexible technologies can adjust their output quickly to match supply with demand and can provide a reliable source of electricity for managing daily and seasonal demand peaks and longer periods of low renewable output (such as 'Dunkelflaute' conditions). Today, most of that flexibility is provided by around 35 GW of unabated gas and around 3 GW of pumped storage hydro[105], currently the only mature technologies capable of providing this flexibility.

Between 40-50 GW[106] of dispatchable long-duration flexible capacity could be needed by 2030. Whilst we expect the majority of this capacity will come from unabated gas, it will be running less frequently as we support the deployment of low carbon alternatives and approach 2030. In this chapter we focus on driving forward the delivery of the low carbon long-duration technologies, such as power CCUS, H2P and LDES, that are closest to maturity and could play a key role in a 2030 system. Biomass and BECCS are covered in more detail in the Renewable and nuclear project delivery chapter.

Deploying new low carbon long-duration flexible technologies can add significant value to the system as they can replicate the role of unabated gas currently plays, minimise system costs and reduce delivery pressures on other technologies, such as offshore wind. NESO have noted in their report that even relatively small levels of operational capacity materially reduce the overall challenge of the rest of the programme.

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[105] DESNZ (2024), '*DUKES*' (viewed in December 2024).

[106] The sum of low carbon dispatchable power, unabated gas, and LDES capacities in Table 1, rounded to the nearest 5 GW. Dispatchable technologies are ones which combust fuel to produce electricity and, by varying the rate at which fuel is burned, can respond to meet the needs of the grid with varying levels of flexibility.

Power CCUS and hydrogen to power plants in Great Britain present a great opportunity for low carbon long-duration flexibility. We will also need to scale up the deployment of pumped hydro storage and drive forward innovation in more nascent LDES technologies.

Government is committed to the transition away from unabated gas whilst maintaining security of supply.

Taking action

Power carbon capture, usage and storage

Power CCUS, which is natural gas fuelled generation equipped with carbon capture technology, can provide non-weather-dependent, dispatchable low carbon generation that will support a renewables-based 2030 system. The Power CCUS business model, known as the Dispatchable Power Agreement (DPA), has been designed to ensure that Power CCUS plays a valuable mid-merit role, dispatching behind renewables, but ahead of unabated gas generation. The DPA will enable both new build projects and the retrofit of existing plants which will be key to enabling the transition away from unabated gas.

NESO have suggested that we could need to deploy up to 2.7GW of power CCUS and H2P by 2030 – see Table 1[107]. The importance of power CCUS beyond 2030 is also highlighted by the Climate Change Committee in their Carbon Budget 6 report where they model that power CCUS would provide 30TWh of generation a year by 2035 as part of the balanced pathway scenario[108].

As well as supporting the clean power mission, CCUS more broadly is vital to decarbonising a range of industrial sectors and the deployment of negative emission projects. It will enable a just transition for industrial regions by decarbonising in a way that drives growth in the UK, with CCUS projected to support up to 50,000 jobs as the sector matures in the 2030s and adds £5 billion of value annually by 2050[109]. Carbon capture is a safe technology, and geological CO_2 storage is a proven technology that has been in operation globally for decades. In the UK we have the technical expertise and a geographical and geological advantage with a shallow seabed and 78 billion tonnes of theoretical CO_2 storage capacity distributed across the UK continental shelf[110].

Additionally, the proximity of emission centres to the geological storage sites provides the right opportunity for these industrial clusters to decarbonise through the CCUS cluster approach that we have established. This approach involves the strategic selection of industrial clusters to maximise the number of capture projects and is designed to fairly distribute cost and enhance the cost efficiency of transport and storage infrastructure, benefiting a larger number of capture projects. The deployment of CCUS in the UK will pioneer technical advancements and a world-leading regulatory framework to help Britain benefit from the opportunities of first mover advantage.

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[107] NESO (2024), '*Clean Power 2030*' (viewed in December 2024).
[108] CCC (2020), '*The Sixth Carbon Budget*' (viewed in December 2024).
[109] DESNZ (2019), '*Energy Innovation Needs Assessments*' (viewed in December 2024).
[110] Energy Technologies Institute (ETI) (2016), '*Strategic UK CCS Storage Appraisal*' (viewed in December 2024).

Net Zero Teesside

The world's first at scale gas power plant with carbon capture.

Groundbreaking deals announced on 10th December 2024 mean construction of the UK's new carbon capture industry will start in 2025.

Contracts were signed with Net Zero Teesside, the world's first at scale gas power plant with carbon capture, supplying up to one million homes with low carbon, secure power from 2028.

Combined with Northern Endurance Partnership (NEP), the supporting CO_2 Transport and Storage project, the East Coast Cluster will capture and store carbon emissions from the region. This investment will directly support an average of 2,000 jobs in the North-East, marking the latest milestone in the government's mission to reignite its industrial heartlands, tackle the climate crisis and turbocharge growth for decades to come. It follows the government's £21.7 billion funding commitment to ensuring the UK's vision for CCUS becomes a reality in the UK.

By signing the first Dispatchable Power Agreement (DPA) with industry, the government is proving that this world-leading CCUS business model – developed over years in collaboration with stakeholders – is delivering real results by attracting investment and getting this game-changing technology off the ground. The DPA has been specifically designed to support projects like Net Zero Teesside to dispatch low carbon power ahead of unabated gas but not displace renewables.

The DPA showcases the UK's ability to create innovative solutions to address the challenges of achieving net zero and this milestone is a testament to the collaborative efforts of industry and government, reflecting our shared vision of a decarbonised power sector. This is a landmark step forward in our plan for Clean Power 2030.

HyNet and beyond

In addition to Net Zero Teesside in the East Coast Cluster, there is a strong pipeline of potential Power CCUS projects in development across the UK which can deploy and play a key role in a decarbonised power system[111]. In north-west England and north Wales, government is working with industry to deliver the HyNet Cluster, which aims to store up to 4.5 million tonnes of CO_2 per year by 2030[112]. The HyNet CO_2 Transport and Storage (T&S) network will enable the safe onward transport of CO_2 from CCUS projects to permanent undersea storage. There is a power CCUS project which, among other CCUS projects, is aiming to connect to HyNet by 2030.

In addition to the East Coast Cluster and HyNet Cluster, the UK has an exciting pipeline of further CCUS clusters at a mature stage of development. These include Acorn in north east Scotland and Viking in the Humber which contain power CCUS projects at the heart of their plans.

Upstream emissions

We are clear that future emissions from the production of natural gas will need to reduce in the UK and across the world. Domestically, DESNZ is working with industry to decarbonise upstream emissions of natural gas production. The North Sea Transition Authority (NSTA) estimates that between 2018 and 2023, operators have reduced flaring by 49% and overall emissions from domestic upstream oil and gas production have decreased by approximately 28%. Through the North Sea Transition Deal, industry is committed to extend the overall emissions reduction to 50% from 2018 to 2030[113].

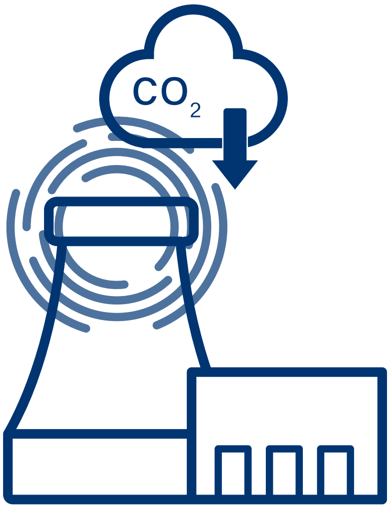
Internationally, we are also committed to the World Bank's zero routine flaring initiative which aims to eliminate the practice by 2030 for oil producing platforms. The UK is also a member of the Global Methane Pledge, to collectively reduce global methane emissions by at least 30% by 2030 compared to 2020 levels[114]. In addition, we are working with the US, EU and others to develop a framework to better measure, monitor, and report methane emissions from imported gas. We also share technical expertise and best practice internationally on reducing emissions in the energy sector.

Financing

CCUS was one of the five sectors which will benefit from the additional £5.8 billion allocated to the National Wealth Fund. This capital will be deployed by the National Wealth Fund to finance projects which are facing barriers to investment, helping to mobilise private finance into them.

CCUS for net zero

In the 2030s and as we accelerate to net zero, it is important industry and government enable the development of a self-sustaining UK CCUS sector that supports delivery of our Missions, jobs and reduces emissions, putting the UK at the forefront of global CCUS.



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[111] Subject to meeting necessary planning and other regulatory approvals.
[112] Eni (2024), '*HyNet North West Project*' (viewed in December 2024).
[113] North Sea Transition Authority (2024), '*Emissions Monitoring Report 2024*' (viewed in December 2024).
[114] Global Methane Pledge (2024), '*Global Methane Pledge*' (viewed in November 2024).

Hydrogen to Power

Hydrogen to Power can play a key role in our electricity system at a range of scales and is the primary low carbon technology capable of providing low carbon inter-seasonal storage, whilst providing a decarbonisation pathway for unabated gas. Our analysis indicates H2P is economic at lower load factors (below 30%), enabling it to be cost effective in a clean power system where flexible load factors are expected to fall as renewable generation increases[115]. H2P faces two primary deployment barriers – increased investment risk and cost from being a first of a kind technology, and exposure to cross-chain risks from reliance on a nascent hydrogen value chain. There is a critical dependence on access to enabling grid-scale hydrogen infrastructure, such as new build transport and storage facilities, which typically have long lead-in times. Ensuring the deployment of hydrogen transport and storage infrastructure, alongside supporting H2P plants, will be critical in enabling delivery of H2P to deploy whilst also providing the infrastructure to support industrial decarbonisation through hydrogen.

Hydrogen to power business model

To accelerate deployment of H2P, government is implementing a H2P business model (H2PBM) to de-risk investment and mitigate our identified deployment barriers, as committed in the government's December 2024 response to the consultation on 'H2P need for and design of a market intervention'. We will deliver a H2PBM based on a Dispatchable Power Agreement style mechanism. To progress development of the H2PBM, we intend to publish a market engagement document in Spring 2025 outlining further detail on the proposed design of the H2PBM. We are establishing an H2P expert working group to support our policy development.

Hydrogen storage

Hydrogen storage will play a vital role in the hydrogen economy and the wider energy system. Storage is key for managing within day network balancing and providing security of supply to hydrogen off takers. Large-scale deployment of H2P will require access to geological hydrogen storage via hydrogen pipelines, to enable delivery of H2P plants.

Developers face barriers to investment including high costs, long lead-times, and uncertainty around how quickly demand for transport and storage will increase. This is why we are committed to designing, in 2025, new business models for hydrogen transport and storage infrastructure to address these barriers and unlock private investment. Public and private investment in transport and storage infrastructure will in turn unlock further private investment in the wider hydrogen economy, by helping to increase the geographical availability, reliability and cost-effectiveness of hydrogen supply.

The Energy Act 2023 provides the legislative framework that will underpin the delivery of the hydrogen transport and storage business models. We are currently progressing the design of the commercial models and the process for awarding them at pace.

Hydrogen production

Hydrogen production capacity is vital to increase the supply of the fuel for H2P plants and support is being provided through the Hydrogen Production Business Model. This provides hydrogen production projects with a route to market and we are already making progress, with the October announcement of £21.7 billion of available funding to

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[115] DESNZ (2023), '*The Need for Government Intervention to Support Hydrogen to Power*' (viewed in December 2024).

launch the first CCUS projects including CCUS-enabled hydrogen[116].

Eleven electrolytic hydrogen production projects were selected for contract award in the first Hydrogen Allocation Round (HAR1), and we expect these projects to be operational by 2026. We intend to publish a shortlist of HAR2 projects in due course and we are currently developing our approach to future HARs, including HAR3, and we will invite feedback through a market engagement exercise in due course.

We intend to publish the next edition of the Hydrogen Strategy Update to the Market shortly.

Financing

Hydrogen was one of the five sectors which will benefit from the additional £5.8 billion allocated to the National Wealth Fund. This capital will be deployed by the National Wealth Fund to finance projects which are facing barriers to investment, helping to mobilise private finance into them.

Long-duration electricity storage

Long-duration electricity storage (LDES) is a key enabler to a secure, cost-effective and low carbon energy system. LDES can help to decarbonise the system by supplying electricity continuously from several hours to up to several days without recharge, replacing flexibility from unabated gas and helping to alleviate constraints on the grid. It includes pumped storage hydro, a long-established and mature technology, and other more recently developed technologies such as liquid air energy storage. As well as providing electricity during protracted periods of low wind/sun, LDES technologies also provide a range of essential grid services such as inertia, voltage support, short circuit and demand response.

There is currently 3 GW of pumped storage hydro capacity connected to the grid[117], but long build times combined with revenue uncertainty have inhibited investment in LDES development over the last 40 years[118]. This has been the greatest challenge to LDES development, which this government has now addressed through announcing our decision to introduce a cap and floor investment support scheme with Ofgem acting as regulator and investment support scheme delivery body[119].

The Clean Power Capacity Range in Table 1 suggests that we could need 4-6 GW of LDES in total by 2030[120]. The actions below will help bring forward more LDES onto the system.

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[116] DESNZ (2024), '*Government reignites industrial heartlands 10 days out from the International Investment Summit*' (viewed in November 2024).
[117] LDES in Table 1.
[118] DESNZ (2024), '*Long-duration Electricity Storage Policy Framework Consultation*' (viewed in November 2024).
[119] DESNZ (2024), '*Consultation outcome: Long-duration electricity storage: proposals to enable investment*' (viewed in December 2024).
[120] NESO (2024), '*Clean Power 2030*' (viewed in December 2024).

Cap and floor scheme

Following government's decision in October 2024 to introduce a cap and floor investment support scheme for LDES:

- Ofgem will publish an open letter on specific aspects of the scheme where it would like further stakeholder input and will provide further information around cap and floor scheme implementation timings.
- In Q1 2025, DESNZ and Ofgem will publish a Technical Decision Document to provide clarity on outstanding areas of the cap and floor scheme design
- Ofgem expects to open the first cap and floor allocation round in Q2 2025 following publication of the Technical Decision Document
- NESO have agreed to provide advice on the range of LDES capacity that Ofgem should seek to provide cap and floor schemes for in the first allocation round, and support Ofgem in assessing projects that apply

Financing

Building on the two investments the National Wealth Fund has already made in LDES companies, it will continue to engage with LDES projects at Technology Readiness Level 7 and above – including those preparing to apply for the cap and floor – exploring financing solutions where there are barriers to private investment.

Capacity Market

The Capacity Market is the primary mechanism to secure capacity and ensure security of electricity supply in Great Britain. The scheme provides participants with revenue (£/MW), allocated through competitive auctions. This revenue is provided in exchange for the capacity being available at times of system stress. LDES projects, where meeting qualifying criteria, are eligible to and currently participate in the Capacity Market.

DESNZ will, ahead of the 2025 Capacity Market pre-qualification period in summer 2025, implement the Capacity Market policy proposals as outlined in its July 2024 and October 2024 responses to the 2023 Phase 2 Capacity Market consultation. Changes include increasing the build period extension available to support projects qualifying for the Capacity Market long stop mechanism. This will allow generators requesting an extension (at the point of application), to have up to 6 years in a T-4 Capacity Market agreement to come online (via a 24-month extension). We expect this specific change to be in place ahead of the auctions in early 2026. This will be an addition to the existing 12-month extension option.

Innovation

Innovation can make an important contribution to the deployment of LDES. More nascent technologies, such as liquid air energy storage, offering greater locational flexibility than pumped storage hydro, have quicker build times, and help to diversify the LDES technology portfolio. Approximately £100m of innovation funding has been provided over the last decade to support the advancement of many novel LDES technologies[121]. The current Net Zero Innovation Portfolio has funded novel technologies such as liquid air and flow battery energy storage, advancing them to demonstrator stage and catalysing investment in them, which has enabled these innovations to be viable options for low carbon flexible capacity by 2030 and beyond. Further innovation will ensure that

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[121] Approximate cumulative innovation funding for LDES provided by the Department since 2014 from innovation funding programmes, including the Energy Innovation Programme and the Net Zero Innovation Portfolio.

a range of novel technologies develop and deploy at pace and scale.

Planning and grid connections

Government, Ofgem, NESO, and network companies can ensure grid connection reforms and acceleration of grid infrastructure delivery timelines that result in sufficient capacity (in line with 2030 clean power capacity ranges) of LDES projects connecting by 2030, including those that co-locate with renewables projects. We will work with the Ministry of Housing Communities and Local Government to consider how LDES, and its importance to clean power in 2030 and net zero, could be referenced in future planning reform.

In Scotland, responsibility for planning and consenting is devolved to the Scottish Government. Through their Fourth National Planning Framework (NPF4), the Scottish Government has placed climate and nature at the centre of their planning system and made clear their support for all forms of renewable, low-carbon and zero emission technologies, including transmission and distribution infrastructure. Potential impacts on communities and nature, including cumulative impacts, are important considerations in the decision-making process.

Unabated gas

As clean power substantially reduces the amount of electricity generated by gas-fired plants, unabated gas will change its role in the system. Under a clean power system, it will play a back-up role at specific times throughout the transition to clean power. This means retaining sufficient unabated gas capacity until well beyond 2030, when it can be safely replaced by low carbon technologies that can provide the amount of long-duration flexibility necessary to keep the system balanced at all times. We currently rely on ~35 GW of unabated gas on the system to provide long-duration flexible capacity[122]. This firm capacity is crucial for electricity security, and will be required as strategic back-up to respond to certain periods of high demand, even as we aim to reduce fossil generation (i.e. gas running hours) overall.

Existing assets

Retaining the existing gas fleet where possible is likely to be the most cost-effective means of meeting the capacity we need for gas to fulfil its strategic function in 2030. Current fleet intelligence suggests most existing gas assets will remain online until 2030, but we are also consulting on measures to make it easier for gas assets to stay in the Capacity Market and for plants to access multi-year Capacity Market agreements, encouraging investment in life extension of older plants.

Decarbonisation readiness

To provide the clarity investors need to make long-term decisions, we are introducing decarbonisation readiness requirements. This will ensure that new or substantially refurbishing combustion power plants in England, which submit their environmental permit application from 28th February 2026, must have a credible plan to decarbonise either through converting to hydrogen firing or through retrofitting carbon capture. Requiring developers to demonstrate the viability of their decarbonisation plan will ensure that the developers of new or substantially refurbishing combustion power plants have considered how they will access low carbon hydrogen or CO_2 storage in the future, and that land necessary to enable that decarbonisation has been set aside. This will support providing visibility to investors over which sites are well placed to decarbonise in future.

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[122] NESO (2024), '*Clean Power 2030*' (viewed in December 2024).

Moreover, to help ensure that capacity coming forward before the implementation date consider their decarbonisation plans, we are placing an obligation on substantially refurbishing or new combustion power plants in England, participating in the 2026 Capacity Market auction to declare that they will comply with the Decarbonisation Readiness requirements.

We are complementing this with measures intended to enable gas assets tied into long term Capacity Market agreements to exit without penalty and transfer to the power CCUS Dispatchable Power Agreement, enabling conversion to low carbon through retrofitting carbon capture equipment. We are exploring additional routes for gas assets in the Capacity Market to decarbonise including the feasibility of gas assets exiting long term agreements to enable conversion to H2P through H2PBM support.

As low carbon flexible technologies become more established, unabated gas will increasingly move to a reserve role on the system, essentially called upon as a last resort to meet peak demand, and demand during long periods of low supply from variable sources. Maintaining this reserve generating capacity is important for reaching clean power by 2030. As set out in the market reform chapter, we are taking steps to reform the Capacity Market to ensure there is sufficient unabated gas capacity on the system to maintain security of electricity supply as it moves into this reserve role.

The reforms we are announcing to existing market frameworks are the best way to ensure that the necessary strategic reserve capacity of unabated gas generation remains on the system. The government's view is that a novel out-of-the-market mechanism to manage that reserve may have a role in the long-term phase-out of unabated gas capacity once its volume in the system has significantly reduced and long-duration low carbon flexible technologies have been deployed at scale.

Next steps

The actions outlined in this section will be critical to delivering a strong pipeline of low carbon long-duration flexible technologies and driving forward innovative and nascent technologies that can play an important role in delivering clean power. It also makes clear the important role that unabated gas will continue to play in a new back-up role to provide security of supply into the 2030s and beyond, whilst giving clarity for investors on the future routes to decarbonisation for these assets.

Supply chains and workforce

Summary

Lowering barriers to investment into resilient supply chains and workforce development is vital to ensuring we meet the demand for Clean Power 2030 and to capturing the benefits of this change for our economy. This is an opportunity to support UK growth by building domestic supply chains, growing the skilled workforce and spreading good jobs across the country. Government will support industry to secure the supply chains and skilled workforce they need by:

Giving developers greater route-to-market certainty so that they can plan and secure necessary supply chains and workforce, sooner.

Rapidly convening a new supply chains and workforce industry forum for key Clean Power 2030 sectors, including trade unions, to develop a deep understanding of system-level supply chain and workforce planning needs for Clean Power 2030 delivery, exploring bold solutions and devising targeted collective actions to ensure they are met.

Maximising domestic opportunities for clean energy supply chains through cross-economy work such as the UK's Industrial Strategy in Spring 2025, and clean power specific policy actions.

Exploring where international collaboration can support supply chains, including via trade agreements and international co-operation. The government is determined to work with other countries to diversify international supply chains.

Driving an increase in capacity of our domestic clean energy workforce to match the scale of the deployment challenge through our investment into clean energy sectors, and accelerating wider reforms led by the Office for Clean Energy Jobs, the Department for Education, and Skills England alongside targeted clean power offers, working closely with the devolved governments, industry, and trade unions.

Boosting awareness of clean energy job opportunities by publishing data on future clean energy workforce and skills needs, to ensure a common understanding of trends and challenges to inform action.

The challenge

Supply Chains

To deliver Clean Power 2030 we need secure, sustainable, competitive and reliable supply chains to provide the components and materials it requires. The UK will need to source more components by both powering up our domestic manufacturing and ensuring access and competitiveness in international markets. As we achieve this, we are committed to unlocking the growth benefits that come with scaling up deployment and manufacturing of clean energy technologies. Our ambition is to see a sustained increase in supply chain activity both up to 2030 and continuing out to 2050.

Domestically, the UK has established manufacturing capacity in some of the key technologies needed to deliver Clean Power 2030. We have strengths in offshore wind engineering services, cables, electrolysers and electrical equipment, as well as parts of the wind turbine generator and monopiles. We also have suppliers with expertise in both high-voltage alternating current and high-voltage direct current (HVDC) electrical systems and are aiming to build capacity in HVDC cables. The upcoming Industrial Strategy will look to attract investment in growth-driving sectors including clean energy industries, and work is being carried out to determine the key subsectors on which it will focus. More broadly, we are a world-leading investment location, with a strong pipeline of potential projects that could strengthen our base further, although we will always need to also buy inputs and finished components from the international market.

We have been working with industry to make an initial assessment of the industry procurement challenges that may be faced for Clean Power 2030, building on previous evidence produced in collaboration with Baringa and the Industrial Growth Plan[123,124]. This work has identified constraints across several key sectors, with supply chains close to full manufacturing capacity, long lead times for key components, and reliance on single international sources in places. Alongside these constraints, there are several cross-sectoral challenges associated with procuring components and delivering the resilient supply chains we need for Clean Power 2030:

- **Investment confidence for buying components and investing in domestic manufacturing.** Developers need greater certainty in the clean power deployment pathways and associated order books to secure supply chain components as early as possible, especially those with long lead times. In turn, this will give greater confidence to the supply chain to make investment decisions committing to basing or increasing future manufacturing capacity in the UK. We also know that UK supply chain companies need early, strategic engagement from developers to help develop and refine their product and service offerings to market needs.
- **International buying power.** There is growing global competition for clean energy supply chains, with competition for key components across different countries and sectors, which can result in prices being driven up. The UK will always be reliant on international supply chains to some extent: alongside stronger domestic supply chains, it is essential that UK developers have reliable access to and are able to compete in international markets for materials or components.
- **Logistical constraints.** On a sector-by-sector basis, there are specific issues that prevent or delay transport and deployment of supply chain components – most prominently in transmission networks, offshore and onshore wind, where ports, vessels, and abnormal load issues are acute.

Workforce

The wider transition to net zero is expected to support hundreds of thousands of jobs, with Clean Power 2030 playing a key part in stimulating a wealth of new jobs and economic opportunities across the country[125]. These jobs will cross a range of skill levels and occupations, including technical engineers at levels 4–7 (and particularly 6+ including roles in civil, mechanical, electrical and design), along with electrical, welding, and mechanical trades at levels 2–7, and managerial roles including project and delivery managers at levels 4–7[126]. Many of these occupations are already in high demand across other sectors such as house building, construction, and wider manufacturing, and there also is a relatively high degree of transferable skills and knowledge between many carbon-intensive sectors and clean energy sectors, so wider coordination will be vital[127]. The 'Assessment of the Clean Energy Skills Challenge' evidence annex sets out further evidence on key clean energy occupations, gathered through a range of sources.

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[123] Baringa (2024), '*UK renewables deployment supply chain readiness study*' (viewed in December 2024).

[124] RenewableUK, Offshore Wind Industry Council, TCE, & The Crown Estate Scotland (2024), '*Offshore Wind Industrial Growth Plan*' (viewed in December 2024).

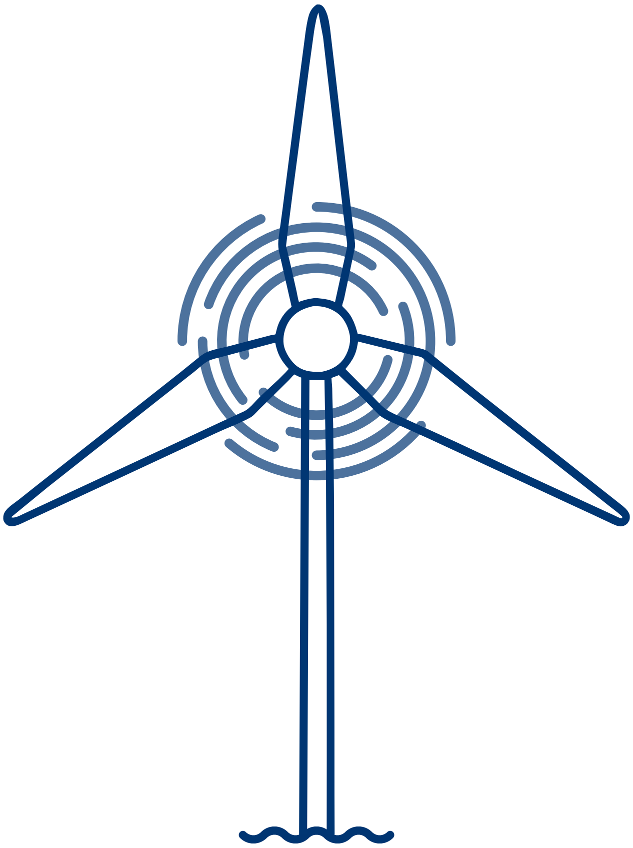
[125] CCC (2023), '*A Net Zero Workforce*' (viewed in November 2024).

[126] UK Government, '*What qualification levels mean*' (viewed in December 2024).

[127] Experimental job advert analysis shown in figure 14 suggests there is relatively high transferability of skills from many carbon-intensive sectors to clean energy sectors, suggesting workers in carbon-intensive sectors are likely to have many of the skills needed across the Clean Power workforce. The challenge will be in enabling the reskilling of these workers, quickly.

The challenge of finding employees with the right skills to take on these roles is already significant and expected to remain so. Through industry engagement, we have identified several key barriers to securing the Clean Power 2030 workforce:

- **Delivering future skills needs:** There are a number of gaps and key occupations that need to be better targeted in the post-16 skills system. Exacerbating the challenge is the high proportion of small and medium sized enterprises in clean energy sectors, some of whom have struggled to engage with the existing skills system. The UK also has an ageing workforce, and many individuals with the skills we need have left the workforce or are retiring soon.
- **Reskilling and transferability:** Most of the workforce we need for 2030 is already employed, so retraining, upskilling, and increasing the transferability of workers between sectors is essential.
- **Awareness, perceptions and accessibility of clean power jobs:** Lack of awareness of green sector jobs is exacerbating role shortages and putting future skills supply at risk. The Learning and Work Institute reported that 87% of 16–24-year-olds did not know what 'green skills' were when asked[128], reducing uptake of skills and training provision. In addition, we are not fully utilising the talent and ambitions of our workforce, for example, only 16.5% of the engineering workforce is female[129] and only 7% of the offshore wind workforce are from non-white backgrounds[130].
- **Regional pressures:** Several clean energy sectors, like offshore wind and carbon capture, are heavily clustered in specific regions of the UK. With limited data on skills needs, local skills providers are struggling to identify and tailor skills requirements around the rapidly evolving needs of their local areas. They can also find it challenging to respond to these needs given constraints on the teaching workforce and on the availability of facilities and equipment that support clean energy skills development.



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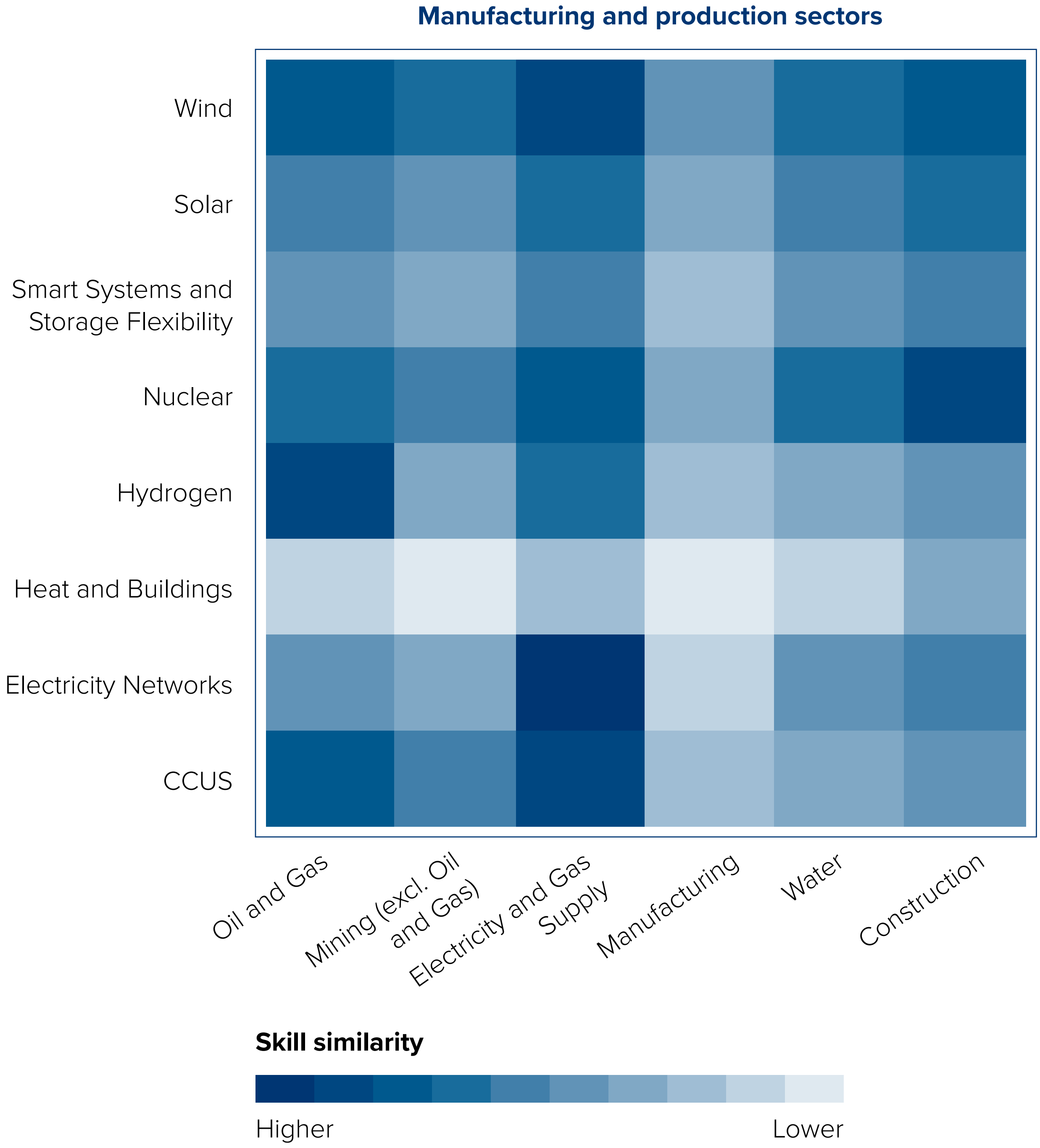
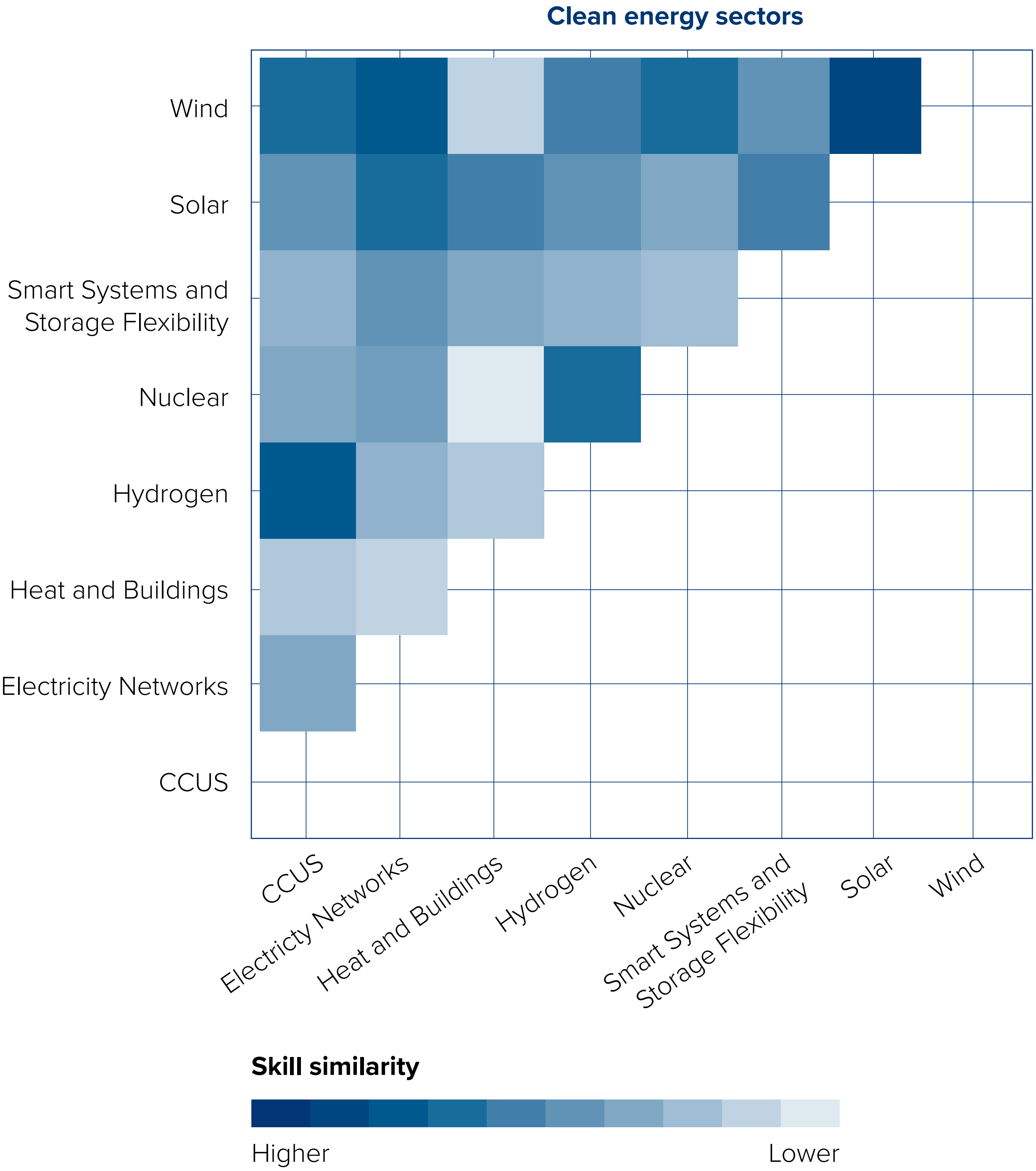
[128] Learning and Work Institute (2023), '*Skills for a net-zero economy: Insights from employers and young people*' (viewed in November 2024).
[129] EngineeringUK (2022), '*Women in Engineering: Trends in women in the engineering workforce between 2010 and 2021*' - Based on ONS Labour Force Survey data (viewed in December 2024).
[130] Offshore Wind Industry Council (2023), '*Offshore Wind Skills Intelligence Report*' – Based on job record data provided by employers (viewed in December 2024).

Figure 14: Similarity of skills demanded by online job adverts across several carbon-intensive and clean energy sectors



Note: 'Similarity' refers to cosine similarity, calculated using skills and their prominence across SIC groupings and clean energy sectors. The following traditional sectors are considered: Construction (Section F), Water (Section E), Electricity and Gas Supply (Section D), Manufacturing (Section C), Mining excl. Oil and Gas (SIC 05, 07, 08, 099), Oil and Gas (SIC 06, 091). There may be a small proportion of job adverts which fall into both groups being compared.

Source: DESNZ experimental analysis of Lightcast online job advertisement data (2024). The Clean Energy Job Adverts Analysis: Charts and Methodology document provides more detail on this analysis.



Note: 'Similarity' refers to cosine similarity, calculated using skills and their prominence across SIC groupings and clean energy sectors. The following traditional sectors are considered: Construction (Section F), Water (Section E), Electricity and Gas Supply (Section D), Manufacturing (Section C), Mining excl. Oil and Gas (SIC 05, 07, 08, 099), Oil and Gas (SIC 06, 091). There may be a small proportion of job adverts which fall into both groups being compared.

Source: DESNZ experimental analysis of Lightcast online job advertisement data (2024). The Clean Energy Job Adverts Analysis: Charts and Methodology document provides more detail on this analysis.

Taking action

We will take action to address these barriers, through broad UK government industrial policy, English skills reforms and through targeted Clean Power 2030 initiatives. Similar approaches are being taken across the devolved governments, such as those outlined in the Scottish Green Industrial Strategy,[131] the Welsh Economic Mission[132] and the Northern Ireland Executive's Path to Net Zero Energy[133]. We want to give developers of clean power infrastructure the best chance of securing the supply chains and workforce they need to deliver Clean Power 2030, and we are committed to delivering Clean Power by 2030 in such a way that retains value for money and balances cost considerations with delivery.

This starts with giving developers greater clarity and certainty over their routes to market, to enable them to plan and mobilise the supply chains and workforce they need to deliver new generation. This will help give forward sight to supply chain companies to prepare and have capacity to supply clean power infrastructure projects. We have aimed to do this elsewhere in this plan, particularly in sections covering market reform, Contracts for Difference reform for upcoming allocation rounds, proposed changes to planning and consenting, and connections queue changes. For network companies, greater flexibility to secure supplier capacity earlier and for the longer term will be given primarily through the launch of Ofgem's Advanced Procurement Mechanism[134].

The Clean Power 2030 Unit, in collaboration with the Office for Clean Energy Jobs, will convene key stakeholders from Clean Power 2030 sectors in a new industry forum in early 2025. This will be a collaborative vehicle for proactive supply chain and workforce planning. Further information on this forum is included in the government's approach to delivering Clean Power 2030 chapter as a case study for how we will drive delivery through a new, mission-focused approach.

Alongside the work of the forum to develop collective actions for Clean Power 2030 delivery, UK government has a further role in:

- **Maximising domestic opportunities for clean energy supply chains** through cross-economy work such as the UK's Industrial Strategy in Spring 2025, and clean power specific policy actions.
- **Exploring where international collaboration can support supply chains,** including via trade agreements and international co-operation. The government is determined to work with other countries to diversify international supply chains.
- **Driving an increase in capacity of our domestic clean energy workforce to match the scale of the deployment challenge** through our investment into clean energy sectors, such as the Clean Industry Bonus and Great British Energy, and accelerating wider reforms led by the Office for Clean Energy Jobs, the Department for Education, and Skills England alongside targeted clean power offers, working closely with the devolved governments, industry and trade unions.

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[131] Scottish Government (2024), '*Green Industrial Strategy*' (viewed in December 2024).
[132] Welsh Government (2023), '*Economic mission: priorities for a stronger economy*' (viewed in December 2024).
[133] Northern Irish Executive (2021) '*Path to Net Zero Energy*' (viewed in December 2024)
[134] Ofgem (2024), '*Electricity Transmission Advanced Procurement Mechanism Consultation*' (viewed in December 2024).

- **Boosting awareness of clean energy job opportunities by publishing data on future clean energy workforce and skills needs**, to ensure a common understanding of trends and challenges to inform action.

Maximising domestic opportunities for clean energy supply chains

A range of work is already underway in government to support cross-economy development of domestic supply chains. **In spring 2025, we will publish an Industrial Strategy including a clean energy sector plan**. Government's approach to stimulating investment and activity in growth-driving sectors will be set out in this upcoming Industrial Strategy, which we will continue to actively shape to maximise its benefits for clean power industries. The strategy will outline government's next steps to securing growth opportunities in these industries, and a clear approach to enabling sectors to overcome barriers to growth and investment, including in supply chains. A new **supply chains taskforce** will assess where supply chains critical to the UK's economic security and resilience are vulnerable – focussing in the first instance on supporting the development and delivery of the Industrial Strategy.

In addition, we are taking action to focus investment into boosting our supply chain capacity and create pathways for efficient procurement processes:

- **Delivering the new Contracts for Difference (CfD) Clean Industry Bonus**. This initiative allows clean energy developers in fixed and floating offshore wind to access additional CfD revenue for investments in manufacturing in our coastal and energy communities and cleaner, more sustainable supply chains.
- **Consulting on targeted reforms to the CfD mechanism for upcoming allocation rounds**, including improving transparency and predictability in the timing and scale of future CfD allocation rounds, which in turn can support increased investment in clean power supply chains. Further detail on these reforms is included in the Renewable and Nuclear Project Delivery chapter.
- **Delivering the Floating Offshore Wind Manufacturing Investment Scheme** (FLOWMIS) which was set up to provide grant funding to support the development of port facilities for large-scale floating offshore wind deployment. The Port of Cromarty Firth and Port Talbot have been placed on the FLOWMIS primary list, meaning they have been taken forward for detailed due diligence, subsidy control assessment and negotiation of grant terms. Further detail on the role of floating offshore wind is included in the Renewable and Nuclear Project Delivery chapter.
- **Mobilising government investment into the clean power sector** via the National Wealth Fund and Great British Energy. At least £5.8 billion of the National Wealth Fund's capital will focus on five other sectors relevant to clean power: green hydrogen, carbon capture, ports, gigafactories and green steel. £8.3 billion over the course of this Parliament has also been committed to the newly created Great British Energy, which will work in lockstep with the National Wealth Fund. It will work to support the growth of clean power supply chains across the UK, ensuring the benefits of these are widely distributed.
- **Supporting Ofgem's development of the Electricity Networks Advanced Procurement Mechanism** to be launched in early 2025 with the aims of providing greater flexibility for Transmission Owners to secure supplier capacity and to bulk procure multiple factory slots across a portfolio of projects ahead of need.

Exploring where international collaboration can support supply chains

We recognise that, though it is crucial to build domestic capacity, some of our supply chain needs will be met by the global rather than the domestic market. Where this is necessary, we want to give developers the best possible opportunity to secure what they need. We will do this through:

- **Collaborating with international partners** through international initiatives such as the Global Clean Power Alliance and other bilateral and multilateral initiatives, to diversify and strengthen supply chains. This has the potential to support new sources for critical clean power components, address bottlenecks and reduce costs.
- **Exploring international solutions to ensure the UK is able to secure the critical goods it needs** for the energy transition and explore international trade frameworks and institutions that can support the transition to net zero.

Driving the increase in capacity of our domestic clean energy workforce

Wider reform of the skills and employment system are underway across government to shape the domestic workforce and support the delivery of Clean Power by 2030. The skills and expertise of workers from the oil and gas will be central to the success of our Clean Energy Mission. There is a huge opportunity for re-skilling and transferability of skills of the oil and gas workforce across the economy. As skills policy is devolved, we will commit to continue our ongoing dialogue and collaboration with our counterparts in the devolved governments to ensure a coordinated and joined-up approach.

The Scottish Government published the Green Industrial Strategy in September 2024[135]. This outlines that the availability of high quality, appropriately skilled and ambitious people is critical to the willingness of a business to start, scale and invest. Significant work is progressing to reform the Scottish education and skills system so that it is more responsive to economic needs and ambitions. The Scottish Government will continue to invest in that system and the infrastructure that supports it, including for example, schools, colleges, universities, apprenticeships and our Innovation Centres, to enable the transition to net zero as well as broader ambitions.

The Welsh Government has published the Stronger, Fairer, Greener Wales: Net Zero Skill Action Plan[136], to provide practical steps towards understanding where and how skills needs will change over time and indicate how the Welsh Government will support this transition. Other planned Welsh initiatives include the publication of Clean Energy Sectors Skills Roadmaps, an Energy Sector Deal, supporting the Heat Strategy for Wales to advance decarbonisation, developing a new renewable energy apprenticeship framework and fostering industry collaboration to enhance supply chain opportunities.

The Northern Ireland Executive is also looking to influence and shape developments in green skills and has facilitated an industry-led Green Skills Action Plan. The Green Skills Action Plan initially focusses on the following three areas: large-scale energy production; infrastructure; and domestic low carbon technologies and energy efficiency to ensure that courses and apprenticeships are in place to provide the skills needed for the energy transition.

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[135] Scottish Government (2024), '*Green Industrial Strategy*' (viewed in December 2024).
[136] Welsh Government (2023), '*Stronger, Fairer, Greener Wales: Net Zero Skill Action Plan*' (viewed in December 2024).

Ongoing UK government work includes:

- **Setting up The Office for Clean Energy Jobs,** which has been created to focus on ensuring we have the skilled workforce in core energy and net zero sectors critical to meeting Clean Power 2030. It will focus on supporting regions transitioning from carbon-intensive industries to clean energy sectors, ensuring clean energy jobs are high quality, with fair pay, favourable terms and good working conditions, and increasing diversity in the clean energy workforce. It will engage across the energy sector, trade unions and industry to deliver on this.
- **Designing a pilot scheme to support regional skills interventions** that will help transition the UK workforce from carbon-intensive sectors to clean energy sectors. This will be achieved by identifying and addressing skills gaps and challenges through targeted interventions trials on a regional basis. Interventions could include local skills and workforce mapping, career transition advisors, funding for direct training provisions.
- **Setting up Skills England to provide an authoritative assessment of national and regional skills needs**; work with Combined Authorities to ensure these are met; align a comprehensive suite of apprenticeships, training and technical qualifications with skills gaps; and advise on a new growth and skills offer. DESNZ will work with DfE and Skills England, together with the devolved governments, on early reform priorities to ensure that policy implementation begins as soon as possible to have the greatest impact on Clean Power 2030. The government will also evolve the apprenticeships offer into a more flexible growth and skills offer, delivering greater flexibility for learners and employers, aligned to the Industrial Strategy, creating routes into good, skilled jobs in growing industries such as clean energy. DESNZ will work with DfE, Skills England, and the sector to inform the offer. DESNZ will also work with DfE on transforming further education colleges into specialist Technical Excellence Colleges and on ways to enhance the further education workforce in clean energy and related sectors. The Curriculum and Assessment Review closed its call for evidence recently, and many clean energy industry bodies provided information.
- **Taking forward the 'Get Britain Working' White Paper.** This sets out plans for reforms to employment support to tackle economic inactivity, such as the Youth Guarantee, a new jobs and careers service to support more people into work and help them get on in work, and locally led Get Britain Working Plans for areas across England. DESNZ, DWP and DfE will work together to develop proposals for how the specific reforms mentioned within the White Paper will be implemented to support delivery of the workforce needed for Clean Power 2030.

In addition to this cross-economy work, we are taking the following clean power specific action to secure the 2030 workforce demand:

- **Exploring targeted skill interventions to reskill and upskill workers across the economy**, including identifying the regions that will be most impacted by the transition to clean energy. As of October 2024, DESNZ has come onboard as a strategic partner of the Skills Passport project. The passport is an industry led initiative overseen by Renewable UK and Offshore Energy UK and supported by the UK and Scottish Governments which will align standards, recognise transferable skills and qualifications and map out career pathways for suitable roles. This new digital tool for workers is set to be piloted by January 2025.

- **Developing ways to support access to training schemes in key clean power sectors needed for 2030**. Government is developing several new economic and investment policies which will crowd investment into the sector and create future potential opportunities to channel funding into skills provisions and training.

Boosting awareness of clean energy job opportunities

Ensuring an improved uptake of clean energy upskilling and reskilling offers will be essential, we will do this by establishing a common understanding of the barriers and collaborating with industry to overcome them. We will do this by:

- **Publishing the 'Assessment of the Clean Energy Skills Challenge' evidence annex alongside this Action Plan**, comprising data gathered across government, industry and company leaders, academics and further education representatives. This evidence is based on previous 2035 targets. However, the key near-term occupation shortages and workforce challenges sectors are expecting to face are anticipated to be largely similar. This evidence will be used as a basis for government, industry, and other key partners to better understand the 2030 workforce requirements and support targeted skills planning with confidence.

- **Exploring public awareness campaign options**, working between government and industry to see how we can coordinate messaging promoting the opportunities from clean energy jobs, help employees and employers navigate the skills landscape, and improve diversity in the clean energy workforce.

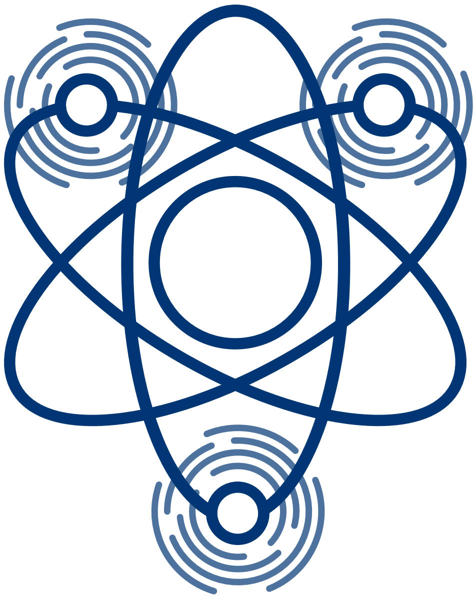
Next steps

- The first meeting of the new collaborative forum will take place in early 2025, convening key partners across private and public sectors to work collaboratively on supply chain and workforce planning.

- Our new, modern, Industrial Strategy 'Invest 2035', including a sector plan for clean energy industries, will be published in Spring 2025, setting out the government's approach to growth opportunities in clean energy industries across both supply chains and skills.

- We will deliver an updated carbon budget delivery plan in due course to the end of Carbon Budget 6 in 2037 with full detail of policy packages for all the sectors. This will provide a long-term line of sight, outlining the policies and proposals needed to deliver carbon budgets 4-6 and the Nationally Determined Contributions in 2030 and 2035 on a pathway to net zero.

- Government is developing a new Trade Strategy which will support the energy transition in alignment with Clean Power 2030, and ensure resilient global supply chains.



Taking us to 2030: Our approach to delivery

Delivery of large-scale transitions is nothing new for the energy sector, but the challenge of achieving clean power by 2030 is substantial. The Clean Power 2030 Action Plan defines the UK government's role in the clean energy transition. Government will work with industry to unlock barriers and will take an innovative approach. Additionally, it is important that government looks at a clean power system beyond 2030, where demand is expected to increase.

Leveraging the UK's industrial expertise

Clean Power 2030 needs a large amount of infrastructure to be delivered in just a few years, almost all of which will be delvered by private companies – including making key components, designing and developing projects, installing infrastructure, operating power generation plants, and financing new ventures.

All these companies are key to successful delivery of Clean Power 2030, and the UK is fortunate in having many people with a great deal of practical experience and knowledge in all these areas. The Clean Power 2030 Unit draws together a mix of skills from within the Civil Service and industry expertise, ensuring the right insight and expertise is available to support delivery.

The Clean Power 2030 Unit itself is underpinned by an advisory commission made up of 8 leading figures from across industry and academia who provide insight and advice on all aspects of its work.

The Clean Power 2030 Unit is also committed to working closely with those involved in practical delivery. The engineering, commercial, market, regulatory and policy landscape is complex, and we will need deep skills in all these areas combined with an ability to engage all parties to cut through issues quickly, together with creating and sustaining a mindset of collaborative endeavour across the industry.

To create the Action Plan, experts from government and the clean power sector explored policy approaches and assessed their deliverability. We believe the actions in this plan define the necessary policy landscape for successful delivery of Clean Power 2030, with a clear statement of intent and potential route to Clean Power 2030. However, we recognise that this is just the start, and the coming years will see a complex programme of activity, relying on the work of a wide range of businesses, many parts of government at central, regional and local level, the third sector, and individuals. We are committed to working hand-in-hand with industry, to provide both direction and support to deliver our common goal. The work of the Vaccines Task Force during the pandemic demonstrated what can be achieved when tight focus, strong direction, and full collaboration come together.

Tracking and supporting delivery of the system as a whole

A key role of the Clean Power 2030 Unit is to build and maintain a comprehensive view of the power infrastructure that is currently in various stages of development and delivery, and of the wider enablers across the electricity system, to understand what is likely to be delivered by when, where challenges may be emerging, and early warning signs for these, and what actions can be taken to keep key investments on track.

The Unit will take a whole-system approach, tracking power generation, transmission and distribution infrastructure, and with a particularly close focus on the development of flexible power production and consumption and smart demand, as well as the parallel evolution of the heat and transport sectors, and how the system contributes to our overall emissions.
The Unit will also track vital wider enablers across the length and breadth of this Action Plan, to effectively identify whether the mission is on track.

Where emerging problems are identified, the Unit will work with government sector experts to investigate what can be done in more detail, develop actions that can be taken, and drive their implementation. The Advisory Commission will have a key role in advising both on emerging issues, and on the priorities for action.

Taking a data driven approach

We commissioned NESO to provide advice on the potential pathways to achieve clean power by 2030. This suggested Clean Power 2030 is achievable, with insights on the pathways to delivery.

The Unit will bring together data and insights from across government and the clean energy sector, to track the delivery of clean power infrastructure and metrics for vital wider enablers, with analytical and data science expertise embedded within the Unit. This capability will provide decision-makers with up-to-date insight on progress across the infrastructure projects critical to 2030 and will inform actions taken to promote effective delivery and address emerging issues. The Unit will work to promote collaboration on collecting and using these data across government and our delivery partners where appropriate.

This work will also involve managing dependencies and ensuring that our future power system works as a coherent whole.

The Clean Power 2030 Unit will continue to develop this data capability in the New Year. We currently envisage an expert team across all necessary fields, supported by strong data flows and backed by the Mission Board, the Secretary of State, and ultimately the Prime Minister, all within a structured engineering program delivery environment.

This is a once-in-a-generation opportunity to deliver clean power – and we are committed to operating a robust system of evaluation and innovation to drive continuous improvement throughout the system.

An industry forum for system-level supply chain and workforce planning

With global competition for resources for clean energy technologies we know that developers face challenges in securing both the materials and skills they need. Our approach to delivering Clean Power 2030 presents a unique opportunity for government and industry to come together to more proactively plan and coordinate supply chain and workforce delivery. We will have clearer line-of-sight of what needs to be built and by when, so are uniquely placed to work in lockstep with industry to help them manage and navigate supply chain and workforce constraints.

In addition to the policies and actions discussed in the Supply Chains and Workforce chapter, we see a core role for the Clean Power 2030 Unit in bringing together key industry players to think radically about the challenges facing our supply chains and workforce. This group will meet for the first time in early 2025 and will look to quickly move to agreeing specific policy actions that can be taken to address shared risks in this area.

To do this we will establish a new forum, convened by the Clean Power 2030 Unit in close collaboration with the Office of Clean Energy Jobs, which brings together key partners, across private and public sectors, including trade unions, in infrastructure delivery. Drawing on past government experience of working innovatively with industry, this forum will quickly form a view of the Clean Power 2030 system-level supply chain and workforce needs and then devise targeted collective actions to ensure these needs are met.

We will engage with industry in the development of this forum, exploring what role it should take to be most impactful. This could be a more active role for government in supporting workforce planning across key sectors for 2030 or enabling greater collaboration and sharing of insight across industry. The new forum will join up work already being done across the Offshore Wind Industry Council, the Onshore Wind Taskforce and the Solar Taskforce. The new collaborative forum will look to complement the work of these groups to drive forward bespoke actions for 2030. This group will meet for the first time in early 2025 and will look to quickly move to agreeing specific actions that can be taken to address shared risks in this area.

The key role of the Devolved Governments

The Devolved Governments will play an important part in meeting the targets for Clean Power 2030. The governments have significant devolved powers in areas around energy and will need to be a part of the UK wide initiatives to ensure effective implementation of Clean Power 2030 policies. Not least, we will need their support in streamlining the planning and consenting processes to facilitate faster development of clean power projects.

The development of clean power infrastructure will create jobs for local areas, and we will need support to ensure that the skills development is in place to fill these roles. The UK government has been working closely with the devolved governments to ensure there is a consensus and understanding with what will be needed to achieve Clean Power by 2030.

Wales

The Welsh Senedd was the first government to declare a climate emergency. Welsh Government has set a target for Wales to host sufficient renewable capacity to meet its own needs from 2035 and to keep pace as we move away from fossil fuels and demand for clean electricity increases.

Welsh Government welcomes the Clean Power Plan, which is necessary if Wales is to achieve its ambitions for a prosperous low carbon future. This plan will be important in accelerating the start of what must be a long term pathway for the next thirty years. We need future certainty to secure long term investment in the nation's energy infrastructure, and in the skilled workforce we need to build it.

Whilst we recognise the importance of large scale generation and transmission networks, our Future Energy Networks for Wales work also recognises the role of smarter and more local energy use. Wales is taking a proactive approach to planning for the new energy system, supporting local authorities to develop plans that show how transport, heating and industry will change as we use cleaner fuels and more efficient processes. Our Ynni Cymru programme is supporting a range of projects that look to meet energy needs locally, keeping value local and reducing the need for large scale change. We look forward to contributing evidence from this innovative programme, to how we collectively achieve the future energy system at least cost and least impact for people.

Scotland

The Scottish Government is committed to working closely with the UK government on shared ambitions to decarbonise energy generation and drive progress towards net zero. Close collaboration is vital to ensuring coherent delivery of the Action Plan across Great Britain, and devolved areas – such as Scotland's terrestrial and offshore planning and consenting systems – will play a key role.

Scotland's significant renewable energy potential, strong pipeline of projects, and growing supply chain will be essential to achieving a secure, affordable and clean power system across Great Britain. The Scottish Government's objective is to ensure this brings significant wider benefits – such as boosting economic growth, supply chains and green jobs; delivering renewable energy with tangible benefits to communities; and reducing costs for consumers.

Scotland has already made significant progress towards a clean, fair and secure energy system. Scotland is a net exporter of electricity to the rest of Great Britain, and in 2022, more than 70% of electricity generated in Scotland was from renewable sources. Scotland's renewable energy capacity continues to grow, with a strong pipeline of future projects that will play a key role in decarbonising the power system across the UK.

The Scottish Government is already taking action to build on this progress and accelerate deployment of clean energy – this includes measures to improve the planning and consenting regime for energy infrastructure; delivering the Green Industrial Strategy; investing in the offshore wind supply chain in Scotland; and actions to achieve the Scottish Government's existing 2030 ambitions for onshore and offshore wind.

The Scottish Government will continue to work with the UK government to maintain investor confidence and boost renewables deployment, whilst also securing clear benefits for consumers and communities throughout the transition.

Northern Ireland

The Clean Energy Superpower Mission will benefit UK taxpayers, which includes Northern Ireland. Energy policy is largely devolved to the Northern Ireland Executive, and they are producing their own plan to decarbonise the power sector. Taking a holistic four nations approach will increase the benefit for the entire UK. Clean Power 2030, whilst a target for Great Britain, is on the pathway to reach net zero by 2050, which as enshrined in law, includes Northern Ireland.

Role of power sector actors

The delivery of Clean Power 2030 will rely heavily on the collaboration and input from a huge range of public and private sector organisations. Government will work in close collaboration with these groups to deliver Clean Power 2030. Whilst the list of organisations essential to our successful delivery is long, particularly key groups include:

The role of industry

Private sector input is essential, bringing the expertise and investment required to achieve the ambitious Clean Power 2030 target. This plan outlines the policy actions being taken by the government, but the industry will play the core role in the delivery of the Clean Power 2030 target, from securing the initial investment and undertaking early project design, through to building and operating Clean Power 2030 assets. The government has engaged with the industry while developing the action plan and will continue to do so as progress is made towards the 2030 target.

The role of Ofgem

Ofgem is Great Britain's independent energy regulator, whose primary responsibility is to protect energy consumers, especially the most vulnerable, while at the same time working with government, industry and consumer groups to deliver a net zero economy at the lowest cost to consumers and drive economic growth. Ofgem works closely with the Clean Power 2030 Unit, the National Energy System Operator, consumer groups and across government, to support its aim of delivering a clean power energy system by 2030 and a net zero economy by 2050. Its governing body is the Gas and Electricity Markets Authority, which comprises non-executive and executive members, and a non-executive chair. Members are appointed by the Secretary of State of the Department for Energy Security and Net Zero. Ofgem's Senior Executive Committee is chaired by Ofgem's Chief Executive Officer and is responsible for our overall performance; it is made up of the CEO and seven Director Generals and Directors from across Ofgem.

Ofgem works on behalf of energy consumers to ensure that households and businesses across Britain can rely on a safe, affordable and environmentally sustainable energy supply. The UK has one of the most ambitious climate change goals in the world and at the heart of this is our transition from a high carbon traditional energy system to one that is fully decarbonised. Ofgem has a key role in this transition, making sure that customers' interests are looked after along the way. As a Non-Ministerial Department and independent regulator, Ofgem uses the duties and powers set out for it by Parliament to:

- Ensure fair prices so consumers pay a reasonable price for their energy and are protected from unfair costs.
- Drive up standards by ensuring energy suppliers abide by the rules and treat customers properly.
- Keep down costs by fostering innovation and attracting investment so consumers can make greener choices through new products and services.
- Grow our energy resilience by helping to deliver a future energy system that is not reliant on global energy imports so consumers have access to stable, affordable, and secure supplies of energy.
- Deliver government schemes for renewable energy, energy efficiency and to protect the poorest energy customers.

The role of the National Energy System Operator (NESO)

NESO was established in October 2024 as a publicly owned system operator, with new responsibilities in strategically planning the whole energy system and giving advice to government and Ofgem. NESO's advice to government on achieving clean power by 2030 has been a key input in shaping this plan. NESO will be a key partner in delivering clean power, working closely with government Ofgem and industry.

As a first step, NESO is consulting on the reform of connections processes, which includes aligning those processes with government's clean power plan and with future iterations of the Strategic Spatial Energy Plan. This will enable the generation capacity required to meet clean power to efficiently connect to the system and provide longer term clarity for industry.

As the System Operator, NESO will be working to ensure that its own operations, processes and systems are prepared for the drive to clean power. This will include developing an implementation and putting in place its ongoing industry engagement plan.

NESO will work with Ofgem to continue to push forward energy code reform and help to identify the direction of future code changes for clean power provided through the Strategic Direction Statement and assess how code change can be more effective and responsive to changing system or market needs. In November, NESO launched a consultation on its business plan which sets out how NESO will work to implement clean power by 2030[137].

The role of DNOs

DNOs are responsible for the infrastructure that delivers electricity from the national transmission network to consumers. This includes the maintenance and operation of towers, transformers, cables, and meters. They are key players in the energy transition, given their intrinsic responsibilities to enable the distribution of renewable energy.

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[137] NESO (2024), '*Have your say on our first business plan as NESO*' (viewed in December 2024).

The role of Transmission Operators

The three Transmission Operators are responsible for owning and maintaining the high voltage electricity network ensuring high voltage electricity can reach one of the fourteen Distribution Networks Operators across GB. They are key players in ensuring the energy system is suitably maintained and equipped to transport renewable energy across the country.

The role of public finance institutions

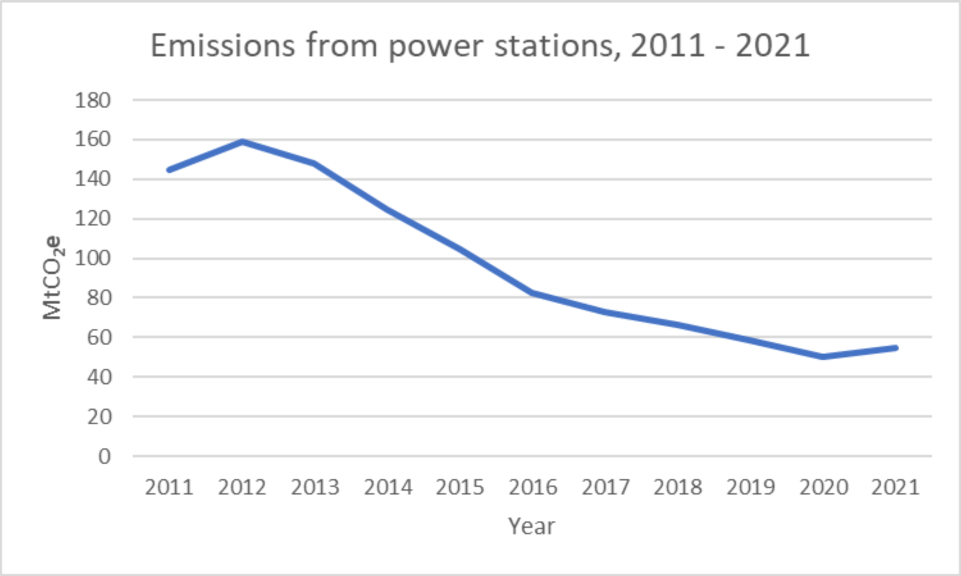
The UK's public finance institutions are empowered to deliver a range of financing tools to support government policy goals in line with their government set mandates.

They play a key role in providing finance to clean power sectors and technologies, supporting them to commercial maturity and scale. This includes support for earlier stage innovation (UK Research and Innovation), smaller businesses vital to commercialisation of green technologies (British Business Bank), and first-of-a-kind commercial deployment, or later stage scaling-up and growth stages for businesses and technologies (National Wealth Fund and UK Export Finance).

The National Wealth Fund will build on the UK Infrastructure Bank's (UKIB) leadership and investment expertise with an expanded suite of financial instruments (such as performance guarantees), additional capital, a broader mandate, additional resource to conduct more proactive development, a commitment to trialling new blended finance solutions with government departments, and a greater regional focus. It will continue to invest in UKIB's previous priority sector of clean energy (including renewable generation, nuclear, flexibility, storage, grid, retrofit, heat networks and clean energy supply chains) for projects which have a financing gap, helping to mobilise private capital into them. At least £5.8 billion of the Fund's capital will focus on five other sectors relevant to clean power: green hydrogen, carbon capture, ports, gigafactories and green steel.

The public finance institutions are actively involved in financing clean power 2030, including battery storage facilities, renewable energy generation, and electricity network infrastructure and supply chains.

Department for
Energy Security
& Net Zero


Emissions from power stations, 2011 - 2021
MtCO$_2$e
180
160
140
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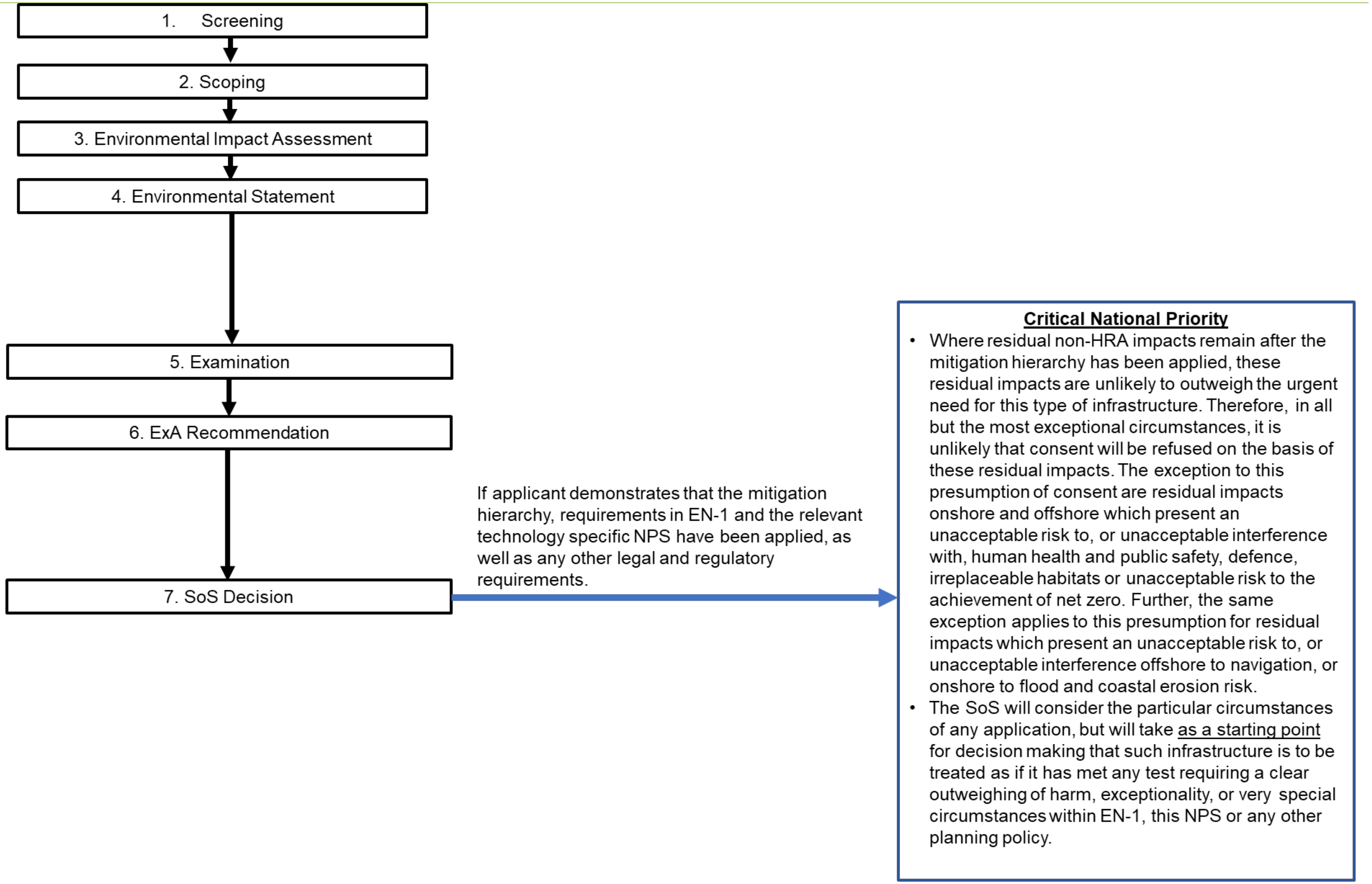


1. Screening

2. Scoping

3. Environmental Impact Assessment

4. Environmental Statement

5. Examination

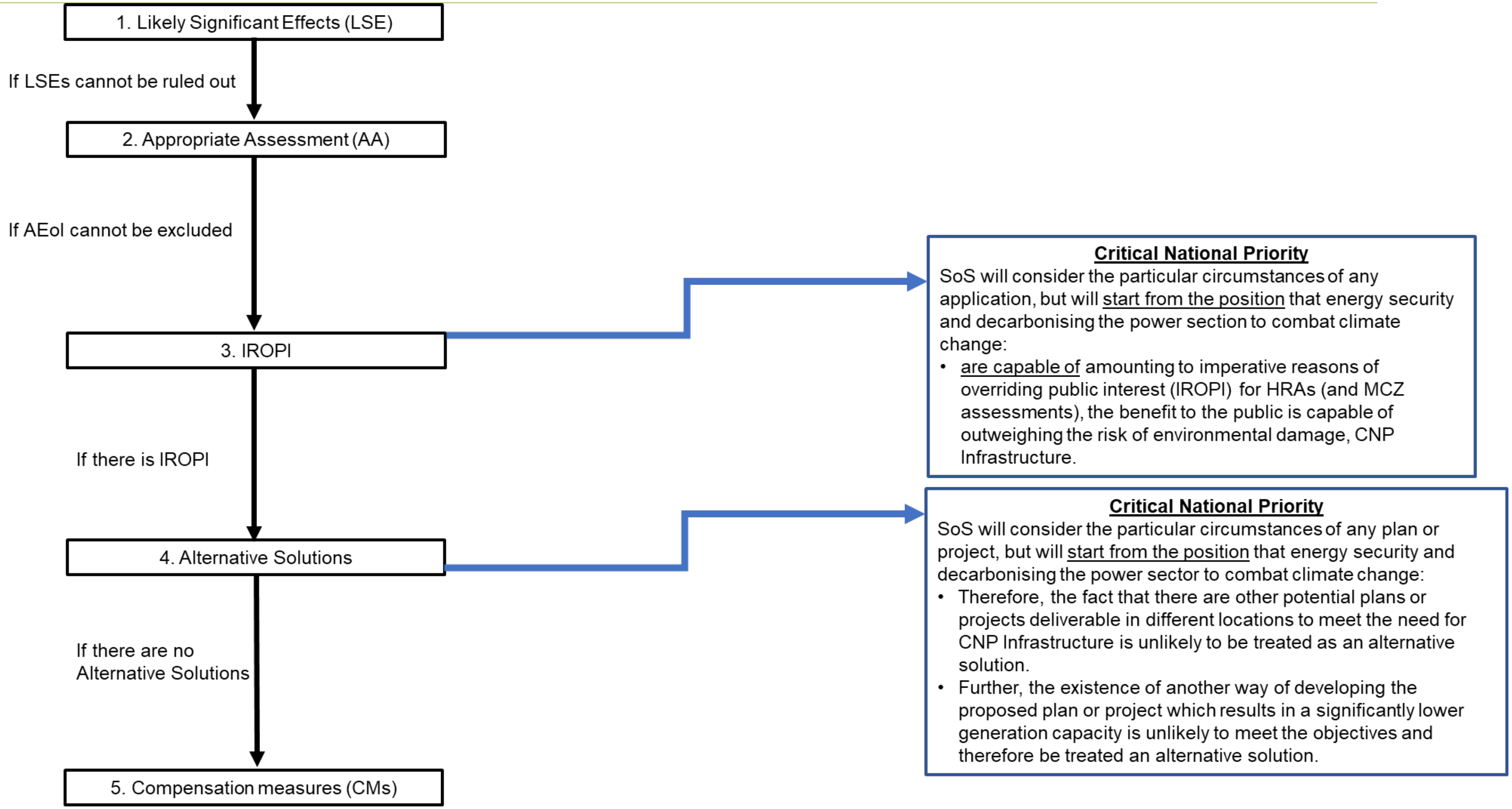
6. ExA Recommendation

7. SoS Decision

If applicant demonstrates that the mitigation hierarchy, requirements in EN-1 and the relevant technology specific NPS have been applied, as well as any other legal and regulatory requirements.

Critical National Priority

- Where residual non-HRA impacts remain after the mitigation hierarchy has been applied, these residual impacts are unlikely to outweigh the urgent need for this type of infrastructure. Therefore, in all but the most exceptional circumstances, it is unlikely that consent will be refused on the basis of these residual impacts. The exception to this presumption of consent are residual impacts onshore and offshore which present an unacceptable risk to, or unacceptable interference with, human health and public safety, defence, irreplaceable habitats or unacceptable risk to the achievement of net zero. Further, the same exception applies to this presumption for residual impacts which present an unacceptable risk to, or unacceptable interference offshore to navigation, or onshore to flood and coastal erosion risk.
- The SoS will consider the particular circumstances of any application, but will take as a starting point for decision making that such infrastructure is to be treated as if it has met any test requiring a clear outweighing of harm, exceptionality, or very special circumstances within EN-1, this NPS or any other planning policy.



1. Likely Significant Effects (LSE)

If LSEs cannot be ruled out

2. Appropriate Assessment (AA)

If AEoI cannot be excluded

3. IROPI

If there is IROPI

4. Alternative Solutions

If there are no Alternative Solutions

5. Compensation measures (CMs)

Critical National Priority

SoS will consider the particular circumstances of any application, but will start from the position that energy security and decarbonising the power section to combat climate change:

- are capable of amounting to imperative reasons of overriding public interest (IROPI) for HRAs (and MCZ assessments), the benefit to the public is capable of outweighing the risk of environmental damage, CNP Infrastructure.

Critical National Priority

SoS will consider the particular circumstances of any plan or project, but will start from the position that energy security and decarbonising the power sector to combat climate change:

- Therefore, the fact that there are other potential plans or projects deliverable in different locations to meet the need for CNP Infrastructure is unlikely to be treated as an alternative solution.
- Further, the existence of another way of developing the proposed plan or project which results in a significantly lower generation capacity is unlikely to meet the objectives and therefore be treated an alternative solution.

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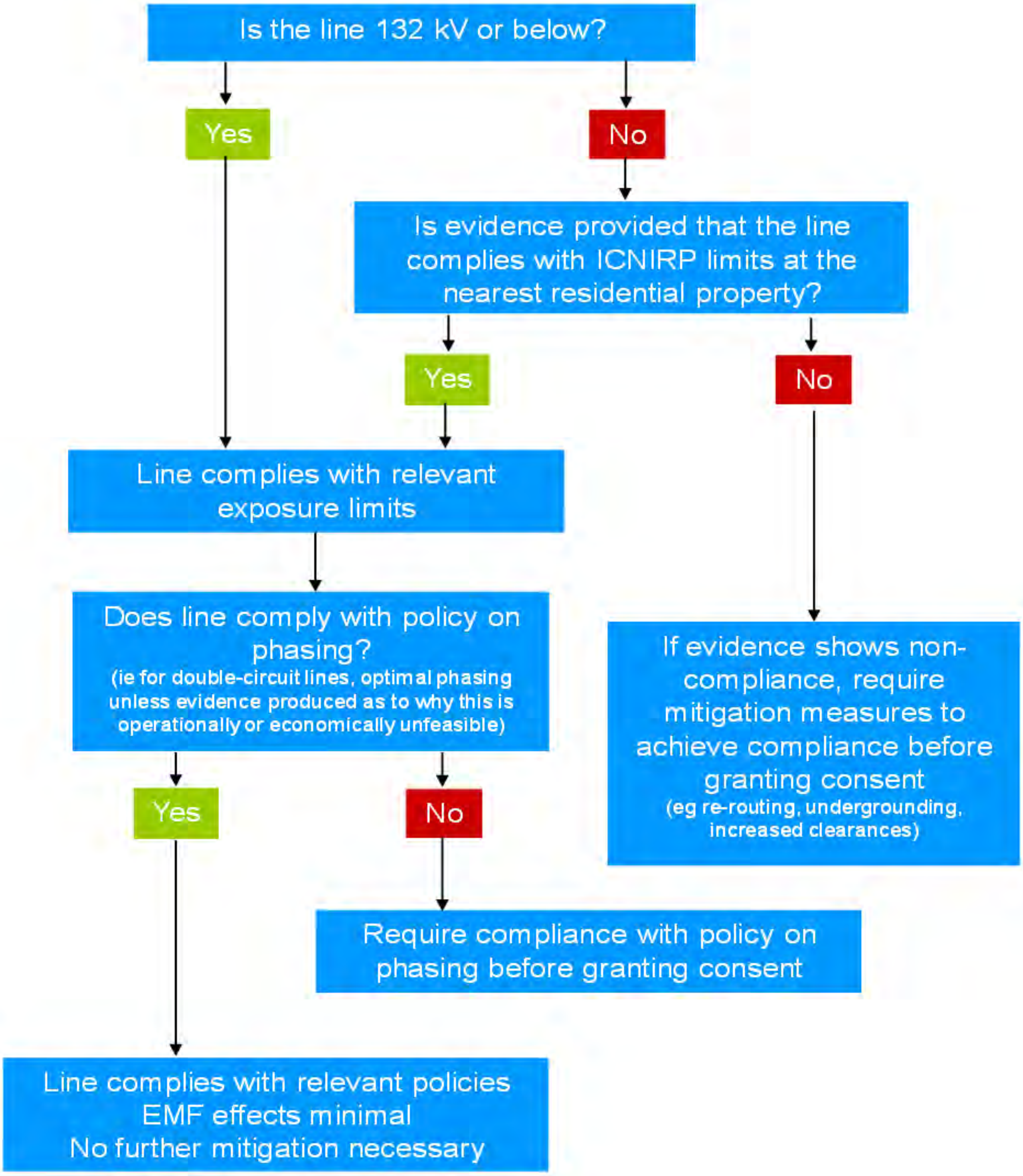
Is the line 132 kV or below?
Yes
No
Is evidence provided that the line complies with ICNIRP limits at the nearest residential property?
Yes
No
Line complies with relevant exposure limits
Does line comply with policy on phasing?
(ie for double-circuit lines, optimal phasing unless evidence produced as to why this is operationally or economically unfeasible)
Yes
No
If evidence shows non-compliance, require mitigation measures to achieve compliance before granting consent
(eg re-routing, undergrounding, increased clearances)
Require compliance with policy on phasing before granting consent
Line complies with relevant policies
EMF effects minimal
No further mitigation necessary

Electricity Networks Commissioner –

Companion Report Findings and Recommendations

June 2023

Contents

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1. About Energy Systems Catapult

Part of a world-leading network of innovation centres, Energy Systems Catapult was set up to accelerate the transformation of the UK's energy system and ensure UK businesses and consumers capture the opportunities of clean growth.

We are an independent, not-for-profit centre of excellence that bridges the gap between industry, government, academia, and research – with around 250 staff based in Birmingham with a variety of technical, commercial and policy backgrounds.

We take a whole system view of the energy sector – from power, heat and transport to industry, infrastructure, and consumers – helping us to identify and address innovation priorities and market barriers to decarbonise the energy system at the lowest cost.

To overcome the systemic barriers of the current energy market, we work to unleash the potential of innovative companies of all sizes. Helping them to develop, test and scale the products, services and value chains required to achieve the UK's clean growth ambitions as set out in the Industrial Strategy.

2. Introduction

In June 2022 the Electricity Networks Commissioner (ENC) was appointed and tasked with providing advice to Government on how to reduce the time it takes to deliver transmission infrastructure in Great Britain. The Commissioner has now delivered his report as a letter to the Secretary of State.[1]

The Commissioner was supported in his efforts by Energy Systems Catapult (ESC). ESC undertook work focussed on building deep understanding of the current delivery process and how it might be improved, enabling options to be identified and recommendations for change to be prepared.

The purpose of this document is to summarise and present ESC's findings and recommendations. This ESC report is a companion report to the Commissioner's letter; the two should be read and considered together. The ESC findings and recommendations inform and complement those presented by the Commissioner and provide additional detail. Each of the Commissioner's areas of recommendation is supported by one or more of ESC's recommendations.

The document begins with a summary of the context and the transmission infrastructure delivery challenge. The method used in the work is then described and an overview of key themes is presented. Together these provide the foundation for recommendations that will enable a significantly improved delivery time of around seven years to be achieved. The document closes with comments about immediate actions and further work that would be beneficial.

In undertaking its work ESC engaged with academic, Government, industry, and other stakeholders. ESC would like to express its appreciation to this community of committed organisations and individuals. ESC gratefully acknowledges their significant contributions through direct engagement, the Advisory Board, the Consult and Review Group and stakeholder workshops:

> Department for Energy Security and Net Zero; Department for Levelling Up, Housing and Communities; Department for Education; Department for Environment, Food and Rural Affairs; Planning Inspectorate
>
> Scottish Government; Welsh Government
>
> Ofgem
>
> Climate Change Committee
>
> National Infrastructure Commission
>
> National Grid Electricity Transmission; Scottish Hydro Electric Transmission; Scottish Power Transmission
>
> National Grid Electricity System Operator

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[1] Letter from the Electricity Networks Commissioner to the Secretary of State, June 2023

The Crown Estate; Crown Estate Scotland

BEAMA; Cardiff University; Electric Power Research Institute; Elexon; Energy Networks Association; Energy UK; EU Skills; GE Renewable Energy; Hitachi Energy; Imperial College London; Local Government Association; Morgan Sindall; Natural England; Natural Resources Wales; Neath Port Talbot Council; Renewable Energy Association; Renewable UK; Royal Academy of Engineering; Siemens Energy; The Association for Decentralised Energy; University of Bath; University of Strathclyde

Powerlink Queensland Australia; Guidehouse Germany

ESC also acknowledges the valued work of the industry expert champions Tim Pick (UK Offshore wind champion), Jane Toogood (Hydrogen champion) and Simon Bowen (Interim Chair for Great British Nuclear (GBN)) and the publicly available reports on Offshore Wind[2] and on Hydrogen[3].

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[2] Independent Report of the Offshore Wind Champion

[3] Hydrogen Champion Report

3. The Need for Action

The UK Government has committed to a fully decarbonised electricity system by 2035, subject to security of supply considerations, and to Net Zero by 2050[4] (2045 in Scotland). Nearer term objectives include ambitions to deploy up to 50GW of offshore wind and to progress up to eight new nuclear reactors by 2030. In addition, there is an expectation for a five-fold increase in solar deployment of up to 70GW, by 2035.[5] Electricity demand is expected to increase two-fold or more by 2050 as different sectors – including transport, heat and industry – electrify.[6] Supporting this growth will require transformation of the energy system, including the electricity transmission network that will connect clean generation capacity to demand centres, many of which could be in distant locations. Transmission network build will be needed at an unprecedented scale and pace.

Development of new transmission infrastructure currently takes twelve to fourteen years and is often on the critical path for the connection of new generation. The UK has been successful in stimulating investment in generation from renewables but there has not been commensurate investment in transmission networks. This means that the 'queue' to connect to the transmission grid is extremely congested, with more than 230GW of generation projects in the connection queue (compared to c.80GW of generation currently connected).[7] This has resulted in renewable energy developers and other connection customers receiving connection offers for the 2030s, slowing the energy transition.

National Grid Electricity System Operator (ESO) estimates that even with optimal reinforcement of the grid, annual constraint costs could rise from around £0.5-1 billion per year in 2022 to a peak of £2-4 billion per year around 2030.[8] Part of the solution is connection reform for which the UK Government is developing an action plan, but this is not sufficient. New infrastructure is needed to support the increase in the number of renewable projects. In Great Britain, around four times as much new transmission network will be needed in the next seven years as was built since 1990.[9]

Similar issues are being faced and responded to around the world. An estimated $21.4 trillion of investment will be needed worldwide by 2050. The US Inflation Reduction Act has assigned $29 billion to electricity networks out to 2030, aiming to stimulate $83 billion in investment in the same period.[10] With the global move towards low-carbon electricity systems, there is fierce competition to secure essential supply chains, for example for high voltage cables, power transformers and High Voltage Direct Current (HVDC) equipment, and for skilled personnel.

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[4] Plans unveiled to decarbonise UK power system by 2035

[5] HMG British Energy Security Strategy 2022

[6] Department for Energy Security and Net Zero (2022), Electricity Networks Strategic Framework: Enabling a secure, net zero energy system, Appendix 1: Electricity Networks Modelling, section 2.1,p 11.

[7] National Grid Electricity Systems Operator (2022) GB Connections Reform

[8] National Grid ESO (2022) Modelled Constraint Costs NOA 2021/22 Refresh – August 2022

[9] DESNZ Analysis Calculated based on transmission network project length data provided by the three Transmission Owners.

[10] Bloomberg NEF (2023). New Energy Outlook: grids

The rapid transformation of the electricity system will require significant levels of investment but the impact on consumer costs will depend on other key components that make up energy bills, for example cost reductions resulting from moving away from fossil fuels. HM Treasury's Net Zero Review suggested that the average electricity bill in 2050 for a household with an electric vehicle and a heat pump could be broadly similar or even lower than the average electricity, heat and transport fuel costs for a household in 2019, where that household has an internal combustion engine vehicle and a gas boiler.[11] Decreasing the amount of time to build electricity transmission infrastructure means a growing variety and number of generation and demand customers will be able to connect to the grid more quickly and cost-effectively. This will enable consumers to be offered more ready access to the benefits that arise from electrification and use of low carbon technologies, thereby serving the needs of both consumers and the system as a whole. Other benefits will also arise; for example, more network capacity will mean that costs from constraining generation will be reduced, which will be reflected in consumer bills.

If there is commitment to development of the transmission grid to respond to the challenges and opportunities presented by decarbonisation of the power system, and the necessary investments are made, it is estimated that 50,000 to 130,000 additional jobs could be supported across the country. Investment in network infrastructure could contribute £4-11 billion to the economy.[12] The increased pace of rollout of renewable energy generation projects that a reinforced grid will allow, would also make the UK more energy independent, whilst helping protect consumers from volatile international energy markets.

The appointment of the Electricity Networks Commissioner reinforced the focus placed on timely and sufficient network investment and specifically how to significantly reduce the time taken to deliver transmission infrastructure. The Commissioner's work was intended to offer options to reduce the time by three years initially, and ultimately to halve the time taken. The Commissioner has responded on the basis that it is necessary and possible to achieve a delivery time of around seven years.

Options for change must build on existing efforts where these efforts are well-founded and ambitious, and there is alignment of objectives and implementation approaches. There is a significant body of work across the sector which reinforces the need for action, illuminates areas to be considered, and offers important contributions to achieving the goal of building transmission infrastructure more quickly and delivering energy system transformation more broadly.

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[11] HM Treasury (2021), Net Zero Review Final Report, p. 56, https://www.gov.uk/government/publications/net-zero-review-final-report

[12] https://www.gov.uk/government/publications/electricity-networks-strategic-framework BEIS/OFGEM Electricity Networks Strategic Framework (2022) GVA, undiscounted, 2020 prices. Section 7 'Future employment & GVA impacts from onshore network investment' in 'Appendix I: Electricity networks modelling'.

Key aspects of some of these works are as follows:

> **Improving strategic planning:** Until recently, identification of need has been a slow, iterative, and case-by-case process. The Holistic Network Design (HND), published in July 2022[13], provides a strategic blueprint for the coordinated connection of 23GW of offshore wind to the network by 2030. The HND will be followed by the Centralised Strategic Network Plan (CSNP), to be delivered in 2024-2025 by the new independent Future System Operator (FSO)[14]. The CSNP is intended to provide a blueprint for the whole transmission network to enable coordinated and accelerated network development, including alignment between onshore and offshore networks.
>
> **Streamlining planning consent:** A consultation on the revised energy National Policy Statements (NPS) has been published[15]. It proposes amendments to bring forward new transmission infrastructure by reflecting the importance of strategic network planning and clarifying presumptions, including for example, on when underground cabling may be used.
>
> **Expediting regulatory approval:** Ofgem plays a key role as the regulator of regional monopoly transmission network owners (National Grid Electricity Transmission (NGET) in England and Wales, and Scottish Hydro Electric Transmission (SHET) and Scottish Power Transmission (SPT) in Scotland). Ofgem's Accelerating Strategic Transmission Investment (ASTI) decision[16] will speed-up c.£20 billion worth of key strategic transmission infrastructure projects for 2030 delivery.
>
> **Community acceptability:** Government is consulting on community benefits for network infrastructure[17], so communities hosting transmission infrastructure can benefit from supporting their delivery.
>
> **Connections reform:** Connections are delayed by lack of physical network capacity, but speculative developments can also take up space in the connections queue. The UK Government is working with Ofgem and the transmission network owners to develop solutions and will publish a Connections Action Plan in the summer of 2023.

While these initiatives (and others) contribute to making progress in certain areas, they are not sufficient to achieve the needed improvement in the time it takes to deliver transmission infrastructure.

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[13] Holistic Network Design: https://www.nationalgrideso.com/future-energy/pathway-2030-holistic-network-design/holistic-network-design-offshore-wind

[14] The creation of the FSO is being introduced through the Energy Bill, currently passing through the Houses of Parliament (https://bills.parliament.uk/bills/3311)

[15] National Policy Statements: https://www.gov.uk/government/consultations/planning-for-new-energy-infrastructure-revisions-to-national-policy-statements

[16] https://www.ofgem.gov.uk/publications/decision-accelerating-onshore-electricity-transmission-investment December 2022

[17] Community benefits for electricity transmission network infrastructure: https://www.gov.uk/government/consultations/community-benefits-for-electricity-transmission-network-infrastructure

The following issues should also be considered in establishing the path forward:

Citizen engagement: The needs and preferences of citizens are not considered in a timely and effective way. People and the communities in which they live and work will be impacted by transmission infrastructure build. These impacts may be seen as negative (e.g., loss of visual amenity) or positive (e.g., economic opportunities) but in either case, there is a need for constructive engagement to ensure that citizens have the benefit of clear information to enable proper individual and collective assessment. Community benefits have a role to play in engagement, but do not in themselves satisfy the requirement.

Whole process transformation: Efforts may feel ambitious individually, but they are largely constructed to address incremental improvement in a particular aspect of the end-to-end delivery process and do not account for interactions, inter-dependencies and trade-offs that will be required. Change needs to be transformative, not incremental. Strategic planning is required and must be accompanied by strategic delivery that coordinates these efforts and places them in a whole system context.

Skills: There is an acknowledged shortage of skills in the organisations that are required to deliver existing programmes, let alone respond to the need for more infrastructure being delivered at an accelerated pace.

Wider transition decisions: The focus on transmission infrastructure is both important and urgent, but not sufficient for achieving Net Zero. Generation, storage, distribution networks and demand are all relevant to the infrastructure discussion, although not within the scope of this study. As an example, to illustrate this dependency, distribution networks will also need to be significantly transformed to deliver low carbon electricity to consumers in a much more decentralised, distributed system. New transmission infrastructure is necessary to deliver this electricity to the distribution networks, but without the distribution networks being ready, it will not be possible to achieve the degree of decarbonised electrification anticipated.

Network asset utilisation: The focus of this study is on the question of how to build transmission infrastructure more quickly. It is acknowledged that answering this question will be partly informed by other considerations which could enable faster connection of low carbon generation, including for example, the contribution of well-functioning flexibility markets, opportunities for use of grid-forming technologies or dynamic rating to increase capacity of existing infrastructure, deployment of storage to delay or avoid the need to build networks and application of digitalisation including Artificial Intelligence to enhance operations, amongst others.

Strategic coordination: There is high risk that objectives for 2030, 2035 and 2050 will not be met unless concerted, courageous action is taken by strategically coordinated Government, regulator, industry and citizen efforts. The approach to achieving coordination is not yet established in practice although there are encouraging signs this need is accepted in principle.

Failure to achieve dramatic transmission build time improvements will jeopardise the statutory commitment to Net Zero, erode, rather than build energy security, and lead to higher capital and operational costs to deliver energy services. In addition, there will be both direct and indirect economic and social impacts if clean energy is not available on a timely and affordable basis.

The required changes are profound and urgent. They impact policy, regulation, planning, technology, construction, and commercial environments. But these changes to improve delivery of GB transmission infrastructure are both possible and achievable if there is sufficient commitment and a sense of urgency.

4. Approach

Recommendations for change in the transmission delivery process should be based on a sound understanding of the current process, the findings from review and analysis of potential areas for improvement and insights from validation of potential changes with those who understand the realities of delivery well. The task of preparing recommendations requires a clear focus on achieving substantial, but realistic reduction in the time taken to deliver needed infrastructure whilst ensuring that good climate, economic and social outcomes can be achieved.

ESC used two complementary approaches to identify issues in the current process and potential interventions for change; these were carried out in parallel and allowed cross-validation of their respective findings:

1. Process mapping and identification of areas for improvement.
2. Understanding the minimum time required for each stage of the end-to-end process.

The process mapping approach developed a shared, deep understanding of the current process; analysed it; created intervention options; and iteratively matured interventions into recommendations. Each of these steps involved engagement with a broad community of stakeholders, through structured and informal workshops and bilateral meetings. The key steps followed in this approach are shown in Figure 4.1. The importance and value of stakeholder engagement is underscored; more than 200 stakeholders from across the sector were involved in this work.

Figure 4.1 Process mapping approach - key steps

The minimum process approach looked at the fastest method of delivery for different stages of the end-to-end process. It began by quantifying the estimated time it takes to physically construct a typical network reinforcement. This was established through a series of bilateral conversations with stakeholders from the supply chain, construction companies and TOs. The next step was to understand how to rearrange the remaining parts of the process to achieve the desired objective, with this understanding being validated and updated through a workshop with key stakeholders. The steps followed in this approach are illustrated in Figure 4.2.

Figure 4.2 Minimum process approach - key steps

4.1 Mapping the Process

Establishing a solid understanding of the current process for transmission infrastructure delivery was key to enabling identification of issues, potential opportunities for change and possible interventions. This understanding provided a baseline for engagement and for measuring potential improvements. Early in the project, key stakeholders and organisations, including the Transmission Owners (TOs), ESO, the planning bodies - Planning Inspectorate (PINS), Department for Levelling Up, Housing and Communities (DLUHC) and Scottish Government, the regulator (Ofgem) and the Department for Energy Security and Net Zero (DESNZ) were engaged and information on the current process requested.

The responses to the requests for information were analysed with the findings forming the basis of the first draft of a system process map. This end-to-end process map considered system interactions, where responsibilities lie, the rough time frame for interactions and reviews, artefacts produced as part of the process and bottlenecks.

The content of this map was validated and modified through a series of workshops with a broad range of stakeholders. This enabled an increasingly accurate version of the current process to be established and shared. Further workshops and one-to-one discussions with stakeholders also helped identify key challenges and issues in each step of the process. This content was captured and analysed.

This exercise enabled identification of potential improvements and efficiencies within the end-to-end process. Figure 4.3 shows a simplified high-level map of the current process. A more detailed version was used to explore issues and “bottlenecks” for each process activity and for each stakeholder(s) involved in the activity.

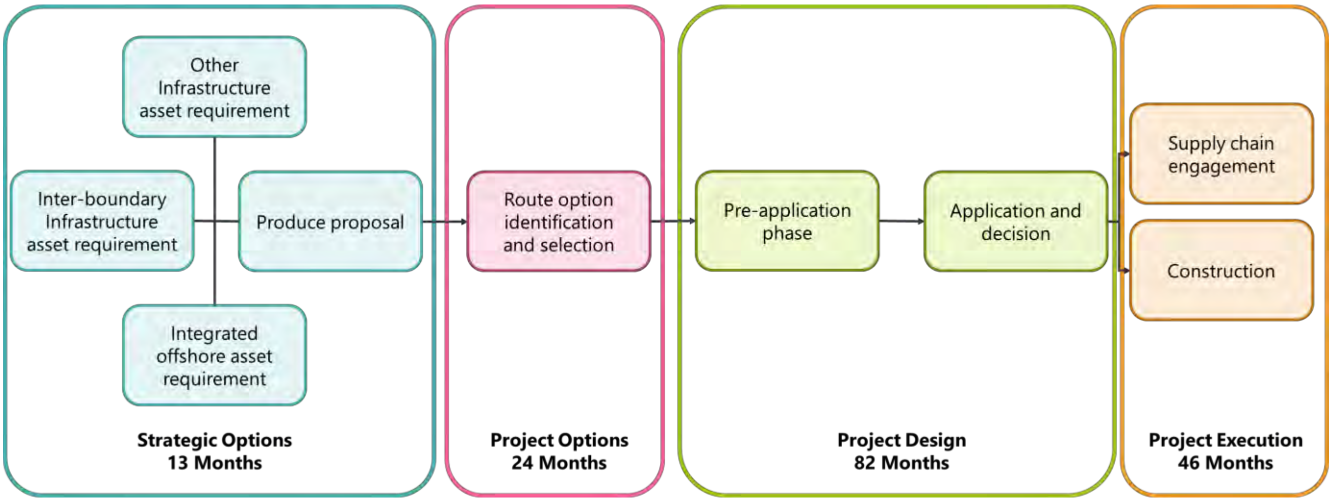

Figure 4.3 High level process map of current process

4.2 Identification of key themes

Review and analysis of the current process, and the insights offered by key stakeholders, allowed several key challenge themes to be identified. These themes shaped and formed a foundation for the work and for the task of considering options for change.

> **Strategic plan:** There is broad recognition of how hard it is to make decisions given the complexity and uncertainty of energy system transformation. There is also recognition that this is made harder if an incremental, project based, siloed approach is followed. This has led to there being an appetite for a strategic approach manifested in a shared energy system strategic plan. A key aspect of this plan would be transformation of the transmission grid to support and enable system change. The strategic transmission plan should sit within a whole energy system plan that looks across the energy value chain, considers multiple vectors and sectors, addresses the roles of technology, markets, policy, regulation, innovation and people and accommodates interactions with other adjacent sectors where dependencies are particularly strong. Progress can be made in the absence of such a plan, but risks will be higher, pace will be slower and costs will be higher; these impacts will arise because interactions, dependencies and trade-offs will not be as visible or as well understood.
>
> **Design standards:** The visual impact of new infrastructure on communities can often lead to local opposition to projects. New infrastructure should seek to be environmentally viable, satisfactory from a regulatory perspective and acceptable to citizens and communities. Design standards can play a role by offering clarity on what infrastructure might look like and potentially by opening opportunities for more meaningful discussion about choices. This could result in improved time to reach decisions and as well, potentially lessen disruption where use of standard approaches can help in the speed of construction. Transmission network project delivery would benefit by virtue of improvement in community dialogue and facilitation of design and approval activities.
>
> **Regulatory approval:** The regulatory approval process has responded to the transmission infrastructure build challenge with measures to approve groups of

projects rather than giving approval on an individual project basis. This initial response has shown the value in this thinking and offers a foundation for further measures that will maintain the key objective of assuring that consumers receive value for money while achieving greater pace in infrastructure delivery. Infrastructure design standards are a good example of an intervention that could be helpful in this context; adherence to an endorsed design standard should facilitate approvals. The regulatory approval process has a strong interaction with the planning approval process; a system perspective could offer insight into the dependencies and trade-offs that are implied in that interaction and could reveal opportunities for change that would enable faster infrastructure delivery.

Planning Approval: Planning and planning approvals are much commented on as key aspects of the transmission infrastructure delivery process. There is a tension between the need for infrastructure to support social and economic well-being and the impact that this infrastructure has on the environment, people and communities, in both the near and longer term. Failure to address and resolve this tension will jeopardise the journey to a Net Zero future by delaying electrification and the uptake of low carbon technologies. The objective should be to achieve the right balance wherein the best possible, albeit difficult choices are made, informed by the right information and constructive engagement with stakeholders. Planning sits at the centre of several decision-making processes including the regulatory approval process; land rights, and environmental assessment for example, and illustrates the value of taking a system perspective to support complex decision making.

Supply chain: The scale of transmission infrastructure build will place unprecedented demands on supply chains for products and services in electrical, mechanical and civil engineering and other sectors. These demands will be international in scope as all countries seek to address their respective needs and commitments to Net Zero. There are several specific challenges in engaging with the supply chain including when and who engages; how to compete on the increasingly competitive global market; ensuring assets are available when needed and the risk of escalating costs, amongst others. Failure to address these challenges could delay build projects, result in higher project costs, or make certain projects undeliverable which in turn, would jeopardise achieving Net Zero objectives.

People and skills: There is a growing need for people with a broad spectrum of skills to enable transmission infrastructure build; this need will become greater as the pace of infrastructure build increases. Additional professional and vocational skills are needed to serve many if not all aspects of the end-to-end process for transmission delivery. This is not just a matter of recruitment. It includes attracting, training, retraining, recruiting and retaining people, and doing so in a landscape where there will be fierce competition globally for skills. It will be important to create an environment where response to the requirement is valued and the potential social and economic benefits are understood by individuals and communities.

End-to end process: The process for delivering transmission infrastructure involves many parties undertaking complex, interacting activities. However, currently this process is in reality, a collection of processes without any point of oversight or coordination. An end-to-end process perspective, both in principle and practice, could help achieve pace and efficiency in delivery. This requires clarity in purpose and direction and in roles and responsibilities. Provision of oversight means that an entity has to be identified to provide it. It also means that mechanisms and incentives need to be in place to encourage alignment and coordination across stakeholders.

Outage planning: Work to connect new generators or reinforce the network requires outages to be taken on existing assets. These outages often involve major works meaning that emergency restoration of a circuit to service is not possible as the planned work must be completed first. Historically, outages that cannot be restored in an emergency have been planned cautiously to limit the risk of such outages combining with a fault outage(s) to compromise system security or lead to large constraint costs. As the programme of transmission infrastructure build grows, there will be a requirement to allow more projects access to the transmission network in shorter timescales. There is a need to understand how to plan and undertake outages so that risks to system security and the assurance of service delivery to consumers are balanced against the need for scale in building network capacity and pace in project execution.

It is important to emphasise that these themes are not independent of each other but rather, represent facets of a complex problem. The interactions and dependencies between them, and the trade-offs that can be implied are reflected in the recommendations. The key themes have been mapped to the current process in Figure 4.4 below. The mapping shows that some themes are impacting certain points within the end-to-end process which can slow down decisions and slow down moving onto the next step. Other themes impact across more of the end-to-end process and can slow down process through multiple steps.

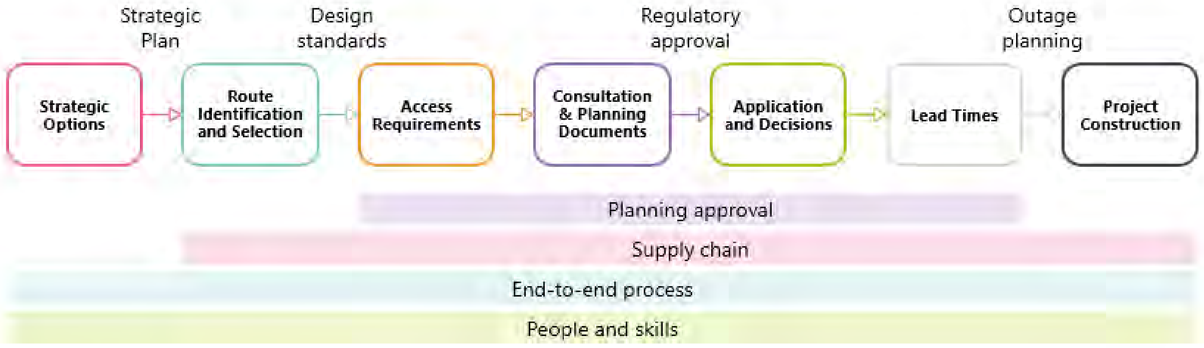

Figure 4.4 Mapping of themes against current end-to-end process

4.3 Creating options for change

The themes - both individually and in combination - were used to structure engagement and to organise the intervention ideas that were collected as part of stakeholder engagement exercises. The ideas were refined into draft options for discussion in a further series of workshops with stakeholders. The objective of the workshops was to have an open discussion on effective solutions while gathering additional ideas and options that could then be analysed and refined. This step enabled detailed conversations around risks and opportunities but also offered a chance for stakeholders to think of different future solution options for the same problems. Eight workshops were held and over one hundred and fifty people attended representing fifteen different organisations involved within the end-to-end process.

The output from these workshops was then further elaborated before a thorough analysis of the impact of each option was explored. The main considerations for the analysis were:

- Impact on timescale.
- Ability to address the challenge.
- Ease of implementation.
- Organisational and societal implications.

Recommendations were drafted based around the themes and the insights and findings that emerged from engagement and analysis.

The outputs from the minimum process approach were used to review, test and update these recommendations. The resulting enhanced recommendations form the basis of a potential new process that would satisfy the challenge of significantly reducing the time taken to deliver transmission infrastructure.

4.4 Minimum process approach

The minimum process approach took a different perspective on the same problem, focussing not on process improvement, but on the minimum time needed to undertake an activity. It was intended to help strengthen and validate recommendations arising from the process mapping approach.

The minimum process approach consisted of two phases. The first phase was to understand what the minimum time could be for physically constructing transmission infrastructure. This was developed based on insights from interviews with a range of key supply chain stakeholders (e.g., construction and manufacturing companies).

The second phase involved a workshop with key stakeholders. The objective was to consider how the end-to-end process could be completed within seven years. The results of the workshop were then analysed and used to identify new recommendations and to update or validate the recommendations from the process mapping approach.

The minimum time for constructing transmission infrastructure was identified to be thirty months. In comparison, the process mapping approach identified the current construction period to take forty-six months. Figure 4.5 shows the process with this minimum construction time and all other parts of the process remaining the same as the current process. This reduces the end-to-end process time to one hundred and forty-nine months (more than twelve years), with a target to reduce it further to eighty-four months (seven years).

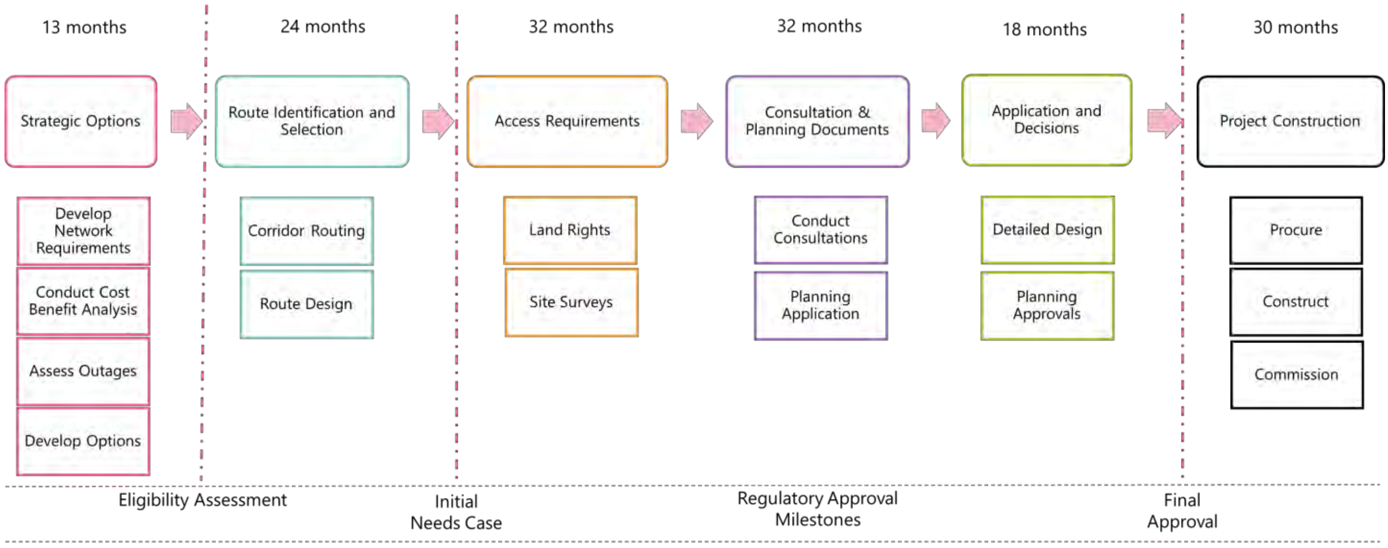

Figure 4.5 End-to-end process diagram with minimum project construction time

The following potential changes were considered as part of a response to the challenge to reduce the time for delivering transmission infrastructure to seven years,

Remove a process.
Make a process ex-ante or ex-post.
Make a parallel process.
Put more resource into a process to shorten the time it takes.
Make a process more efficient.
Redesign or integrate a process.

The resulting seven-year end-to-end minimum process was then discussed and validated in the stakeholder workshop noted above. The output of the workshop and bilateral conversations were then used to enhance the set of recommendations from the process mapping approach resulting in recommendations that incorporate thinking from two key perspectives on change.

4.5 The proposed new process

A new process that takes seven years from identifying the need for new infrastructure to building and commissioning it, was created using the two approaches described in the preceding sections. The new process and the recommendations required to achieve the time saving are shown in Figure 4.6. The recommendations are described in Section 5.

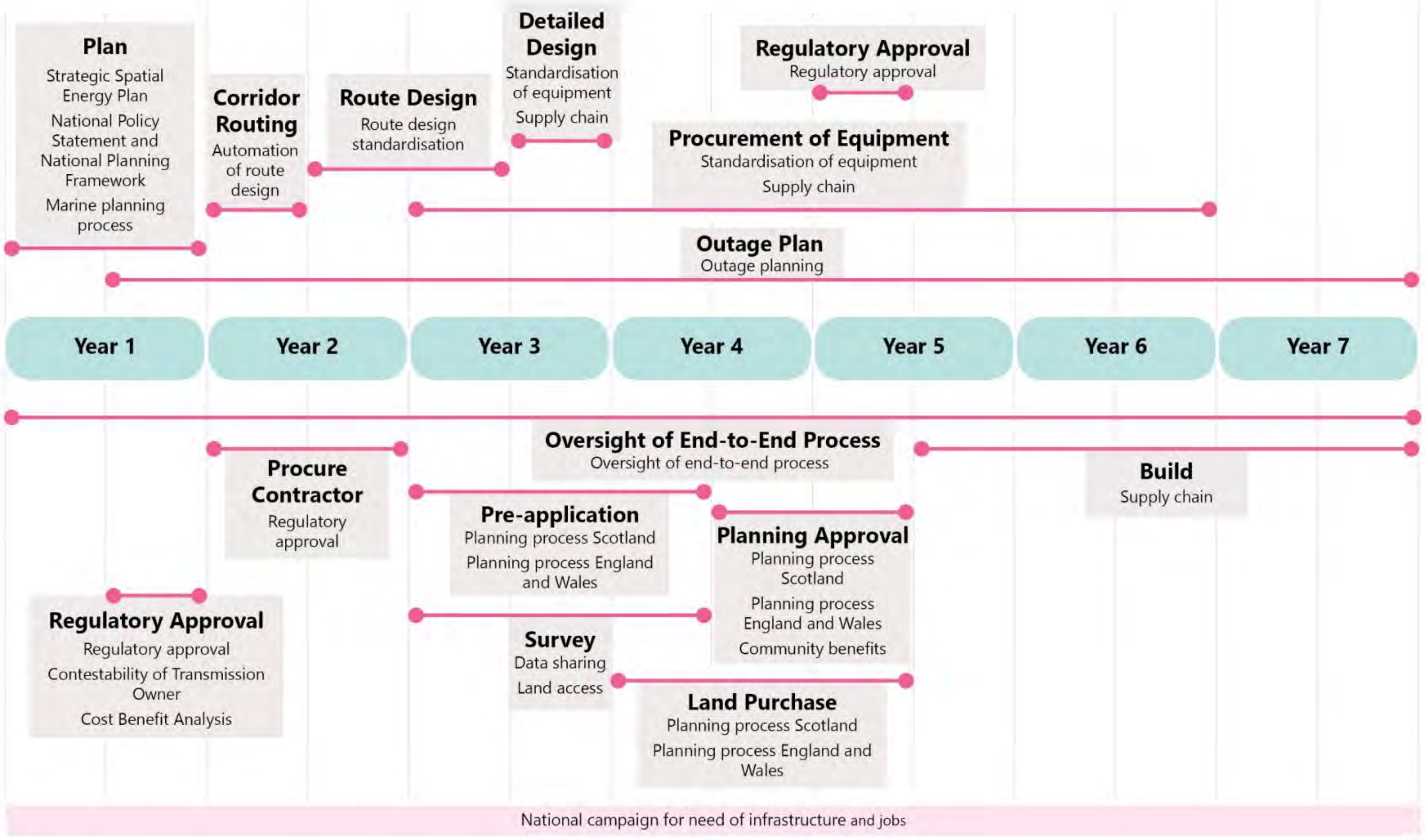

Figure 4.6 New seven-year process map and recommendations required.

Figure 4.6 maps at a high level, the scope of influence of each recommendation group to an activity in the process. For the process to be reduced to seven years, the full set of recommendations would need to be implemented. The implementation mechanisms and relationships between recommendations are further described in Section 5.

In the first-year certainty of need will be established early in the process through elements such as a Strategic Spatial Energy Plan (SSEP), National Policy Statements (NPS) and the National Planning Framework (NPF). This will allow for appropriate resourcing of design and appointment of contractors in the second year. TOs will also benefit from certainty arising from recommended changes in regulatory process and contestability. This certainty will also allow for earlier consideration and actioning in the outage planning process, thereby avoiding potential delays or conflicts in outages when they are required at the building stage.

The corridor routing stage has been optimised to six months; this is possible through use of meaningful automation while maintaining assurance of outputs through efficient involvement of technical experts. The route design process will be streamlined through standardisation which also facilitates and supports engagement with communities. Elements of the design will have been defined early and will be highly standardised. By the end of the second year, the supply chain can be engaged, and manufacturing slots can be booked in advance, reducing pressure in the procurement process. Given that the appropriate contractor has been procured, detailed designs can be finalised by the end of the third year.

Simultaneously, a streamlined pre-application process can occur informed by surveys available through simplified land access and data sharing mechanisms. Additional certainty, maximised standardisation, meaningful community engagement and national awareness will help expedite the planning approval process.

In this new process it is expected that approvals and land purchases will have been achieved mid-way through the fifth year allowing for an earlier build start and delivery within seven years.

5. Recommendations

Recommendations have been developed that are focussed on being realistic and ambitious. They are structured in groups based on the themes summarised in Section 4.2 and on issues identified within the themes. They reflect the insights gained through stakeholder contributions and challenge.

The recommendations are offered as a package. This reflects the interconnectedness between them needed to respond to the dependencies between the issues and the complexity of the challenge.

The recommendations are described and supported with commentary of how they could be implemented. Where possible, estimates of timeframes for implementation and cost implications have been included.

5.1 Strategic Spatial Energy Plan

Challenge:

ESO's Electricity Ten Year Statement (ETYS) provides a view of future electricity transmission system requirements and capability for the next ten years. Its Network Options Assessment (NOA) provides recommendations for which network reinforcement projects should go ahead and when. Both reports are published annually and recommendations for reinforcements are assessed and can be changed from, "proceed with reinforcement" to "hold". Such changes can delay projects starting and gaining a proceed signal from the regulatory approval process (i.e., Ofgem).

ESO's Holistic Network Design (HND) introduced a new way of planning the transmission network reinforcements required to meet the Government target of 50GW of offshore wind by 2030. A difference in this plan compared to the ETYS and NOA is that the recommendation for the need for each project will not be revisited in subsequent refreshes and updates. This has given TOs certainty on the need for each project.

The HND, along with the NOA 2021/22 Refresh, form the first transitional Centralised Strategic Network Plan (CSNP). The objective of the future CSNP is to plan holistically, onshore, offshore and across vectors. The second transitional CSNP will be the Holistic Network Design – Follow Up Exercise (HND-FUE) which is due to be published in 2023.

The challenge which underlies the planning process is creating sufficient certainty of need to enable progress at increased pace.

Recommendations:

SS1: A Strategic Spatial Energy Plan (SSEP) should be developed to bridge the gap between Government policy and Network Development Plans; the SSEP should be refreshed regularly. Government targets across the whole energy system would be spatially mapped across GB and over a time period of several years. For example, green hydrogen production targets would be translated into volumes in specific locations. This plan would create an overarching reference for many energy network plans such as the Centralised

Strategic Network Plan (CSNP), a hydrogen network plan, a Carbon Capture Utilisation and Storage (CCUS) plan and Regional Energy Plans (REP).

The process for preparing the SSEP should consider all options for achieving required outcomes. This should include, amongst others:

the role of well-functioning flexibility markets that would help shape demand and thereby potentially reduce or delay the need for transmission reinforcement; this acknowledges the need to align with the interactions with Distribution Network Operators (DNOs) necessary to do this.

the use of technologies such as grid-forming technologies or dynamic line rating (DLR) to increase capacity of existing transmission lines.

deployment of storage to delay or avoid the need to build networks.

application of digitalisation including Artificial Intelligence (AI) to enhance operations.

These interventions might facilitate quicker connection of low carbon generation.

SS2: A Marine Environmental Assessment (MEA) and offshore delivery routemap should be included as part of the Strategic Spatial Energy Plan (SSEP). Coordination and cooperation would be required between the FSO, Governments, The Crown Estate (TCE) and Crown Estate Scotland (CES) to support identifying seabed where offshore generation can be located along with required connection and transmission infrastructure. Preparation of the routemap would be led by TCE. It would coordinate the development of electricity, gas, hydrogen and CO2 networks and other infrastructure to facilitate Net Zero.

SS3: Two Centralised Strategic Network Plans (CSNP) should be developed from the Strategic Spatial Energy Plan (SSEP) by the Future System Operator (FSO) – a shorter-term plan and a longer-term plan. The shorter-term plan should cover a ten-year period and be refreshed on a yearly basis. While recommendations suggested within this report are being implemented to achieve a seven-year end-to-end process, a shorter-term CSNP with a timeframe longer than ten years may be required to ensure all projects are identified in time to be delivered. The longer-term plan should cover a minimum of twenty-five years and be refreshed every five years. In the near-term there may be a need to refresh the plan more regularly due to changes in Government policy, learning gained through moving to new processes and as the pace of decarbonisation increases.

The CSNP should consider the role that other measures including well-functioning flexibility markets (and noted in Recommendation SS1) could play in delivering required outcomes.

SS4: Projects identified in the shorter-term Centralised Strategic Network Plan (CSNP) should become the baseline and the need for them should not be revisited in the next shorter-term CSNP. A Strategic Environmental Assessment (SEA), for onshore projects, and a Marine Environmental Assessment (MEA) (see Recommendation ME1: Marine Planning Process) for offshore projects, should be used as part of CSNP assessment. The inclusion of the environmental assessments can support endorsement of the CSNP by Ofgem and by Governments in the National Policy Statements (NPS) and National Planning Framework

(NPF) and remove the need for the Transmission Owners (TOs) to develop a needs case as part of the regulatory approval process.

SS5: The longer-term Centralised Strategic Network Plan (CSNP) should be used to support Transmission Owner (TO) engagement with the supply chain and evidence the scale of investment required over a longer time period. If lead times for some equipment e.g., cables, continue to increase, consideration should be given to how this longer-term plan can be used to bulk purchase equipment ahead of need identification in the shorter-term plan.

SS6: The longer-term and shorter-term Centralised Strategic Network Plans (CSNPs) are to be used to support long-term resource planning for all parties (e.g., Transmission Owners (TOs) and statutory consultees) within the end-to-end process. Each party in the end-to-end process should identify the skills and resources required to support delivery of the longer-term and shorter-term plans. Each party should work with the Department for Education (DfE) to identify training courses and university places needed to meet the skills and resources required. This activity should extend beyond identifying course numbers, it should include activities to attract people to these courses, from school years through to retraining of experienced workers.

Implementation:

SS1: The FSO would produce the SSEP working in close collaboration with the Department for Energy Security and Net Zero (DESNZ) and with the benefit of a flow of policy information that will come from DESNZ. The FSO will require additional resource to prepare the SSEP. Where policy gaps exist, or decisions need to be made that will influence the SSEP, these will be highlighted back to DESNZ for action. Consideration should be given to how uncertainties around the plan can support Government decision making. The cost of producing and managing the plan will include amongst other considerations, the costs of people, tools, stakeholder engagement activities and acquiring access to services from expert bodies. These costs will be offset by the benefits of increased certainty that will arise from the plan and the reduction in time to deliver new transmission infrastructure.

The cost of this activity could be expected to be of the order of a few millions of pounds per annum for the FSO, with some additional initial costs to establish the capabilities and their operation.

SS2: There would be a cost associated with carrying out an MEA, refreshing it as needed and integrating it with the SSEP. TCE has completed an environmental survey as part of the Celtic Sea leasing round which may provide a helpful reference on effort and cost. The cost of carrying out surveys is expected to be offset by the benefits arising from improving the quality of the CSNP and facilitating the plan being endorsed in the NPS and NPF (see Recommendation NP2: National Policy Statements and National Policy Framework). This endorsement is expected to support reducing the delivery time of projects by creating certainty and helping to gain early alignment of generation (and other interests) with network build activity.

The coordination of FSO, Governments, TCE and CES will require resource in the short-term to understand where suitable areas are located for offshore wind and transmission infrastructure and how it can be coordinated with other offshore infrastructure required for Net Zero. It is expected that this increase of resources at the planning stage will be offset by an improved CSNP, more robust project proposals and reduced examination time for licensing. This arises by reducing the number of factors being considered during the planning stage. Recommendation ME1: Marine Planning Process supports this recommendation.

SS3: The development of the CSNP is currently being progressed by Electricity System Operator (ESO) and the first outputs are expected in 2025. It is expected additional resources would be required by the FSO, when it comes into operation, to create and manage two plans, including their periodic refresh. It may also be necessary to develop or acquire new toolsets and to gain access to expert parties to provide specialised input. These costs would be expected to lead to benefits, including savings realised by improved foresight to support business planning, facilitation of coordination of the parties, faster and more certain decision making, which should be reflected in reduction of the time taken to deliver new infrastructure.

SS4: Projects identified in the HND will not have their needs case revisited within the next iteration of the CSNP. As this method has been established and exercised in the HND it should be carried into subsequent versions of the CSNP. The benefit of doing this will be to provide certainty on projects and support engagement with the supply chain. Ofgem providing strategic oversight of the CSNP process will help remove the initial needs case from the regulatory approval process (see Recommendation RA1: Regulatory Approval). This will remove the initial needs case activity from the TO and Ofgem and create a time saving of around six months.

For the CSNP to be endorsed by Ministers under a revised NPS and NPF, environmental assessments will need to form part of the CSNP. An SEA would take several months to complete and needs to be updated regularly to feed into the annually refreshed, shorter-term CSNP. Consultations to update the NPS and NPF would need to happen which would take around nine months. The first CSNP is due to be published in 2025, providing sufficient time to carry out environmental assessments and update the NPS and NPF. Recommendations NP1 and NP2: National Policy Statements and National Planning Framework support this recommendation. Carrying out environmental assessments both onshore and offshore at the planning stage will incur a cost, both initially and in support of the refresh and update of the plans. It is expected this cost would be offset by the cost savings arising from the reduction in time for delivering new infrastructure. Other significant benefits will also arise in terms of certainty for supply chain development for example.

SS5: The TOs are actively engaging with the supply chain today. A longer-term plan will support this engagement and show the long-term needs for GB. Engagement on a programme of projects over a longer timeframe will support the supply chain with investing in additional capacity as they will be able to see a long-term order book. This recommendation supports Recommendation SC1: Supply Chain. This recommendation interacts with Recommendation CT1: Contestability of Transmission Owner as forming long-term relationships with the supply chain becomes increasing important to deliver needed outcomes such as easing constraints.

SS6: The availability of a longer-term plan will give the TO greater insight into the volume of work required in the future and will support near-term resource planning, training and recruitment. These are activities that should take place in all organisations involved in the end-to-end process. Information will need to be given to the DfE to support setting the right number of training and university places. Where new skills are required, organisations should work with the DfE and training providers to develop new courses. Consideration is required in the geographical location of training opportunities as this can support community acceptance of new infrastructure. There will be opportunities for organisations to expand their own training provisions alongside national initiatives, (e.g., TOs increasing the number of apprenticeships they offer covering new skills).

The cost of additional resources for all parties will be covered in different ways. The TOs will be able to use this information to understand the impact on future price control periods and agree with Ofgem the level of funding required. The TOs will also be able to understand the resourcing required by statutory consultees and funding that may be required to fund these parties to support planning applications. For Government bodies additional funding may be required from central or devolved Governments.

5.2 Route Design Standardisation

Challenge:

The design of new infrastructure and the visual amenity mitigations used within the transmission network design, can draw on different approaches and technologies; for example, different tower designs, use of indoor or outdoor substations and use overhead line (OHL) or underground cable. Rules and guidance set out in the National Policy Statements (NPS) and National Planning Framework (NPF) and the Holford rules[18] can be open to interpretation by different parties. This can lead to differences arising in regulatory and planning approvals and the requirement for multiple route designs to be considered.

Community engagement is an important part of the planning approval process. There is a strong relationship between route design and visual mitigations and community acceptance. Transmission Owners (TOs), Ofgem, planning approval authorities or communities may not be clear on which parts of route design can change and what visual mitigations can be included to gain community acceptance. This can increase the time to engage with communities and gain planning approval. Ofgem can also disagree with measures taken to gain community acceptance leading to the TOs being required to redesign the route and apply for planning approval again or pay the difference in cost themselves. The has led to an increase in time taken in pre-application stage to try and avoid this situation.

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[18] The Holford Rules are guidelines used for the siting of new overhead line transmission lines. https://www.nationalgrid.com/sites/default/files/documents/13795-The%20Holford%20Rules.pdf

Recommendations:

RD1: Electricity Transmission Design Principles (ETDP) should be created to provide greater clarity on the type of asset to be used in different environments. These Principles should be endorsed by Ofgem and Ministers and referenced in the National Policy Statements (NPS) and National Planning Framework (NPF). Guidance around the use of visual mitigations should be enhanced, clearly setting out when undergrounding and offshore routes are, or are not, appropriate. Guidance should include other visual mitigations such as the use of indoor and outdoor substations.

The environmental impact of different assets should be considered as part of the principles and guidance and should look to minimise the overall environmental impact. This would presume that overhead line (OHL) would be used for most of a route unless the criteria for visual mitigations were reached (e.g., undergrounding for areas of outstanding natural beauty).

The use of these principles (and related standards) would remove the need to create multiple route designs for the regulatory and planning approval processes, saving time and effort for the Transmission Owner (TOs), Ofgem, Planning Inspectorate (PINS) and Scottish Government. Standardising route design will support balancing national and local needs and concerns. This will be achieved by agreeing, outside of the end-to-end process, what design features are acceptable for local visual mitigation.

RD2: Engagement with communities hosting transmission infrastructure should be focused on the choices that they can influence. Communities should be given choices around the infrastructure they host where possible, within the design principles and guidelines set out within Recommendation RD1: Route Design Standardisation. For example, communities could be given choices around tower design or precise route design.

Clarity is required within the planning approval process on the weighting that should be given to community feedback and concerns. The Transmission Owner (TO) must make a prompt decision after consultation with communities to ensure the process is not delayed. If a local community objects to hosting the infrastructure or asks for further visual mitigations (e.g., undergrounding or offshoring), Planning Inspectorate (PINS) for England and Wales or the Scottish Government for Scotland, must make a decision on the trade-off between local and national interests.

Implementation:

RD1 & RD2: Updating the principles and guidance on route design will require a working group to be set up. This should be led by the Future System Operator (FSO) and include the TOs, Ofgem and Governments. Ofgem's involvement within the working group would be as an observer as they will need to endorse the design principles once created. A public consultation is likely to be required to ensure the views of local communities and interested parties are fully considered as part of the final principles and guidance. This is likely to take around two years, one year for the working group to update the existing Holford rules and guidance and a further year for consultation and any required further update.

A process for updating the ETDP will need to be implemented which could be led by the FSO. This will ensure that the design principles remain up to date and as community views and environmental impacts change, the principles can change with them. Flexibility of design will need to remain within the principles to support designing for the specific local environments as it may not be possible to account for all place-relevant factors.

Inclusion and endorsement of the design principles and guidance within the NPS and NPF will need to happen after the design principles have been prepared which means more time will be taken before they can be used within the planning approval process. Updating the NPS and NPF is set out in Recommendation NP1: National Policy Statements and National Planning Framework. Depending on the timing of updates to the NPS and NPF, endorsement of design standards could be included in a regular update. This endorsement will support reducing the pre-planning application stage of the process from eight years currently to two and a half years in the future. This is achieved by reducing the number of route design options considered and greater clarity on acceptable route design for planning approval. This will support Recommendations SP1 and SP2: Planning Process – Scotland and Recommendation EWP1: Planning Process – England and Wales.

Ofgem’s endorsement of the design principles will be enacted as part of the regulatory framework update set out in Recommendation RA1: Regulatory Approval. This endorsement will contribute to the reduction of the pre-planning application stage, from eight years currently to two and a half. This recommendation would contribute to that by reducing the number of route design options considered and providing greater clarity on acceptable route design for regulatory approval.

This recommendation will need to be implemented to support Recommendation AR2: Automation of Route Design. Agreeing the design standards up front will support automating how the route is designed. Agreement of design principles will save time from the design, pre-application and planning approval processes by removing the need to design all elements of a route for each project. The time saved from automation and making design choices for the majority of the route, will allow more time to focus on local considerations and choices ensuring the route design choices minimise local environmental and visual impacts.

5.3 Standardisation of Equipment

Challenge:

The equipment required to build new or reinforce existing infrastructure must meet a strict set of standards. The standards used within GB are often different to those used across Europe and the rest of the world. This can lead to equipment manufacturers needing to meet GB specific requirements (e.g., the tower design used within GB compared to other European countries). The adoption of innovative solutions can be limited by the standards applied within GB (e.g., a tower design using less steel could be used across Europe but does not meet GB standards).

The equipment standards across the three Transmission Owners (TOs) in GB are not always the same. This can make the GB market even more challenging for equipment manufacturers, as bespoke solutions can be required for different TOs, for the same type of equipment. There is an opportunity with new infrastructure build to introduce new, harmonised equipment standards.

The specification for an asset (e.g., a cable) is often not defined until the detailed planning stage. With the current lead times for the supply chain this can lead to delay in having equipment ready to start construction.

The challenge is to agree a level of standardisation that allows solutions to be built that accommodate genuine differences in requirements, but wherever possible provides access to the benefits of consistency within GB and with other markets. These potential benefits include speed of supply, diversity of supply, lower cost through economies of scale, and introduction of innovation, amongst others.

Recommendations:

SE1: A forum should be created between the Future System Operator (FSO), Transmission Owners (TOs), equipment manufacturers and Ofgem to review and update equipment standards used within GB. Its main aims would be to

Standardise where possible equipment specification across TOs.

Standardise equipment ratings to be used within project design (e.g., circuit breaker rating) to support moving away from bespoke ratings.

Engage with and apply international standards where appropriate and beneficial.

Seek and facilitate innovation that would be enabled by standardisation.

SE2: A process should be created to support and enable the work of this forum. This process should include a mechanism for Grid Code modifications to enable the update of equipment standards if required.

Implementation:

SE1 & SE2: Setting up a forum will require resources from the TOs, Ofgem and the FSO. This forum could be led by the FSO. Open engagement with the supply chain will be required, so as not to favour particular manufacturers, or larger manufacturers – Ofgem should oversee this to ensure competition is not adversely impacted. Ofgem’s endorsement of the standards will be required to support regulatory approval and should form part of Recommendation RA1: Regulatory Approval.

The TOs own their equipment standards and they must adhere to codes and standards when creating them. It is possible to make changes to equipment standards but when considering innovative solutions, they may not meet Grid Code requirements. This means updating equipment standards may require modifications to the Grid Code. Designing a process to update the Grid Code as required will be an essential enabler to updating equipment standards, utilising international standards and deploying innovative solutions within GB.

The use of standard equipment should be endorsed through planning policies as there may be an impact on the amount of land required, access conditions or the environment. For example, a different tower design may have a slightly larger footprint.

The forum should look for early opportunities to standardise; however, this recommendation may take several years to implement. A forum will need to be created and standards updated before being applied to a project. Due to the lead times involved in the supply chain implementing these new standards, it is unlikely to support projects required for 2030 but could start to support projects delivering shortly after. Implementing a process for updating equipment standards and Grid Code should happen as matter of urgency as it will support increasing the number of manufacturers that could be used within the supply chain.

This recommendation combined with Recommendation RD1: Route Design Standardisation and Recommendation AR2: Automation of Route Design will help reducing the pre-application stage of the process. This recommendation will support the supply chain and development of long-term relationships, as discussed in Recommendation SC1: Supply Chain.

Developing, agreeing and maintaining these standards will require resources across all parties. This may be an increase of those already deployed in these organisations. There are likely to be testing and validation needs that will be in addition to those already used. Some of testing facilities may need to be built; others may be accessed through contract or other arrangements.

The cost of this effort will be offset by the benefits arising from improvement in the end-to-end process. This is due to having access to a more diverse supply chain (if there is alignment with other countries/markets) and moving projects from bespoke designs to standard ones. Using standards that are established in other markets will provide access to a wider pool of expertise, knowledge and experience that can be deployed in GB. This will support increasing the number contractors who are able to work in GB. Further benefits will arise in operations and ongoing evolution of networks assuming that standardisation will lead (over time) to more consistent operating and design practices.

5.4 Automation of Route Design

Challenge:

The identification of corridor routes during the design stage can take time and resource as multiple options need to be investigated and many data sources interpreted to find the most suitable corridor routes. Tools that can automate this process have started to be used by Transmission Owner (TOs) in the design process.

Following identification of the corridor route, the route design can start. This is where the exact route within the corridor is identified, and the type of asset used is decided (e.g., overhead line (OHL), cable). Redesign of the route can be required based on the results of community and statutory consultee engagement and environmental surveys which happen during the pre-application stage, thereby adding time and cost to projects.

Recommendations:

AR1: An automated corridor routing process should be adopted as standard practice. This will allow more corridor routing options to be considered than is possible without automation. A landscape architect would oversee the automated process and use the output to make a final decision on the corridor route. Regulatory and Planning approval processes will need to recognise and accept the use of this approach and supporting tools.

AR2: A route design process that uses the Electricity Transmission Design Principles (ETDP) should be adopted. A new tool should be developed that supports this process by supporting design of the location within the corridor route and selection of the type of asset (e.g., overhead line, tower, cable etc) that should be used. A design engineer would oversee the automated process and use the output to make a final decision on the proposed route design. Regulatory and Planning approval processes will need to recognise and accept the use of this approach and supporting tools.

Implementation:

AR1: Tools to automate corridor routing are currently being used by the TOs to support existing methods. The quality of the input data into the corridor routing tool is extremely important and the use of publicly available data will support replicability of the results. There may be shortfalls in data availability or quality which should be addressed as part of adopting automation as standard practice. Recognition of the use of automation would be required in planning approval process, the Development Consent Order (DCO)[19] for England and Wales and Energy Consents[20] for Scotland, to ensure its use is acceptable during the planning approval stage.

AR2: To adopt automation of route design, the standardisation of route design (see Recommendation RD1: Route Design Standardisation) will need to be accepted and the ETDP will need to be created. During this time investment and development of a new tool capable of automating the route design process will need to happen. When the tool has been developed and the ETDP are available, a period of time will be required to include the design principles within the tool. The cost of developing a new tool is expected to be offset by the reduced time and resources required to carry out route design and from reducing the time needed within the end-to-end process. The planning approval processes will need to recognise the use of this tool, as described above in Recommendation AR1 implementation. This recognition is important as a single route design would be created, based on considering many options through the automated process, where today multiple route designs can be requested.

This recommendation would take longer to implement due to its dependence on the standardisation of route design and the need to develop a new technology solution. Early recognition by planning policies and Ofgem for the use of automation to create a single

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[19] https://infrastructure.planninginspectorate.gov.uk/application-process/the-process/

[20] https://www.gov.scot/policies/energy-infrastructure/energy-consents/

route design, would support early investment in developing the technology. Additional funding through the regulatory framework may be required to start this investment.

This recommendation along with standardisation of route design and equipment are required to reduce the pre-application planning stage from the approximately eight years at present, to two and a half years.

5.5 Regulatory Approval

Challenge:

The regulatory approval process is important for both Transmission Owners (TOs) and consumers. It protects consumers from excessive costs and gives TOs clarity on the certainty of their returns. Regulatory approval is given after planning approval has been granted with the review period taking up to six months. If Ofgem objects to a route design or visual mitigations, then the TO may not receive what it deems to be a sufficient return on all of its investment, or it will need to redesign some elements of the route and re-apply for planning approval, adding time to the process.

The regulatory approval process is aligned with the nature of the development of the energy system. Currently this is focussed on achieving the best possible outcomes by ensuring that assets are used effectively and efficiently; these outcomes are measured in terms of delivering services at lowest cost. As the energy system – including the transmission grid – is transformed in support of decarbonisation objectives, a new perspective will be required. This new perspective will look more to system optimisation rather than asset utilisation and account for the more decentralised, distributed architecture of the system This will be supportive of the need to build infrastructure, a need that is being strongly signalled by issues such as the connections queue and escalating constraint costs. Outcomes will still be centred on consumers and lowest cost, but these may also address the mooted Net Zero mandate.

Recommendations:

RA1: Regulatory approval process should be removed from the critical path within the end-to-end process. To achieve this, reformulating the regulatory approval process in the following way would enable this to be achieved:

> The Centralised Strategic Network Plan (CSNP) should be endorsed by Ofgem and become the initial needs case for the programme of projects. Further regulatory approval should then not be required to justify project need. This is supported by Recommendation SS2: Strategic Spatial Energy Plan.
>
> The Electricity Transmission Design Principles (ETDP) should be endorsed by Ofgem. Regulatory approval would refer to these principles when assessing the route design and visual mitigations required. This is supported by Recommendation RD1: Route Design Standardisation.
>
> The use of standardised equipment (rather than bespoke equipment) should be considered when assessing cost and deliverability of projects. This is supported by Recommendation SE1: Standardisation of Equipment.

The contestability of projects should be decided during the planning process to ensure the delivery body is identified when the CSNP is published. This is discussed in Recommendation CT1: Contestability of Transmission Owner.

Cost benefit analyses carried out as part of Strategic Spatial Energy Plan (SSEP), CSNP and across the project lifecycle should consider whole project costs and benefits to consumers. This should include constraint costs, carbon and other benefits such as access to renewable generation. This is supported by Recommendation CBA1: Cost Benefit Analysis.

Project costs should not be fixed at the beginning of the process due to supply chain constraints and variability on price of equipment. Flexibility and transparency should be built into the regulatory process to update project costs if required. Open book financial management could be considered.

The community benefits payment system should be endorsed by Ofgem so that their cost can be reflected in the project cost, reducing the need to further justify them. This is supported by Recommendations: CB1 and CB2: Community Benefits.

The current consultation[21] to update the regulatory framework ahead of the next regulatory period should consider how best to measure efficiency of spend from the Transmission Owner (TO) and how the mechanism for cost recovery for the TO operates.

The delivery incentives placed upon the TOs as part of Accelerating Strategic Transmission Investment (ASTI) are strengthened and expanded to include all of the TOs' involvement in the end-to-end process and are applied to all projects identified by the strategic plan.

RA2: Ofgem should be given Net Zero objectives to support the delivery of electricity networks to meet UK Government targets as provided within the Energy Bill currently in process[22]. The objective of being an economic regulator is retained and expanded to include wider societal benefits (e.g., access to cheaper renewable generation)

These recommendations are intended to create a trusting and transparent relationship between Ofgem and the Transmission Owner (TOs). They are also intended to support the TO with engaging with the supply chain early, making complex decisions at pace and accelerating the delivery of new infrastructure required.

Implementation:

RA1: Ofgem is currently consulting on different regulatory approaches that could be used during the next regulatory period[23]. The recommendations offered in this report could inform the consultation and its findings and help shape the next regulatory framework.

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[21] https://www.ofgem.gov.uk/publications/consultation-frameworks-future-systems-and-network-regulation-enabling-energy-system-future

[22] https://publications.parliament.uk/pa/bills/cbill/58-03/0295/220295.pdf

[23] https://www.ofgem.gov.uk/publications/consultation-frameworks-future-systems-and-network-regulation-enabling-energy-system-future

Change in the regulatory approval process is likely to comprise many changes implemented over a period of time as a coherent programme which responds to identified priorities. Care should be taken to understand, and where necessary act, on any implications for projects. Efforts should seek to minimise any delay to projects. Specific measures should be implemented to ensure that this period of change is well-structured and well-managed.

Taking regulatory approval off the critical path is expected to save around six months by removing the initial needs case and save a further six months by removing the final needs case. Endorsement of standard route design and equipment will support the time reduction expected from these recommendations in the pre-application stage. Changing the regulatory framework will support TOs in engaging and contracting with the supply chain earlier in the process and bringing forward activities such as detailed design.

RA2: Expanding Ofgem's objectives will require primary legislation. The inclusion of a Net Zero remit is understood to be included in the Energy Bill currently passing through Parliament and therefore further action may not be required if it reaches Royal Assent.

A change to the regulatory framework is expected for the next electricity transmission regulatory period, starting in 2026. There would be a risk to changing the regulatory framework for projects which are currently in flight, so careful consideration would be required. The ASTI arrangement has been introduced for 2030 projects identified in the Holistic Network Design (HND). A similar arrangement will be required for projects identified in the Holistic Network Design – Follow Up Exercise (HND-FUE), which follows the HND and is due to be published in 2023. It is recommended that the framework is implemented before 2026 and in time for the publication of the first SSEP and CSNP. The framework should be designed to address Net Zero objectives, support the TO in decision making, facilitate progress at pace and deliver the infrastructure required. The framework should enable Ofgem to play a strategic role and monitor the efficiency of the TOs to protect consumers interests.

5.6 Contestability of Transmission Owner

Challenge:

Competition to deliver and own onshore transmission network is being introduced by Ofgem, to protect consumer interests and reduce costs. Historically, critical national transmission infrastructure projects have not been contested giving the Transmission Owner (TO) certainty on the pipeline of projects they will be expected to deliver. New powers are being introduced by Government through the current Energy Bill to enable contestability of onshore transmission projects. Recently, exemption from contestability has been given through the Accelerating Strategic Transmission Investment (ASTI) initiative, with the Ofgem decision to do so taking around six months.

As efforts towards Net Zero accelerate, GB is increasingly required to compete with the rest of the world for equipment, skills and resources. In order to meet GB targets there is a need to engage with the supply chain and carry out long term resource planning. The party responsible for acquiring needed resources will need certainty on the projects that it is to deliver.

Recommendations:

CT1: Onshore network contestability should be delivered in phases, when certain criteria have been met, (i.e., contestability should not be introduced to all projects at the same time). This is intended to support contestability of some projects in the first instance and suspend contestability of others until a set criterion is reached. Once reached, the next phase of projects will have contestability introduced to them. The criteria for contestability should be strictly designed and absolutely adhered to, to prevent the delay of critical national infrastructure required to meet Net Zero targets.

The biggest risk currently is the supply chain and the increasing global competition to secure manufacturing capacity for transmission equipment (e.g., cables). Long term visibility of projects and certainty for Transmission Owners (TOs) is required to secure manufacturing slots and acquire people and skills. Early engagement with the supply chain is required for the detailed design of most projects. The criteria for introducing contestability should include the constraint with the supply chain and the lead time for equipment.

It is recommended that the first phase (or group of projects) contestability is considered for, are offshore projects. This means that projects physically located offshore should be contested as part of the first phase while contestability of projects physically located onshore are not contested. Offshore projects have been identified for contestability due to there being multiple offshore transmission owners (OFTO) and opportunity to develop a new integrated offshore network.

For current offshore projects identified in Holistic Network Design (HND), Ofgem should urgently decide which projects could be contested and identify the delivery body. In the meantime, TOs should be strongly supported (e.g., pre-construction funding provided to progress route design) by Ofgem to progress the early development and feasibility activity.

A second phase of introducing contestability would be onshore projects that have a long lead time before they are required, to allow engagement with the supply chain. Consideration should be given to several projects being bundled together to allow a new entrant to engage and order at scale with the supply chain.

This phased approach means that the incumbent TOs would be responsible for delivering onshore reinforcements until contestability has been established and supply chain constraints, including equipment lead times and skills, have eased. Phasing contestability for onshore projects will support the TOs in engaging with the supply chain and securing resources and manufacturing slots.

With the ambition to halve the time it takes to build new infrastructure, any decisions on contestability should not add any time into the process. Decisions on contestability should be made at the same time as the strategic plan is created.

Implementation:

CT1: The criteria for contestability will be set by Government but Ofgem will have flexibility in how it is applied. As part of the ASTI framework some of the offshore reinforcements can still be contested; currently incumbent TOs are developing them. Engagement with the supply chain and detailed design of the solution will require the TO to be identified. These projects could be subject to contestability if it does not impact the delivery date. Ofgem should urgently identify the delivery body for these if there may be supply chain constraints. Further projects are expected to be identified in the Holistic Network Design – Follow Up Exercise (HND-FUE) which will be published in 2023. New offshore projects identified here could be subject to contestability. The competition process could be run by the Future System Operator (FSO).

It is expected time will be saved from the process by phasing contestability so that the incumbent TOs know what is expected to be delivered as the strategic plan is published. Time will be saved by Ofgem not needing to decide if projects should be exempt from competition and by avoiding delays with supply ordering equipment and resources.

5.7 Cost Benefit Analysis

Challenge:

At multiple points across the end-to-end process cost benefit analysis (CBA) of each project is undertaken. During the planning stage there is an option assessment; during regulatory approval there is a cost assessment; during outage planning there is a planning and impact assessment. Different methodologies are used for CBA analysis at different stages in the project lifecycle. In the planning and regulatory stages, the main aim is to consider the capital cost of the project. In delivery and outage planning stages the main aim is to understand constraint cost.

The main driver for CBA analysis is to protect consumers from paying too much for infrastructure and system balancing costs. As we move into a period of significant infrastructure build, quick delivery will provide benefit to consumers by enabling access more low carbon generation, reducing carbon and lowering constraint costs. The narrow criteria currently used within CBA analysis may not reflect whole project costs or wider economic and societal benefits from meeting Net Zero targets.

Recommendations:

CBA1: All cost benefit analyses (CBA) that are carried out across the end-to-end process should be reviewed and updated to reflect whole project costs and wider societal benefits (e.g., constraint and carbon costs) where possible. This will create a more holistic view of the costs and benefits of projects to facilitate decision making. For example, an offline network build option may have a higher delivery cost but reduce constraint costs due to a shorter outage requirement. The CBA would show the higher delivery cost is offset by a lower constraint cost and provide net benefits from delivering sooner and connecting low carbon generation.

Implementation:

CBA1: Updating the CBAs should be led by the owner of the CBA and endorsed by Ofgem. If a CBA sits across multiple parties, or multiple parties carry out the same CBA, then a working group should be formed, led by the Future System Operator (FSO), to agree the update to the analysis. Ofgem should oversee the programme of updating CBAs and input the societal benefits that should be included as part of their Net Zero remit (see Recommendation RA2: Regulatory Approval).

Updating CBA methodologies and associated tools is likely to take time, anticipated to be less than a year, depending on how many new factors are included and how complex the CBA becomes. There will be a reliance on data availability and the process for development of new or enhanced methodologies and potentially updates to or new CBA tools. The cost of updating CBAs would be offset by improved decision making by understanding whole project costs rather than trying to optimise individual elements.

Updating CBAs later in the process will potentially help projects already in flight, (e.g., costing the delivery plan and making decisions on outages); this is supported by Recommendation OP3: Outage Planning. Consideration should be given to making a series of incremental improvements rather than a single big change. This will support projects in flight and allow different methods to be tested before reaching an enduring solution. Careful implementation is required to ensure there is no detrimental impact on projects in progress. For example, a project that has created a delivery plan based on optimising delivery costs should not have a CBA applied to it that includes outage costs. This could lead to the delivery plan no longer being optimal for delivery and outage costs; redesigning the delivery plan to reduce outage costs may delay the project. The needs case for any project in progress should not be excluded from any updated CBA methodology.

The Centralised Strategic Network Plan (CSNP) is currently being developed by the Electricity System Operator (ESO). This is an opportunity to expand the CBA process used when identifying new projects. Understanding wider societal benefits at this stage will support decision making around the speed of delivery required. The update of this CBA will support projects delivering 2035 and later.

Updating CBAs will need to be endorsed and agreed by Ofgem, so they are recognised within the regulatory approval process (see Recommendation RA1: Regulatory Approval). Updating CBAs may require endorsement from planning approval policies as they may drive different requirements for route design and delivery.

The creation of an approved CBA methodology and its review will likely require a new team within the FSO. This cost can be estimated at over £10m for the first year, and in the £millions for the subsequent years.

The longer term societal, environmental, and economic benefits identified as part of the CBA will help counter these additional costs.

5.8 Planning Process - Scotland

Challenge:

The decisions on planning consent are devolved to Scottish authorities and Scottish Ministers, but the legislative framework for those decisions is a reserved matter, set out in UK legislation - the Electricity Act 1989. The process is viewed as having become outdated, being not well defined and causing delays to obtaining planning approval for critical national infrastructure. Within the process, there is a lack of clarity on expectations for applications and timeframes for responding to consultation. Updates to the Electricity Act 1989 are carried out by UK Government.

Public local inquiries are often triggered by planning authorities, leading to delays in obtaining planning approval for infrastructure projects. Within the public inquiry a wide range of issues can be examined which can extended beyond the objection to planning consent. Time, resource and expertise are required by all parties.

Recommendations:

SP1: The automatic requirement for a public local inquiry when the planning authority objects should be removed. An alternative process should be introduced that would allow Scottish Ministers to hear more about a specific issue raised by statutory consultees as an alternative to a public inquiry. For example, if a planning authority objected to a project based on visual impact alone, then a hearing could be called by the Minster to investigate this issue. This would provide a quicker alternative to consider specific issues. A public inquiry can still be called by the Minister, based on responses by all statutory consultees. This amendment to the Electricity Act 1989 should be progressed as a matter of urgency in the current Energy Bill passing through Parliament if further amendments to the bill are possible. This is required to support 2030 projects.

SP2: Further improvements should be made to the planning process to reduce the time taken to obtain planning consent to twelve months. Changes to the Electricity Act 1989 could be made or a new supporting process introduced. Changes should include, but are not limited to:

Introduction of pre-application requirements to reduce the need for additional information requests. Pre-application requirements could include environmental surveys and community engagement.

New application form stating what information is required for an application to be accepted.

Clear roles, responsibilities and mandatory timeframes introduced for all parties involved including statutory consultees. This includes funding statutory consultees through the planning application fee to ensure responses are delivered within the consultation timeframe.

Introduction of a process for variations which matches the process electricity generators use. Electricity generators are able to vary their design once planning approval has been granted, (e.g., changing the location of towers based on detailed surveys). An equivalent process should be introduced for electricity transmission infrastructure.

Implementation:

Both recommendations would require primary legislation to make amendments to The Electricity Act 1989. It is strongly recommended that Recommendation SP1: Planning Process – Scotland, the removal of the mandatory trigger for public local inquiry from the planning authority and introduction of a hearing process, is added as a matter of urgency to the Energy Bill, currently passing through Parliament if further amendments to the bill are possible. This change is required to support projects currently in flight and those about to go through planning approval in Scotland, which are critical national infrastructure required to meet 2030 renewable energy targets.

A legislative vehicle would be required for Recommendation SP2 in order to make further amendments to the Electricity Act 1989. A primary legislation change can be achieved quickly if there is the drive to do so but typically it can take up to two years or more. To create a new process that would supersede the Electricity Act 1989, a new legislative act might need to be enacted which could take two years or more. For projects looking to deliver for 2030 and beyond, planning approval needs to be granted within twelve-months of the application being submitted. Acceleration of the legislative process will be required to make the necessary changes in time to support projects looking to deliver for 2030 and beyond.

Scottish Government administers the planning process and adequate resource is required to do so. Additional resource should be provided to Scottish Government in the very near term to work with the Transmission Owners (TOs) in the pre-application stage to help support their applications. Getting an application right first time will help to reduce the time taken to gain planning consent. This will support reducing the pre-application stage from approximately eight years to two and half years.

The needs case for a project can often be considered as part of planning approval. The endorsement of the strategic plan in the National Planning Framework (NPF) and National Policy Statements (NPS) will remove the need for this to happen as part of the planning approval process. This will support reducing the timeframe for planning approval to twelve months.

5.9 Planning Process – England and Wales

Challenge:

The time taken to obtain planning approval for an identified project has been increasing. Projects are taking around eight years in pre-application and one and a half years in the planning application stage. Some of the reasons this timeframe has been expanding are due to the need to design multiple options for the route, undertaking re-design to secure community acceptance and resource availability within Planning Inspectorate (PINS) and the statutory consultees.

The National Policy Statements (NPS) set out UK Government's policy for delivery of major energy infrastructure and are used within the planning approval process. These policy statements are currently being updated. The NPS can be interpreted differently by different parties making it difficult to design routes that satisfy these statements and regulatory approval requirements and respond community acceptance.

Recommendations:

EWP1: The twelve month fast-track approval process[24] should be used for approving all electricity transmission infrastructure in England and Wales. Current activities to streamline and shorten the process should be developed and applied as quickly as possible.

Implementation:

EWP1: The Department for Levelling Up, Housing and Communities (DLUHC) owns the National Strategic Infrastructure Process (NSIP) and is currently in the process of making improvements[25]. Adequate resourcing and priority for this activity are required to support the quick delivery of these improvements. Funding for system improvement and standardisation of applications and assessment of them may be required.

PINS administer the NSIP process and adequate resource is required to do so. Additional resource should be provided to PINS to work with the Transmission Owners (TOs) in the pre-application stage to help support the application. Getting an application right first time will help to reduce the time taken to gain planning consent. This will support reducing the pre-application stage from eight years to two and half years.

Within the current NSIP improvement programme there is a provision to fund statutory consultees. Arrangements to fund statutory consultees and fix timeframes to respond within the planning approval process are required to support the twelve-month timeframe required for gaining planning approval.

The implementation of Recommendation RD1: Route Design Standardisation, will support the reduced timeframe for planning approval. Having rules and guidance set out allows the planning process to refer to these to check if they have been followed. This approach would facilitate the planning process considering more local issues identified by statutory consultees.

The needs case for a project can often be considered as part of planning approval. The endorsement of the strategic plan within the NPS (see Recommendation NP2: National Policy Statements and National Planning Framework) will remove the need for this to happen as part of the planning approval process. This will support reducing the timeframe for planning approval from eighteen months to twelve months.

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[24] Section 3.6 https://www.gov.uk/government/publications/nationally-significant-infrastructure-projects-nsip-reforms-action-plan/nationally-significant-infrastructure-action-plan-for-reforms-to-the-planning-process#reform-area-2-operational-reform-to-support-a-faster-consenting-process

[25] https://www.gov.uk/government/publications/nationally-significant-infrastructure-projects-nsip-reforms-action-plan/nationally-significant-infrastructure-action-plan-for-reforms-to-the-planning-process#reform-area-2-operational-reform-to-support-a-faster-consenting-process

5.10 National Policy Statements and National Planning Framework

Challenge:

The National Policy Statements (NPS) for England and Wales and the National Planning Framework (NPF) for Scotland set out the Government objectives for the development of nationally significant infrastructure. They are referred to during the planning approval stage and projects must meet these objectives.

The National Policy Statements have not been updated in a number of years. A consultation to do so is currently in progress. The National Planning Framework for Scotland was updated in February 2023.

Recommendations:

NP1: The National Policy Statements (NPS) and National Policy Framework (NPF) should be updated regularly to support the need for new electricity transmission infrastructure. The NPS and NPF should be reviewed and updated every five years and allow for smaller changes to be made between the five-year updates.

NP2: The National Policy Statements (NPS) and National Policy Framework (NPF) should refer to and allow Ministers to endorse the Strategic spatial Energy Plan (SSEP) and Centralised Strategic network Plan (CSNP), as statements of the projects required for nationally significant infrastructure.

NP3: The Electricity Transmission Design Principles (ETDP) should be referenced and endorsed in the National Policy Statements (NPS) and National Policy Framework (NPF).

Implementation:

NP1: It is possible for UK Government and Scottish Government to set the timescale on which the NPS and NPF are updated. Consultation is required before updates can be made, which typically takes around nine months to complete. The NPF has recently been updated and the NPS is currently in consultation to be updated. These updates will support projects looking to deliver by 2030. Updating these documents regularly will continue to give strong support for the expansion of the electricity transmission network required to meet Net Zero targets. The cost of updating these documents is expected to be offset by supporting the reduction in time to deliver projects.

NP2: In order for the NPS and NPF to endorse the CSNP a Strategic Environmental Assessment (SEA) needs to have been completed. A Marine Environmental Assessment (MEA) will also need to have been completed as described in Recommendation ME1: Marine Planning Process. Both activities will have an additional cost associated with them. It is expected that this cost will be offset by reducing the planning approval timeframe and the earlier delivery of projects. This recommendation links with Recommendation SP3: Strategic Spatial Energy Plan.

NP3: The ETDP (incorporating route design standards) will need to be created and consulted on as outlined in Recommendation RD1: Route Design Standardisation. An update may be required for these Principles to be included and endorsed in the NPS and NPF; this update may also require consultation. This amendment activity could fall in line with a regular update outlined in Recommendation NP1, but this process should not slow down endorsement of route design standards. Due to the time required to develop and implement this recommendation it will likely support projects delivering for 2035 and beyond. The use and recognition of these standards within the planning approval process should happen given their inclusion in the NPS and NPF.

5.11 Marine Planning Process

Challenge:

Many industries interact in the marine setting and must be coordinated, (e.g., fishing and shipping). The environmental impact can be challenging and costly to offset and some areas will potentially need to be avoided. Understanding the environmental impact and industry interactions often happens after a project has been identified. With the expected increase in the number of offshore cables required to reinforce the onshore transmission network, and deployment other energy infrastructure, there is a risk the environmental impact will be high and costly.

The marine licensing process is devolved across the UK, Welsh and Scottish Governments. Many offshore reinforcements will require multiple planning and marine licences which will add to project complexity.

Recommendations:

ME1: A Marine Environmental Assessment (MEA) should be used to inform the Strategic Spatial Energy Plan (SSEP). An offshore delivery routemap, which would be led by The Crown Estate (TCE), would coordinate the development of electricity, gas, hydrogen and CO2 networks and other infrastructure to facilitate Net Zero. This will support the Future System Operator (FSO) and Transmission Owners (TOs) in understanding the viability of a project, its costs and delivery timeframe.

ME2: Proactive actions should be taken to ensure the licensing processes for England, Scotland and Wales are able to deliver in a twelve-month period. Actions may include process improvements, increased levels of resourcing and working with Transmission Owners (TOs) in the pre-application stage.

Implementation:

ME1: An MEA could be carried out and used within the strategic planning process. There would be a cost associated to carrying out this survey and it may need to be repeated regularly. TCE has completed an environmental survey as part of the Celtic Sea leasing round. TCE and Crown Estate Scotland (CES) could potentially carry out, share and update marine environmental surveys to be used within the end-to-end process. The cost of carrying out surveys is expected to be offset by improving the quality of the plan and facilitating the plan being endorsed by National Policy Statements (NPS) and National Policy Framework (NPF). There are also significant benefits in terms of risk mitigation.

The co-ordination of FSO, Governments, TCE and CES will require resource in the short-term to understand where suitable areas are located for offshore wind and transmission infrastructure and how it is coordinated with other offshore infrastructure required for Net Zero. It is expected that this increase of resources at the planning stage will be offset by an improved Centralised Strategic Network Plan (CSNP), more robust project proposals and reduced examination time for licensing. This is due to reducing the number of considerations made during the planning stage.

ME2: Additional resources should be allocated to marine licensing departments in England, Scotland and Wales to support process improvement activities. There is an expected increase in the number of projects requiring marine licences; making process improvements ahead of this increase will support achieving a twelve-month approval period. Additional resources may be required to work with TOs in the pre-application stage to ensure all information requested as part of the application is right first time and reduces the need for further requests for information. The cost of additional resource in the marine licensing departments is likely to be offset by reducing the time it takes to gain a marine licence and the overall impact on reducing the delivery time for new projects.

5.12 Community Benefits

Challenge:

Communities hosting national infrastructure do not always see a direct benefit for doing so. They are often faced with disruption during construction and left with visual impact once construction is complete. Communities may not see a direct link between connecting low carbon generation and local decarbonisation outcomes. Citizens may respond by strongly opposing projects.

Recommendations:

CB1: Guidance on community benefits which are the subject of a current consultation[26] should be delivered and adopted quickly. This guidance should clearly set out what Transmission Owners (TOs) are able to offer as community benefits and what can be recovered through the regulatory process.

CB2: Residents of properties close to new overhead lines should receive a defined direct payment. Communities should receive a set amount of money for new visible infrastructure they host. The benefit should be a defined value per kilometre of overhead line (OHL) or an appropriate amount for other visible infrastructure. This benefit would only be available for hosting OHL or other visible infrastructure, (e.g., substations).

Implementation:

CB1: There is a consultation on community benefits currently concluding by the Department for Energy Security and Net Zero (DESNZ). It is expected that the outcome of this consultation will be in place to support projects looking to delivery for 2030.

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[26] https://www.gov.uk/government/consultations/community-benefits-for-electricity-transmission-network-infrastructure

CB2: There is a large difference in cost for OHL, underground cable and offshore cable. Underground cables cost between five and ten times more than OHL and offshore cables are more expensive again. Providing a community benefit set per kilometre of OHL is less costly than using an underground cable and will have a lower environmental impact.

To provide this benefit, a further consultation may be required to update the guidance on community benefits. Any value that is agreed will need to be reflected in the regulatory approval process and endorsed by Ofgem, Recommendation RA1: Regulatory Approval describes this.

The implementation of both recommendations is intended to support community engagement. It is anticipated to support reducing the pre-application time to two and a half years.

The costs of these recommendations will depend on final benefit agreed. In each case, this will be realised through the avoided costs by installing a cheaper technological solution (i.e., OHL rather than undergrounded lines) and/or by delivering the asset quicker and avoiding congestion costs. A more sophisticated cost-benefit analysis will be required on a project-by-project basis as the technological choice will not always be as clear as being between under-grounding and over-grounding. The scheme design will need to be well designed with a transparent methodology which clearly shows how the value of the benefit has been calculated.

There will likely be other indirect benefits from these payments for the host community. This benefit will support local communities economically, depending how it is deployed. For example, if it was used for the installation of low carbon community owned generation, or local heat networks, this could translate into lower energy bills in addition to responding to community commitment to Net Zero.

5.13 Data Sharing

Challenge:

Data is a critical asset in enabling the transmission infrastructure delivery process. This data includes spatial, environmental, economic, social, technical and commercial data. It is collected by many parties, used by these parties for their respective purposes and has associated with it, varying degrees of commercial sensitivity. Data is not routinely shared meaning there is duplication of effort in its collection, maintenance and governance and risk of inconsistency between parties who are relying on different versions of the same data to convey information about matters of shared interest or decision making. Assumptions and compromises are by necessity made about data availability, quality, completeness and currency.

As an example, an environmental survey can be required by the Transmission Owner (TO) for planning approval and can be repeated by the contractor building the asset. Surveys are often repeated by parties so they can have confidence in the data they are using to make decisions on risk and financial matters.

The current data management approach is not appropriate if the transmission infrastructure delivery process is to be accelerated.

Recommendations:

DS1: Coordinated data sharing amongst the parties should be established (where currently not happening), matured and mandated, with leadership for implementing this in practice assigned to the Future System Operator (FSO). This will include establishing the necessary governance mechanisms, platforms, tools, obligations, processes and practices. These should draw on well-established data industry practice as well as previous efforts in the energy sector (Ofgem Data Best Practice Guidance [27] for example) and current initiatives such as Government's Energy Digitalisation Strategy and Action Plan[28], the Digital Spine[29] amongst others. Clarity will be required regarding what data is needed by whom and for what purpose so that priorities can be drawn.

Implementation:

DS1: The FSO should develop a Minimum Viable Product (MVP) data catalogue based on a survey of existing datasets that are used and prioritise those that are most likely to be duplicated or from which the benefits of sharing could be most readily realised. This catalogue should use industry standard meta-data to facilitate access and use.

The FSO should then work with industry and other stakeholders and experts to extend the data catalogue to be a more functional data environment for the sharing of data and for aligning the capability provided with the end-to-end process change and the emergence of new requirements and digital techniques. Depending on the future of the 'Digital Spine' project, it is possible that it will be able to contribute to or align with this work. It is noted that the data needed extends beyond traditional energy system data to include other data such as geological, environmental, economic and social data for example, which suggests that it may be helpful to consider other supportive initiatives with a view to possible integrations.

The parties involved will need to agree on where responsibility for data quality and completeness rests and where liabilities lie if decisions are made on inadequate data. This should be addressed as part of programme of work to build a robust data environment and service and may need to be supported by licence or code changes. This environment and service should be provided on a sustained basis by the FSO.

It is expected to take additional resource within the FSO to develop and establish the digital infrastructure and governance for coordinated data sharing. The suggested data catalogue will be an important first part of the effort required. This catalogue can develop in sophistication over time, but it should be possible to establish an initial version in a time scale that will be helpful to projects for delivery by 2030.

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[27] Data_Best_Practice_Guidance_v1.pdf (ofgem.gov.uk)

[28] hEnergy Digitalisation Strategy and Action Plan

[29] https://www.gov.uk/government/publications/energy-system-digital-spine-feasibility-study

Ongoing development will see the MVP catalogue, and other tools and processes, implemented and in addition, will see the scale of the content increased and the intensity of use grow. In building this capability it should be possible to draw on existing initiatives and systems to provide the foundation. This leaves a key challenge enabling the effort to identify and include the data sets themselves. A comprehensive data sharing capability is likely to be available to support projects beyond 2030.

This recommendation is supportive of enabling the flow of information amongst stakeholders to enable good decision making and is of particular importance to enable automation of corridor routing and design processes Recommendations AR1 and AR2: Automation of Route Design.

5.14 Land Access

Challenge:

Access to third party land is required when designing and building new infrastructure. Access is needed to survey the land to ensure it is suitable and to carry out environmental surveys when designing routes. Land needs to be purchased or wayleaves put in place. Access to land is required for the lifetime of the asset for maintenance and future upgrade or replacement.

During the design process voluntary access to land is often refused, requiring a warrant to be issued. Obtaining a warrant takes time and resources from the Transmission Owner (TO) and from the court system. To obtain planning approval land purchase must be completed or wayleaves need to be in place. Compulsory purchase and necessary wayleaves are sometimes required which extends the time to obtain planning approval. Wayleaves to access land for maintenance and replacement can expire or land can change owner. There is a risk that new landowners can ask for higher compensation to agree a new wayleave.

Recommendations:

LA1: The Transmission Owners (TOs) should be given the same statutory powers as other utilities to be able to access land for surveys when voluntary access has not been given. This would allow the TO to access land to carry out surveys required during the route design phase.

LA2: Compensation for wayleaves and purchase of land, voluntary and compulsory, should be set at a national level. A transparent methodology for the amount of compensation should be set up and used when negotiating land purchase and wayleaves. The same methodology would be used when renegotiating wayleaves.

LA3: Further work is required to understand impact of more changes being made to the current land purchase and wayleave process, both voluntary and compulsory. Areas of consideration should include, but are not limited to:

> How to introduce a variation process to allow for small changes from the original land purchase or wayleave. This would allow for small changes once construction has started if a more efficient or less impactful option is identified and reduce the need to go back through the process of land purchase or obtaining a wayleave.

How to set timeframes for compulsory purchase and necessary wayleave process.

How the land right and wayleave process sits alongside planning approval and how planning approval could be granted without land rights and wayleaves in place.

Implementation:

LA1: Primary legislation will be required to amend the Housing and Planning Act-2016 to give TOs additional statutory powers to access land. A legislative vehicle would need to be found for this amendment. It can take around two years to make a primary legislation change but this can vary.

In order to support projects that are currently in the route design phase, and are looking to deliver for 2030, the timeframe to implement this recommendation needs to be accelerated. This will enable time saving in the route design phase. It is also expected there will be a reduction in the burden of obtaining a warrant for the TO and for the court system and thereby represent a cost saving.

LA2: There are two options for implementing this recommendation: guidance or a statutory code of compensation. The first option of issuing guidance is unlikely to require any legislative changes. There would be a cost of setting up and agreeing guidance, but this is likely to be offset through shorter negotiation times and potentially lower land purchase and wayleave costs. It will take around six months to set up the methodology and then potentially another nine months for consultation, so it would be possible to set up this guidance in time for some projects looking to deliver for 2030.

The second option is to create a statutory code of compensation like the telecoms industry has. It is likely to take longer to establish this as primary legislation will be required. A possible approach would be to set up guidance as soon as possible while at the same time looking to make the primary legislation change. Making a statutory code of compensation would support the delivery of projects and manage project costs during construction and on an enduring basis. There have been instances of wayleaves lapsing due to a new landowner and the compensation requested being higher than originally agreed. A statutory code of compensation would help manage the longer-term costs of access to equipment for maintenance.

LA3: Further work is required in this area to understand what needs to change, why it needs to change and how to make the change. A working group, formed and directed by the Energy System Delivery Board (ESDB)[30], with TOs, Future System Operator (FSO), Department for Energy Security and Net Zero (DESNZ), Department for Levelling Up, Housing and Communities (DLUHC), Planning Inspectorate (PINS) and Scottish Government participation should be set up to look at what further changes could be made to the land purchase and wayleave processes, both voluntary and compulsory, to support accelerating the delivery of nationally critical infrastructure. Examples from other utilities and best practice should be considered as part of this working group.

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[30] Please refer to the Commissioner's letter or to Section 7 of this report

5.15 Supply Chain

Challenge:

The supply chain - being able to purchase equipment and services - is becoming more and more constrained. The UK is not alone in trying to decarbonise its electricity system; one result is that supply chains are becoming increasingly competitive on a global scale to secure the equipment and engineering services required.

The lead times for some equipment can be as much as seven years and lead times for many materials and equipment are increasing. The supply chain is looking for greater certainty on the size and content of the order book from Transmission Owners (TOs) and often require upfront payments to secure manufacturing slots. The introduction of the pre-construction budget in Accelerating Strategic Transmission Investment (ASTI) has supported engagement by being able to pay the supply chain earlier in the process.

The challenge is aligned with design and approval processes. The detailed design process is carried out by a contractor following regulatory and planning approval. At this stage equipment will be selected that meets the specification of the route design and the design is optimised. For equipment with a long lead time this will add delay into a project as it has been identified so late in the process. Following the detailed route design some variation to the planning approval may be required. This can mean going back through the planning approval process adding cost and delay to a project.

Recommendations:

SC1: The Transmission Owners (TOs) should form long term relationships with the supply chain and look to book slots and bulk purchase equipment when possible. This approach is moving away from engagement on a project-by-project basis and looking at long term programme of projects that have been identified by the Strategic Spatial Energy Plan (SSEP) and Centralised Strategic Network Plan (CSNP). Long term engagement and contracts should also be put in place for engineering services from detailed route design to construction.

SC2: Contractors, who will carry out the detailed design work, should be procured earlier in the design process. Detailed design work on the routing and a bill of materials should be completed as soon in the process as possible to facilitate the purchasing of equipment with long lead times. Detailed design at this stage will support the planning approval application and reduce the need to seek further approval if the detailed design varies from the original route design.

SC3: Further work and collaboration is required between the Transmission Owners (TOs), supply chain and government to understand how manufacturing capability could be developed in the UK. Further investigation is required around procurement rules and how equipment manufactured in the UK can remain in the UK.

Implementation:

SC1: In order to support the TOs in forming longer term relationships with the supply chain, Recommendation CT1: Contestability of Transmission Owner needs to be implemented. The TOs require much more certainty on what they will be expected to deliver and by when, to form meaningful relationships with the supply chain. Long-term certainty on the portfolio of projects will allow the TO to purchase equipment and services on a programme level and have confidence to spend on securing manufacturing slots. Without this certainty TOs will not be in a position to secure the supply chain and project delivery is likely to be delayed and cost added. This recommendation will support projects identified in the Holistic Network Design – Follow Up Exercise (HND-FUE), which is due to be published this year, and any subsequent projects.

SC2: The introduction of pre-construction funding in ASTI has supported the adoption of this approach. Removing the regulatory approval process from the critical path, Recommendation RA1: Regulatory Approval, will further support the adoption of detailed design earlier in the process. Moving the detailed design to happen before the planning approval is expected to save six months in the end-to-end process. It is also expected to support time savings by being able to order equipment earlier in the process. It is expected to reduce the need to seek further planning approvals for any variation in the route design identified in the detailed design. The time to implement this recommendation will be based on the time to implement a new regulatory approval process, noting that temporary measures may be used before a new process is adopted.

SC3: A working group should be set up between TOs, supply chain and Government to understand what further actions could be taken to help ease supply chain constraints and bring manufacturing capability to the UK. It is suggested that procurement law is an area where further investigation is required.

5.16 National Campaign on the Need for Infrastructure and Jobs

Challenge:

Whilst there is some public acknowledgement of the need for renewable generation to support decarbonisation, there is very limited understanding of the electricity transmission infrastructure required to connect it. There is a need to engage with local communities impacted by the infrastructure when designing it and when applying for planning approval. Frequently these impacts are seen as negative. Communities can be averse to new infrastructure and ask for visual mitigation measures like undergrounding or offshoring without fully understanding the implications of these options.

The impacts of new infrastructure can also be positive. To support the decarbonisation of the electricity network a range of jobs and skills will be required. Skills range from construction, environmental science, planning to engineering. There is a need for more people to work in these areas across all organisations involved in planning and building electricity infrastructure. These jobs, and the economic and social benefits that arise from them, could provide opportunities for people in the local communities affected by infrastructure build.

The key challenge is ensuring there is understanding of the relationship between transmission infrastructure build and achieving good climate, economic and social outcomes.

Recommendations:

NC1: A Government-led national information campaign should be started on the need for electricity infrastructure and how this can lead to good outcomes for people and the communities in which they live and work. This should include how this need can lead to job opportunities for them and their families. This campaign could be like that used by the armed forces. The advertising campaign should show why new electricity transmission infrastructure is required to connect renewable energy to where it is needed. The campaign should also highlight the range of different job opportunities available such as engineering, environmental science, planning and construction, amongst others.

NC2: An independent website, possibly hosted by the Institution of Engineering and Technology (IET) or a similar organisation, should be set up to provide information to the public on:

> The need for electricity infrastructure. This should provide information in addition to that in the advertising campaign and should be easy to understand as well as informative.
>
> The different types of infrastructure and their environmental impacts and why different types of infrastructure are used. This should include an explanation on the cost and environmental impact of using overhead line (OHL), underground cable and offshore cable.
>
> Infrastructures needs as expressed in a simplified version of the Strategic Spatial Energy Plan (SSEP) and Centralised Strategic Network Plan (CSNP) to give context to why infrastructure is needed in a particular area and provide a forward look to further projects that may come to the area.
>
> Jobs and careers available within the industry. The website would host the information on jobs and careers suggested as part of Recommendation NC3.

The website should become a ‘one stop shop’ to find easy to understand information on electricity infrastructure and related jobs. The website should be used when engaging with local communities to give impartial information to them. The website can also be used by the wider community interested in electricity infrastructure.

NC3: Information on all types of careers and opportunities should be provided in a variety of ways to appeal to different age groups; examples include use of profiles of real people, videos, content creation to appeal to younger audiences, using influencers and animations. Links to training schemes and qualifications required should be included so that at any point in your career it is possible to see what is required to enter the industry. This is intended to give information on green jobs in a variety of ways that speaks to different age groups including primary and secondary-school aged children. This recommendation is linked to Recommendation NC2 describing where this content could be hosted.

Implementation:

NC1: Funding would be required to run a national campaign; this would likely come from Government. "Light touch" national campaigns, can cost approximately £15-20milion a year. This cost may not be directly offset against a specific benefit, but it is expected to be offset by improved community engagement, access to needed skills and accelerated delivery of projects.

The TOs have started to create campaigns that show why new infrastructure is required and could be used as part of the campaign. It is expected a campaign could be delivered in under a year and support projects required for 2030.

NC2 and NC3: There would be a cost to set up and maintain a new website with funding likely to come from Government. If the website is used to advertise job opportunities and training courses and university degrees, then a fee to do so could be used to support ongoing maintenance costs of the website. An alternative would be for many organisations to sponsor it including government departments. Creating content, such a videos and photos, could be activity undertaken by the different organisations involved in the end-to-end process. For example, a Transmission Owner (TO) may wish to let a small group of employees create videos showing the work they do from working in the control room to climbing to the top of a tower. An environmental surveyor may wish to share photos of the animals they find while on the job.

To create easy to understand materials on the SSEP and CSNP is an activity that could be carried out by the Future System Operator (FSO) and form part of the materials they would produce when publishing plans. There is existing information on the different types of infrastructure that the TOs have created which could be used as an early version of a website. It is expected that this type of information could be gathered quickly to create a website that could be used to support projects for 2030.

A centralised up to date website can cost approximately between £10m-£16m to set up. This cost is a sum of staff, infrastructure, and software costs. The per site visit cost is a useful measurement to understand the value of the website. The engagement and resources would help achieve community acceptance and also allow for better targeting of national skill gaps.

5.17 National Review of Skills and Jobs

Challenge:

The engineering and technician skills shortage has been a challenge for several years. It is expected that this challenge will grow as we need to build more electricity infrastructure. Competing on a global market for these skills and resources is expected to become harder as more countries look to decarbonise and expand their electricity networks. The issue is broader than technical skills. With an increasing number of projects, the skills shortage is starting to impact across a broad spectrum of disciplines, in professional and vocational roles and jobs at all levels. There have been a number of Government and industry groups that have tried to tackle this issue, but it remains and is becoming a constraint on delivering Net Zero.

Recommendations:

SJ1: Government should fund and lead an urgent review and work with industry and academia to identify the skills gaps and actions required to attract, recruit and retain the large workforce needed to deliver Net Zero. The actions identified should look to address short-term constraints along with actions to tackle the long-term need to ensure the skills shortage can be addressed on a sustained basis. The requirements for transmission infrastructure delivery should be treated as a priority.

Implementation:

A working group should be set up with Government, Future System Operator (FSO), Transmission Owners (TOs), supply chain and other organisations struggling to attract the required resource. The purpose of the group would be to create an action plan to address skills and resources in the short term and in the long term. The group should consider actions such as visas for individuals that could fill current skills gaps, university and training places for a range of skills and long-term actions to encourage entry into the electricity industry. The working group should be set up by the Energy System Delivery Board (ESDB), Recommendation OE1: Oversight of the End-to-End Process. The action plan should be monitored by this group and support its delivery.

The Recommendation CT1: Contestability of Transmission Owner interacts with this recommendation. If the TOs have more certainty on the size of the programme of work they will need to deliver, they will be a stronger position to invest in people and training in the long term. Without this certainty measures will be short term and project-by-project focused. It will become increasingly difficult to compete on a global market for the skills and resources required to meet our Net Zero targets and may ultimately place them at risk. There is an opportunity for Government to facilitate the adoption of green jobs by the UK workforce.

This recommendation supports Recommendation NC3: National Campaign on the Need for Infrastructure and Jobs. The careers section of the recommended campaign website can be used to advertise opportunities identified through this review.

5.18 Oversight of the End-to-End Process

Challenge:

There are many parties involved in the end-to-end process for delivering transmission infrastructure. Different parties have different roles, responsibilities, objectives and licence conditions. There is no incentive for the parties to act in a coordinated way nor are there any mechanisms to encourage, enable or support them in doing so. There is no clear accountability for any party to deliver at speed and there are many dependencies between the parties on the actions of others.

Transmission infrastructure build is only one part of the energy system transformation that is needed to achieve Net Zero, but it is critical. Lack of an end-to-end process places the efforts of all parties at risk and jeopardises Net Zero.

Recommendations:

OE1: The Government should establish an Energy System Delivery Board (ESDB) to monitor and drive delivery of the electricity transmission network delivery programme required to meet Net Zero. The Board would have a whole energy system remit, but its initial efforts would be focussed on transmission infrastructure. The Board should be chaired by a Minister, with representation from Ofgem, Future System Operator (FSO), Transmission Owners (TOs) and other relevant stakeholders required. As recommendations are implemented and the delivery process for building new infrastructure improves, the need for this Board may change or reduce.

OE2: The Government should establish a Change Management Committee (CMC) as part of the Energy System Delivery Board (ESDB) to initiate and facilitate the changes that will be required. This includes determining and overseeing implementation of the governance and institutional changes that will be needed to support and enable the recommendations to be progressed. Change management functions should be established by Ofgem, Electricity System Operator (ESO) (as part of it becoming Future System Operator (FSO)) and the Transmission Owner (TOs) for the same purpose and work closely with and report to the CMC.

Implementation:

OE1 & OE2: Establishing and operating the ESDB and CMC will take time and resource within Government. Other organisations will require time and resource to create support functions and to participate in and engage with the ESDB and CMC. These groups are not intended to become a burden on organisations. They are intended to create an environment where ideas can be exchanged, direction is provided, progress can be monitored, and challenges and barriers quickly escalated and resolved.

The time and resource overhead of these boards is expected to be offset by the benefits of alignment amongst key stakeholders, clarity on needed changes and the roles and responsibilities for implementing them, and the potential to implement the recommendations more quickly and efficiently. This is turn should increase the likelihood of success of the recommendations delivering on the seven-year ambition. It is expected these functions and the processes they use can and should be set up quickly and offering support within the next six months.

Further comments on governance and institutional arrangements can be found in Section 7.

5.19 Outage Planning

Challenge:

The outage plan facilitates access to the network in order to carry out maintenance, add new infrastructure and make upgrades to the network. With an increasing number of transmission infrastructure projects needing to access the network, the outage plan will become congested and could become a delay to project delivery.

When assessing an outage, the cost of securing the operational integrity of the network (e.g., manging voltage) and the costs of constraints are considered. Constraint costs may be incurred during an outage due to the reduction in network capacity for generation in some areas. If the system cost is too high to secure the outage, then it can be delayed until system conditions, (e.g., less windy, more optimal outage/generation background) are less onerous. With an increasing number of outages required in the future, a delay on one project may impact the delivery of others by changing the outage plan.

During the detailed design stage, the impact on the overall outage plan, such as the ability to provide further system access, or the constraint cost element of securing outages, are not always considered. The delivery of the project is currently optimised from a construction point of view without appreciating the overall system operational costs. For example, an offline build of part of the line and a short outage may have higher construction costs but much lower outage constraint costs, providing an overall more economical solution.

Outage plan optimisation is essential to maximise the amount of system access that can be granted at any single point in time and minimise the cost to consumers. System access to plant, assets and equipment is planned closely with system users so that outages (i.e., those that affect transmission, distribution, generation) are aligned and access maximised, whilst maintaining system security. Changes in start and/or end dates of a single outage can lead to knock on impact to other outages which were aligned with the first one. This can lead to sub-optimal alignment of outages, increased balancing costs or delays to outages. Minimising, changes to outage plans. particularly in the short-term, allows much greater optimisation of the system, and in turn, system access. A more firmly settled outage plan built across short, medium and long-term time horizons, for all foreseeable outages, will be a key enabler of the transformation of the power system.

Recommendations:

OP1: Review and regular update of the guidance for the type of outages that can take place at different times of the year should be undertaken. For example, an outage with an emergency return to service (ERTS) of greater than twenty-four hours may be permitted in winter where the system risk is deemed acceptable, following a transparent risk assessment process. This is intended to provide more balance between outages in summer and winter and allow more outages to be agreed throughout the year, where the system risk is deemed acceptable.

OP2: The Electricity System Operator (ESO) should investigate use case where operational rules can be relaxed to allow outages to go ahead, for example, relaxing network security from network minus 3 circuits (N-3) to network minus 2 circuits (N-2) during the right conditions. An impact assessment can be carried out to identify when it would be appropriate to relax security standards. For example, a double circuit can be taken out of service if there is a local impact to demand following a fault, but not if it causes a widespread system issue. This is intended to find specific cases where rules can be relaxed, rather than a general relaxation of rules.

OP3: The Electricity System Operator (ESO) should be involved in long-term outage planning during the route design stage. The ESO should provide guidance and input advising on the overall system benefits of different build approaches, which may require a more expensive asset build (offline) but results in a lower whole system cost when constraints are considered. This is intended to give visibility of outage costs to the Transmission Owner (TO) when planning the project delivery and to give the ESO visibility of the project costs for different outage arrangements.

OP4: The Electricity System Operator (ESO), in collaboration with industry, should lead a review of existing arrangements for outage planning (including, transmission outages, relevant distribution outages and generation outages) in the short, medium and long-term to develop actions to:

Improve the timely identification of all outage requirements and their coordination.

Drive down the number of foreseeable changes to those outage plans to improve greater certainty for stakeholders.

Provide a stronger medium and long-term focus to support the development of medium/long-term solutions to system access whilst minimising short term change and those impacts on an optimal system access plan.

Implementation:

OP1: A risk-based approach has been applied over the past winter to facilitate more outages. Cooperation between the ESO and TOs has facilitated this change. To meet 2030 targets this approach can continue and updates to the System Operator Transmission Owner Code (STC) laying out the methodology can support this. Resources and effort from the ESO and TOs would be required to implement this approach, including its design, validation and on-going review.

OP2: The ESO would investigate which operational rules could be relaxed and the use cases for when there would be a benefit to do so. The Security and Quality of Supply Standards (SQSS) sets out the operational standards to be followed, and a deviation from them may be required. A deviation and a trial of relaxed standards would be required ahead of changes made to SQSS. A trial could be undertaken ahead of the increase in outages expected for 2030 projects. A model to assess the impact-related risk would need to be developed and resource from the ESO required to implement and apply the model. If it is found that SQSS modifications would be beneficial, there would be a requirement to progress a formal change.

OP3: Cooperation between the TOs and the ESO will be required during the delivery planning process. Additional resource will be required from the ESO to support this. A new methodology for evaluating project costs will be required that takes account of delivery costs and constraint costs. Ofgem will need to update the methodology they use when evaluating project costs to support a whole project cost. Resources from ESO, TOs and Ofgem will be required to support this and to undertake development and deployment of a new cost analysis method.

OP4: Cooperation between the TOs, system users and the ESO will be required during the delivery planning process. Additional resource will be required from the ESO to support this. Resources from ESO, TOs and users will be required to develop an action plan.

Outage planning is a risk to the delivery of projects for 2030 and beyond; getting system access and co-ordinating projects will become increasingly difficult to manage. These recommendations do not provide a direct timesaving in the end-to-end process and instead are intended to help manage the risk of delivery. Greater visibility and certainty of the outage plan will support projects making decisions and managing delivery.

6. Achieving the Seven Year Ambition

The challenge of reducing the time taken to deploy transmission infrastructure is complex, with many interactions and dependencies between the activities that comprise the end-to-end process and between the stakeholders tasked with delivery. Today's process shown in Figure 4.3 illustrates the many activities and their sequencing. The themes described in Section 4.2 highlight the issues being faced and help structure the response to the need for change.

The recommendations which are organised into groups around these issues, allow a new process to be proposed as shown in Figure 4.6. This new process could allow the ambition of delivering new transmission infrastructure in seven years to be achieved. However, this requires treating the recommendations as a coherent package. They have been developed and designed in this way, acknowledging the high degree of interconnectedness between them. It is possible to deploy recommendations separately but realising the desired timesaving and other beneficial outcomes will be compromised.

An example that illustrates the positive interactions between recommendations is the role that the Strategic Spatial Energy Plan (SSEP) can play in improving cost benefit analyses, which creates more certainty in the approval process, that in turn allows for more timely booking of manufacturing slots with the supply chain. The SSEP will also enable development of insight into the requirements and approach needed for building required skills.

The relationship between the groups of recommendations and the new process is shown in **Error! Reference source not found.**. This figure also shows the reduction in time taken to d eliver new transmission infrastructure.

Adopting this set of recommendations and associated processes will take some time to achieve; explicit change management will be required. Setting up a Change Management Committee (CMC) (see Section 7) should be addressed as a matter of urgency. The CMC would oversee, monitor and take corrective actions to ensure recommendations are adopted as quickly as possible and are delivering the expected outcomes.

Implementing change will not deliver a new seven-year process immediately; it is expected to take some time to deliver the full benefits of these recommendations. Figure 6.1shows initial thinking on how long each of the recommendations may take to implement and become effective.

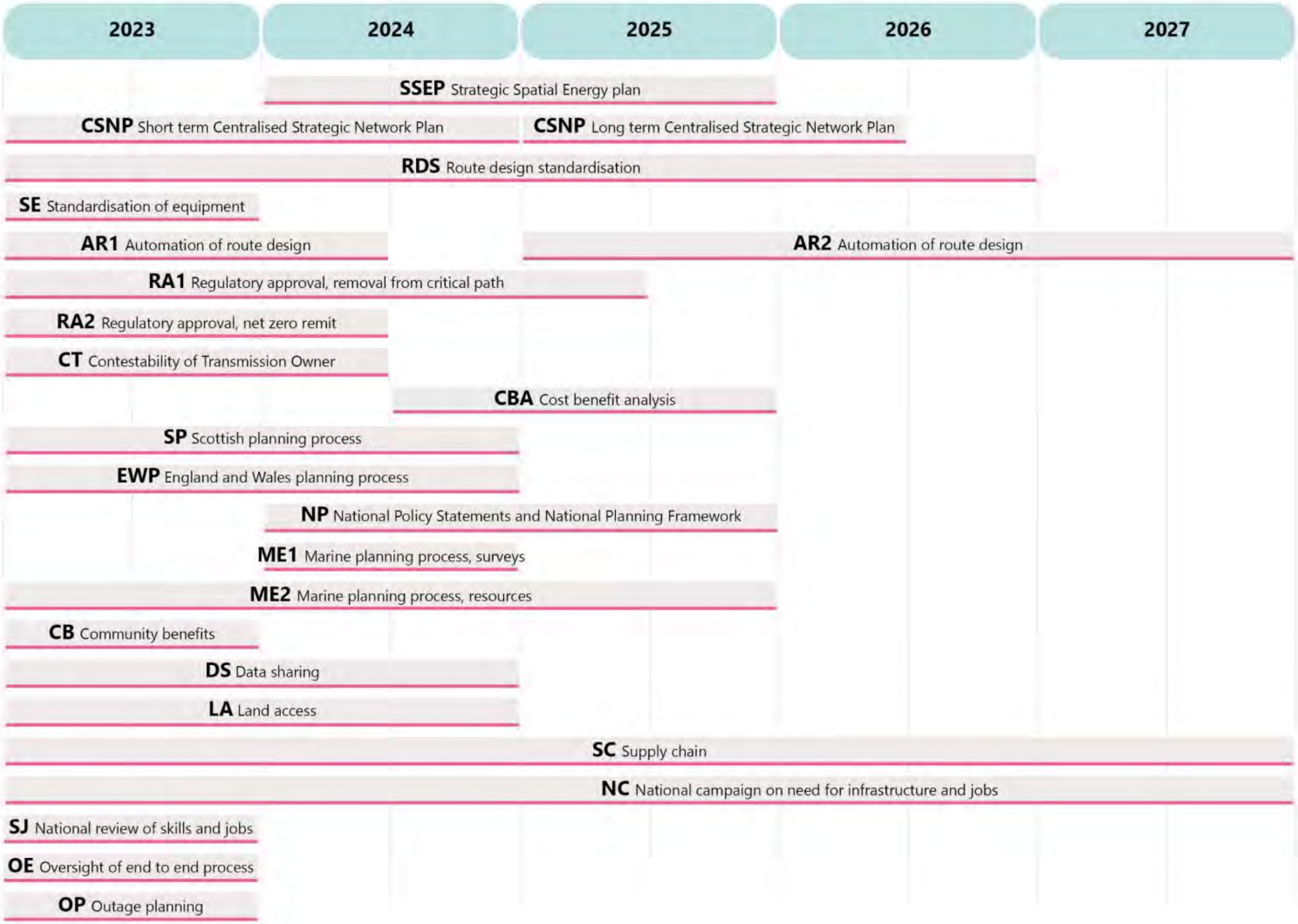

Figure 6.1Timeframe to implement recommendations

The SSEP is foundational for the new end-to-end process. With this in place, network plans, such as the Centralised Strategic Network Plans (CSNPs) can be developed. The first CSNP is due to be published in 2025. This is an opportunity for new processes to be adopted for all projects and gives a two-year timeframe to progress and implement the recommendations offered in this report. Changes to regulatory approval and endorsement of the plans in the National Policy Statements (NPS) and National Planning Framework (NPF) should be prioritised.

The creation of the SSEP and the longer-term CSNP need to be progressed at pace to support the Transmission Owners (TOs) engaging with the supply chain. Building long-term relationships will require a clear pipeline of projects. If these plans are not delivered until 2026 or beyond then forming these important relationships, and promoting an increase in manufacturing capability, will be delayed impacting projects today and in the future.

Implementation of route design principles is likely to be challenging and will require consultation. Enhancing and clarifying rules currently used today is vital to reduce the time spent designing multiple route options. Progress should be made quickly to align with the CSNP being published in 2025. A method of continuous improvement and refinement should be adopted to further enhance the principles to support automation. Design standards and automation of route design underpin the halving ambition. Reaching the seven-year ambition will rely on Governments, TOs and communities agreeing on design principles and investment in automation.

Reforming the regulatory approval process, including cost benefit analysis, is required ahead of the next regulatory settlement period starting in 2026. Interim arrangements, like Accelerating Strategic Transmission Investment (ASTI), will need to be kept for Holistic Network Design (HND) and Holistic Network Design – Follow Up Exercise (HND-FUE) projects. A new regulatory framework should be put in place for projects identified in the first CSNP in 2025. To support projects identified in HND-FUE a decision on the contestability of transmission owner and how contestability will be phased in is needed as a high priority. Delay to this decision will delay the TOs in engaging with the supply chain and risk delaying the delivery of critical national infrastructure.

The timeframe for planning approval and marine licences needs to reduce to twelve months for projects looking to deliver for 2030 and beyond. Making changes to the England and Wales process is expected to take around two years; every effort should be made to accelerate this. Making changes to the Scottish planning process will require primary legislation. Unless these changes are made urgently, projects required for meeting 2030 offshore wind targets will face delay in obtaining planning approval. Proactive actions need to be taken to ensure the marine licensing process in England, Scotland and Wales can deliver in a twelve-month period.

The NPS for England and Wales and the NPF for Scotland will require updates by 2025 to reference the SSEP, CSNP and the Electricity Transmission Design Principles (ETDP). Regular updates to these documents and guidance on community benefits will be required to support continuous improvement of the end-to-end process.

Granting further statutory powers to the TOs to access land should be accelerated to support projects delivering for 2030. There will be an immediate benefit of time and effort saved from making this change.

Carrying out a national information campaign on the need for electricity transmission infrastructure and carrying out a review of jobs and skills required, are activities that could and should be delivered quickly.

7. Call for Action

The recommendations offered seek to respond to the urgency of the need to deliver transmission infrastructure more quickly and are believed to provide collectively a coherent approach for progress to be made and ambitious outcomes to be delivered.

What are the immediate next steps?

Government should receive and give urgent attention to the recommendations, establishing a Change Management Committee (CMC) as part of the Energy System Delivery Board (ESDB) charged with progressing their implementation. The ESDB and CMC are described below and in the Commissioner's recommendations. Implementation should be approached on the basis that the recommendations are a cohesive set that work together to deliver needed outcomes.

Government should commit resources to enable the CMC to be established and become operational quickly.

The CMC should undertake detailed review and if necessary, carry out further study of the recommendations, and deliver a plan for moving forward. This plan would establish priorities and sequencing, consider roles and responsibilities, and identify required resources and processes.

The CMC should work with Government, Ofgem and other key stakeholders to determine and agree the governance and institutional arrangements that will drive energy system transformation.

The CMC should work with Government, Ofgem and other key stakeholders to place delivery of the recommendations as a priority in the whole energy system governance and institutional arrangements.

What considerations should be taken into account in undertaking these next steps?

Immediate actions should be taken to consolidate current programmes and initiatives and understand how these individually and collectively help build the strategy that supports and responds to emerging requirements and the pursuit of Net Zero. This should include developing an understanding of how these align or integrate with the recommendations. Specific alignment between the Offshore Wind, Hydrogen and Transmission expert recommendations should be an early part of this.

All efforts in this regard must be mindful of the need to include the whole energy system with the transmission grid being a first (and critical) use case.

The stakeholder community needs to be brought together to support this work and help ensure there is alignment of purpose and direction.

An important enabling condition

New governance and institutional arrangements will be needed to deliver energy system transformation successfully. These arrangements should be whole energy system in perspective, scope, mandate and powers if good decisions are to be made that account for increasingly numerous and complex system interactions, dependencies and trade-offs. This perspective responds to the fact that the system will cease to be top-down and linear within individual vectors – it will be distributed, decentralised, multi-dimensional and changing at an accelerated pace. Traditional approaches will not be sufficiently aware or agile.

The Commissioner's recommendations respond to what is broadly accepted to be an urgent need but acting at pace should not be allowed to lead to arrangements being established that are limited to transmission infrastructure delivery. This would create the risk of issues arising later. Arrangements should be shaped around the whole energy system with transmission infrastructure delivery being the first priority. This does not mean that all governance and institutional arrangements need to be fully specified and implemented before transmission can be addressed.

Achievement of milestones such as a decarbonised power system by 2035 may require a period of special arrangements to deliver needed pace. These should be subject to continuous review and may change or relax if/when it becomes clear that targets and statutory requirements are going to be met.

A proposed framework for progressing discussion on governance and institutional arrangements

Governance and institutional arrangements must enable many parties to make complex decisions, often with enduring consequences. Their transformation should align with that of the energy system on its journey to a Net Zero future, but do so in a way that balances ambition, risk and pace. Any process of change should acknowledge today’s circumstances and consider carefully how to migrate to new structures.

Making progress may be helped by having a framework that supports needed discussion. A framework helps ensure that the parties are talking about the same thing, using a shared reference point and language. A framework need not be prescriptive; it can allow for additions, deletions, changes, reconfiguration etc.

A key principle that underpins such a framework and that should shape governance and institutional arrangements is **‘function before form’**. A broad set of capabilities will be required to be provided and various roles will need to be performed, but there are options for how these might be deployed. This suggests the need to understand the required functions and their interactions well and then place them into an institutional architecture.

Nine key functions have been identified. Some are new and some are existing, but which may be enhanced.

> **Policy and Direction:** Provide political context and clear purpose and direction.
>
> **Leadership**: Translate policy and direction into a clear expression of objectives and provide active leadership to achieve energy system transformation outcomes.
>
> **Engagement:** Facilitate dialogue with consumers and citizens and the communities in which they live and work.

Analysis: Undertake analysis, modelling and other tasks and deliver consistent outputs that respond to key questions, illuminate problems and reveal insights that can be applied to identify and evaluate potential solution options.

Strategic Planning: Translate transformation objectives into a strategic plan and an approach to change, including how interdependencies and trade-offs can be revealed and managed, with the plan given authority by being endorsed by Government and the regulator.

Delivery Planning and Assurance: Develop and manage a strategic programme plan for acting on the strategic plan and delivering outcomes, with the plan given authority by being endorsed by Government and the regulator.

Execution: Implement and operate energy system solutions at national and regional levels.

Regulation: Assure efficiency in delivery and consumer value for money and support achievement of Net Zero.

Change Management: Manage the process of change in the energy sector, including in its governance and institutions, to enable transformation.

The **principal institutions** responsible for performing these functions and delivering energy system transformation include, but are not limited to:

Government (UK and Devolved): Coordinated across departments and led by the Department of Energy Security and Net Zero.

Energy System Delivery Board: A new group tasked with providing leadership for delivering energy transformation outcomes; chaired by Government and comprising representation from across the energy system.

Government (Regional and Local): Representing the interests and contributions of place in energy system transformation.

Ofgem: Protecting the interests of consumers through regulation and supporting achievement of Net Zero, and where beneficial, working with other regulators to do so.

Future System Operator (FSO): Formed from transformation of the Electricity System Operator (ESO) after its separation from National Grid to provide strategic and delivery planning and coordination of stakeholders across the energy system in addition to its duties for electricity operations[31].

Industry: The collection of existing and new parties that build the energy system and deliver energy services including the networks, supply chain, and many other stakeholders.

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[31] Current position. Operations functions could potentially be extended to other vectors at some point in the future. It is also assumed that the view presented in the Ofgem consultation on the future of local energy institutions and governance will be implemented (in some form); that is, there will be Regional System Planners and a Market Facilitation role, and these roles will be assumed by the FSO.

People and Communities: Consumers and citizens including domestic, commercial and industrial individuals and groups.

The relationships between the functions and the parties that will be responsible for performing them can then be proposed. The placement of functions with an organisation may change over time as circumstances evolve and as experience in operation is gained.

The “mapping” of the functions and their interactions to organisations allows an architecture for governance and institutions to be prepared and discussed. Its operation can then be explored. This will see agreement of “artefacts” or “products” (such as strategies, plans, reports, insights, usually in document form) that will be created, exchanged, endorsed and approved through various processes and interactions. Some of these are already established; others need to be updated or created. Key artefacts would include:

Energy System Objectives: Clear statement of objectives and milestones that reflect policy and must be achieved to support Net Zero and satisfy statutory obligations.

Energy System Strategic Plan: Whole energy system plan (across the value chain and across vectors and sectors), addressing spatial, temporal, functional and operational structure of the energy system, enablement requirements (planning and consents, digitalisation, markets, regulation, for example) and other considerations such as relationships with other interdependent sectors (water, agriculture, land use for example). This would include the Strategic Spatial Energy Plan (SSEP) and Centralised Strategic Network Plans (CSNPs) within its scope.

Energy System Delivery and Assurance Plan: Strategic programme plan for delivering the strategic plan, addressing (amongst other things) cross-cutting delivery issues and dependencies such as supply chain development that span the strategic interventions needed.

Electricity Transmission Design Principles: A public document detailing the principles and methods used to design the system and decide the configuration of assets.

Shared Resources: A portfolio of resources that will grow and evolve over time including tools, models, data, algorithms, standards.

The Commissioner’s recommendations identify artefacts that will be needed for the transmission case and provide the opportunity to extend these to the whole energy system. These artefacts complement other key items such as the National Policy Statements. The Commissioner’s recommendations also describe some needed interactions between parties. The coordination of these interactions is central to success; of note is the endorsement of strategic plans by Government and Ofgem, a key aspect of achieving the seven-year delivery time.

Drawing these ideas together allows a very high-level operational view to be prepared as shown in Figure 7.1.

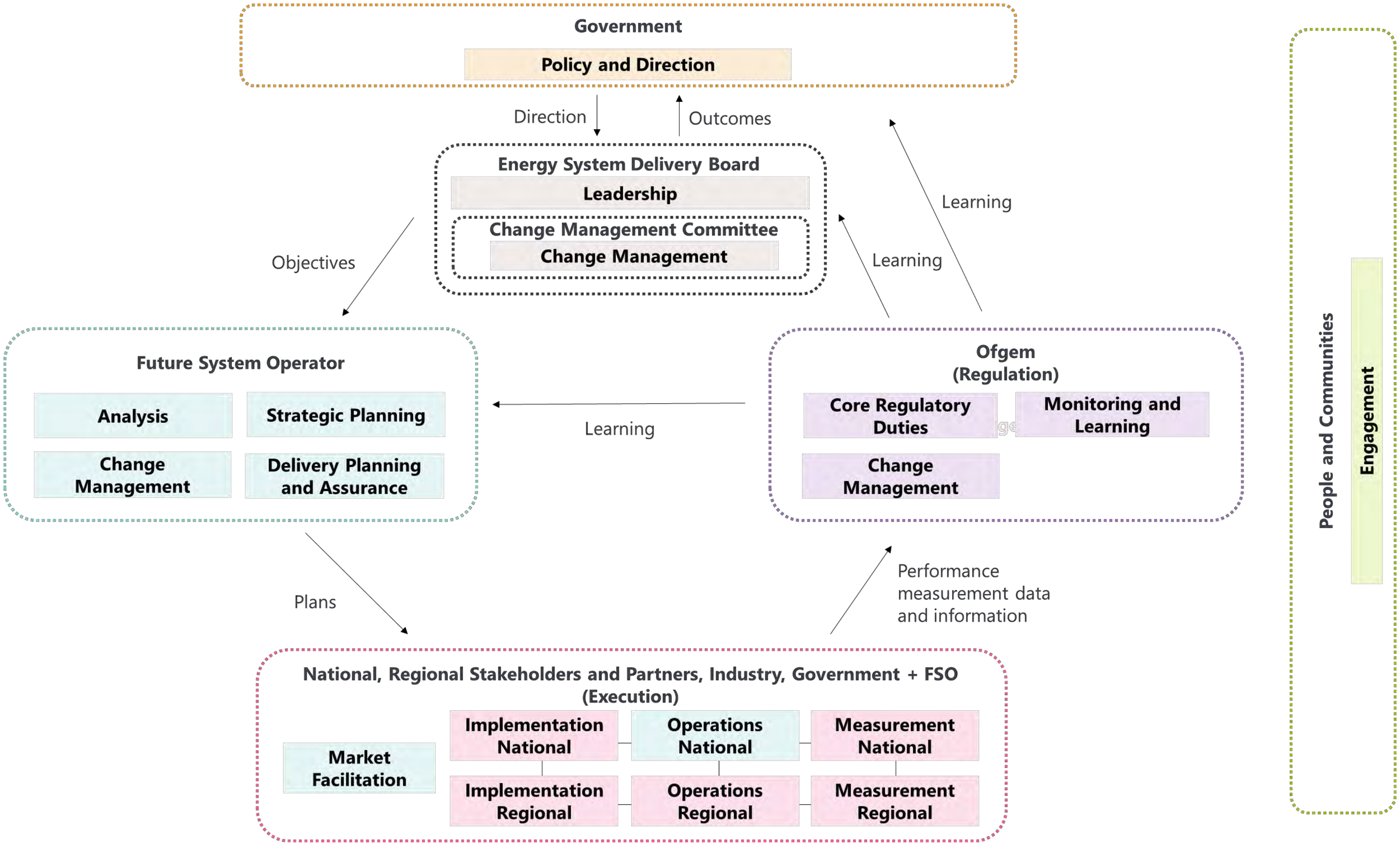

Figure 7.1 High level operational structure

The operating structure acknowledges that there will be a period of change as the energy system moves from its current mode of operation to its future mode of operation.

This change process should not seek to design the perfect answer before acting. Instead, it should build in mechanisms to enable progress to be made quickly, but address the uncertainty implied by explicitly measuring progress and performance. These measurements can then be used as the basis of learning that can be applied to direction, objectives, and plans.

This iterative feedback loop creates the agility needed to address complexity, uncertainty, and pace. It is emphasised that other mechanisms such as the refresh cycle of key government objectives and plans needs to be clear on when and how learning is applied to offer sufficient certainty for long term decision making, or where that isn't possible, to enable risks to be identified and properly assessed.

This framework and other thinking developed using it are offered as an outline of possible arrangements. It builds on the ideas introduced above and is intended to provide a description that could be helpful in facilitating discussion and ensuring that the parties have a shared reference for that discussion. It is expected that this discussion will be led by the ESDB and its CMC.

The key role of governance and institutional arrangements in achieving needed outcomes underscores the importance of the immediate next steps described above.

What other aspects should be addressed in future work?

Delivering transmission infrastructure more quickly is only one aspect of transmission-related change that is important in energy system transformation in pursuit of Net Zero.

> It is important to look beyond process improvement to include other interventions that could deliver benefits, for example, use of grid-forming technologies or dynamic rating to increase capacity of existing infrastructure, deployment of storage to delay or avoid the need to build networks, application of digitalisation including Artificial Intelligence to enhance operations and the contribution of well-functioning flexibility markets amongst others.
>
> The extent to which process automation would improve consistency in information capture and enable better, quicker information flows should be explored in the context of energy system digitalisation and rapidly developing digital techniques, including Artificial Intelligence and Machine Learning.
>
> The relationship with distribution networks and local energy planning is a critical consideration; if distribution networks do not keep pace, the value of transmission development will be diminished.
>
> The scale and pace of local energy initiatives need to be understood so their materiality in the context of transmission (and distribution) networks can be considered.

The impact of multi-vector developments and solutions (potential trade-offs between "electrons" and "molecules" for example) could be substantial and should be investigated in pursuit of benefits.

The uncertainties of demand and the potential impact of demand reduction could be material to future developments and should be addressed.

The impact of both supply and demand flexibility should be better understood. This includes progressing the creation and establishment of well-functioning flexibility markets, ensuring that interactions between national and regional operations are clearly understood and implemented and that integration of enabling technologies such as storage and digital platforms is aligned.

The role that targeted innovation programmes could play in delivering outcomes should be explored with forward programmes being shaped accordingly.

The critical role of supply chains is appreciated, but exploration of the nature and pace of decarbonisation in the supply chain itself is needed. This could be an important consideration with steel and cement for example. A valuable perspective here is the potential for development of UK based supply chains.

Efforts to build transmission more quickly should not ignore adaptation and the need to address impacts of increasingly severe and frequent extreme weather events.

Further exploration of experience from other sectors might give insight. Transport, water and telecommunications are examples, but there may be others that are relevant.

Further exploration of international experience, particularly in countries such as Denmark with large commitments to offshore wind could reveal valuable insights.

As work progresses to address the role that transmission systems play in a transformed energy system, these other aspects should be addressed. Well established governance and institutional arrangements will facilitate this happening in a coherent, productive and timely manner.

8. Glossary

NAME	DEFINITION
ASTI	Accelerating Strategic Transmission Investment
BEAMA	British Electrotechnical and Allied Manufacturers' Association
CBA	Cost Benefit Analysis
CES	Crown Estate Scotland
CMC	Change Management Committee
CO2	Carbon Dioxide
CSNP	Centralised Strategic Network Plan
DCO	Development Consent Order
DESNZ	Department for Energy Security and Net Zero
DfE	Department for Education
DLR	Dynamic Line Rating
DLUHC	Department for Levelling Up, Housing and Communities
DNO	Distribution Network Operator
ENC	Electricity Networks Commissioner
ERTS	Emergency Return to Service
ESC	Energy Systems Catapult
ESDB	Energy System Delivery Board
ESO	Electricity System Operator. This term is used when referring to the current institution and roles
ETDP	Electricity Transmission Design Principles
ETYS	Electricity Ten Year Statement
FSO	Future System Operator. This term is used when referring to the future institution and roles
GB	Great Britain
Government	Unless specified in text refers to UK Government
Governments	Unless specified in text refers to UK Government and devolved Governments
HND	Holistic Network Design
HND-FUE	Holistic Network Design – Follow Up Exercise
MEA	Marine Environmental Assessment
MVP	Minimum Viable Product
NGESO	National Grid Electricity System Operator
NGET	National Grid Electricity Transmission
NOA	Network Options Assessment
NPF	National Planning Framework
NPS	National Policy Statements
NSIP	Nationally Strategic Infrastructure Project
Ofgem	Office of Gas and Electricity Markets
OFTO	Offshore Transmission Owner
OHL	Overhead line
PINS	Planning Inspectorate

SEA	Strategic Environmental Assessment
SHET	Scottish Hydro Electricity Transmission
SPT	Scottish Power Transmission
SQSS	Security and Quality of Supply Standards
STC	System Operator Transmission Owner Code
TCE	The Crown Estate
TO	Transmission Owner

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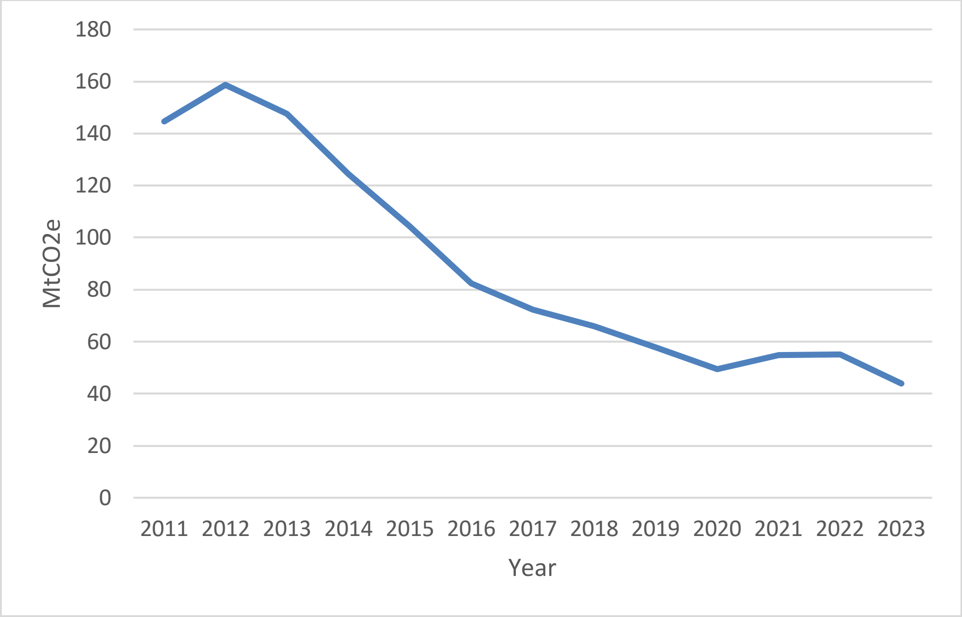
es.catapult.org.uk

Department for
Energy Security
& Net Zero

Environmental Assessment (SEA) and Habitats Regulation Assessment (HRA). Endorsement

Department for
Energy Security
& Net Zero


180
160
140
120
100
80
60
40
20
0
MtCO2e
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Year

batteries and demand side response.

introduced CO2 emissions limits in the Capacity Market.

on average. Existing plants which exceed these

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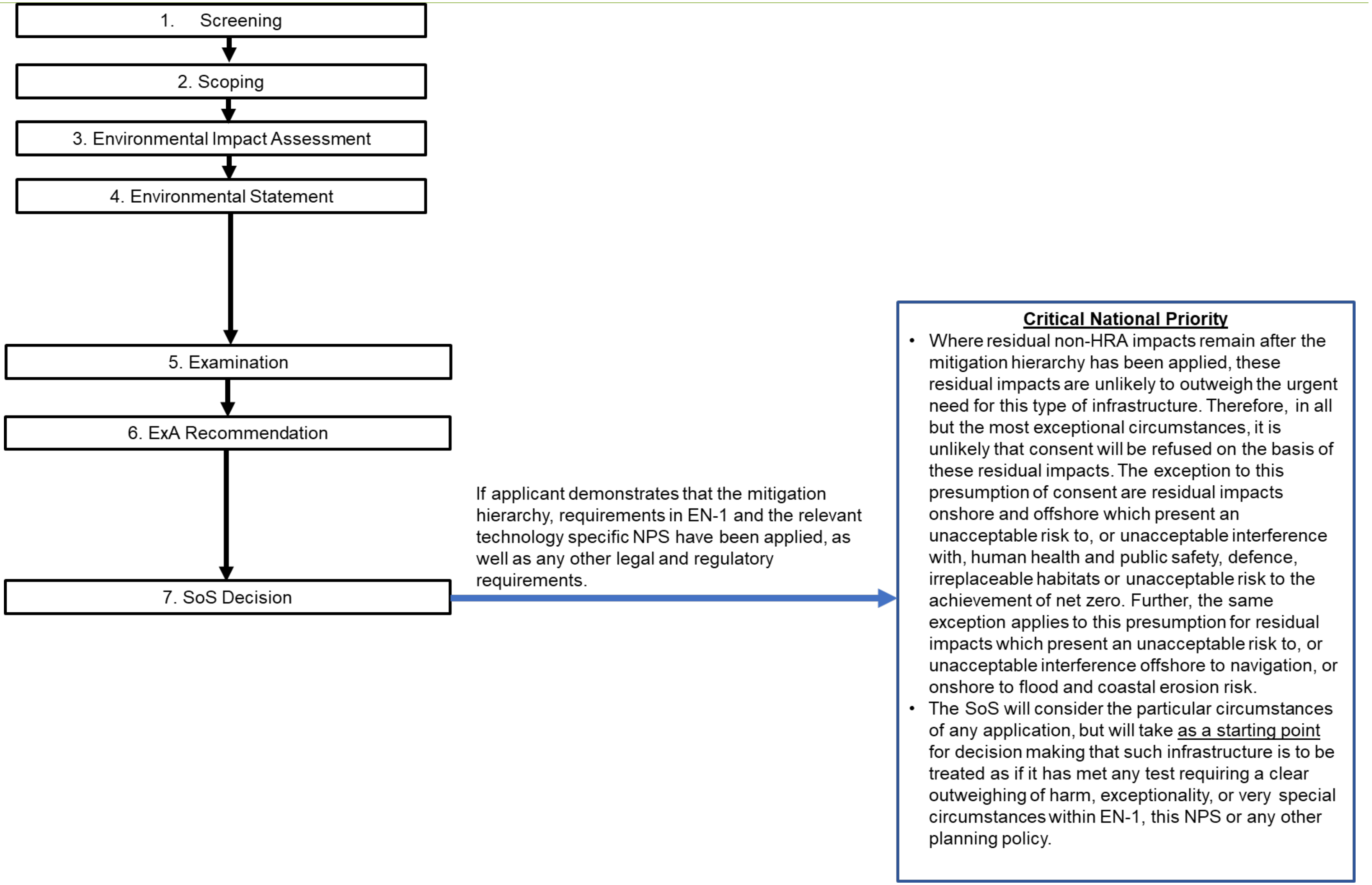
zero objectives. These amendments aim to improve access by

3.3.32



1. Screening

2. Scoping

3. Environmental Impact Assessment

4. Environmental Statement

5. Examination

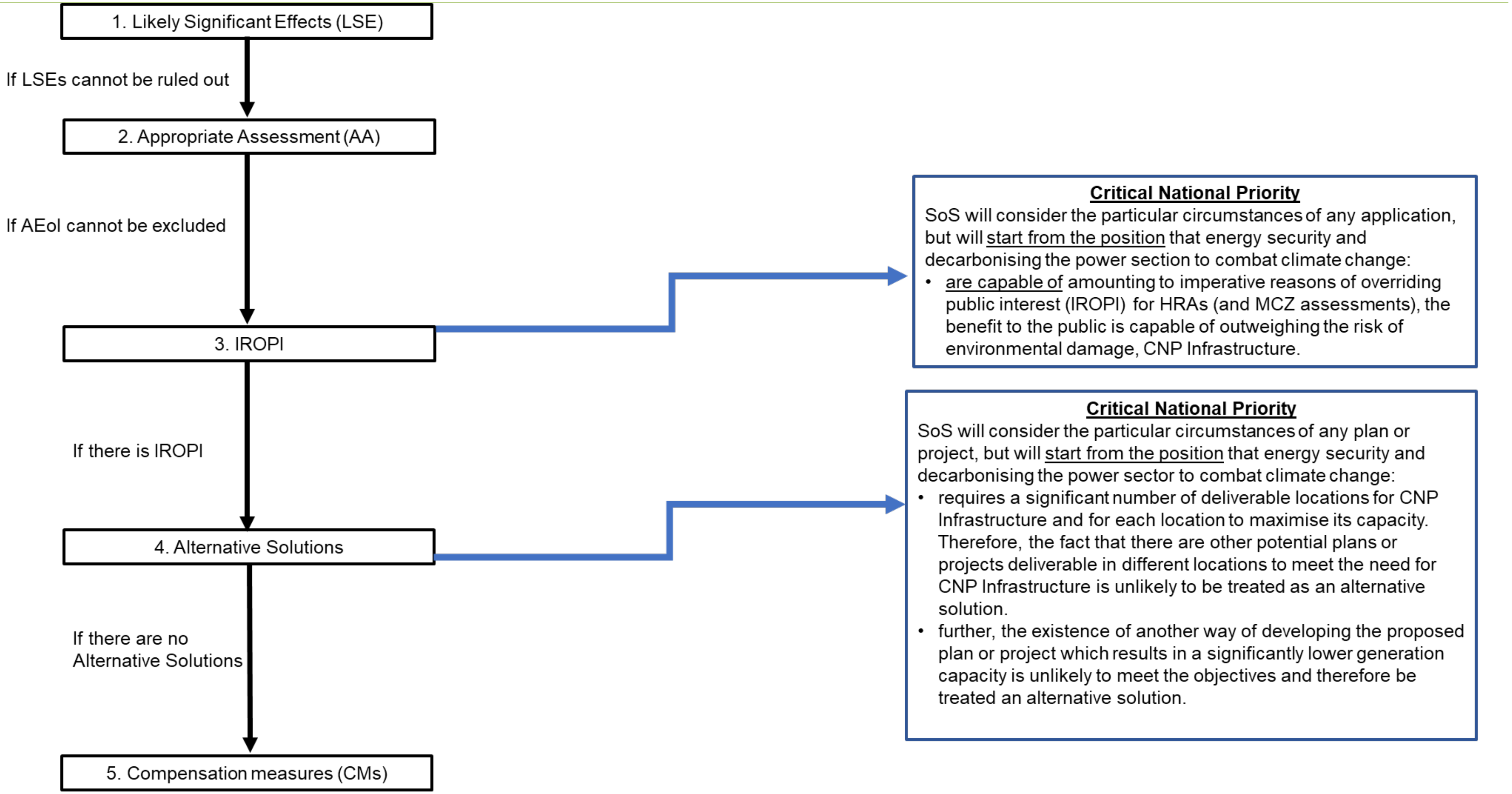
6. ExA Recommendation

7. SoS Decision

If applicant demonstrates that the mitigation hierarchy, requirements in EN-1 and the relevant technology specific NPS have been applied, as well as any other legal and regulatory requirements.

Critical National Priority

- Where residual non-HRA impacts remain after the mitigation hierarchy has been applied, these residual impacts are unlikely to outweigh the urgent need for this type of infrastructure. Therefore, in all but the most exceptional circumstances, it is unlikely that consent will be refused on the basis of these residual impacts. The exception to this presumption of consent are residual impacts onshore and offshore which present an unacceptable risk to, or unacceptable interference with, human health and public safety, defence, irreplaceable habitats or unacceptable risk to the achievement of net zero. Further, the same exception applies to this presumption for residual impacts which present an unacceptable risk to, or unacceptable interference offshore to navigation, or onshore to flood and coastal erosion risk.
- The SoS will consider the particular circumstances of any application, but will take as a starting point for decision making that such infrastructure is to be treated as if it has met any test requiring a clear outweighing of harm, exceptionality, or very special circumstances within EN-1, this NPS or any other planning policy.



1. Likely Significant Effects (LSE)

If LSEs cannot be ruled out

2. Appropriate Assessment (AA)

If AEoI cannot be excluded

3. IROPI

If there is IROPI

4. Alternative Solutions

If there are no Alternative Solutions

5. Compensation measures (CMs)

Critical National Priority

SoS will consider the particular circumstances of any application, but will start from the position that energy security and decarbonising the power section to combat climate change:

- are capable of amounting to imperative reasons of overriding public interest (IROPI) for HRAs (and MCZ assessments), the benefit to the public is capable of outweighing the risk of environmental damage, CNP Infrastructure.

Critical National Priority

SoS will consider the particular circumstances of any plan or project, but will start from the position that energy security and decarbonising the power sector to combat climate change:

- requires a significant number of deliverable locations for CNP Infrastructure and for each location to maximise its capacity. Therefore, the fact that there are other potential plans or projects deliverable in different locations to meet the need for CNP Infrastructure is unlikely to be treated as an alternative solution.
- further, the existence of another way of developing the proposed plan or project which results in a significantly lower generation capacity is unlikely to meet the objectives and therefore be treated an alternative solution.

The Environmental Improvement Plan

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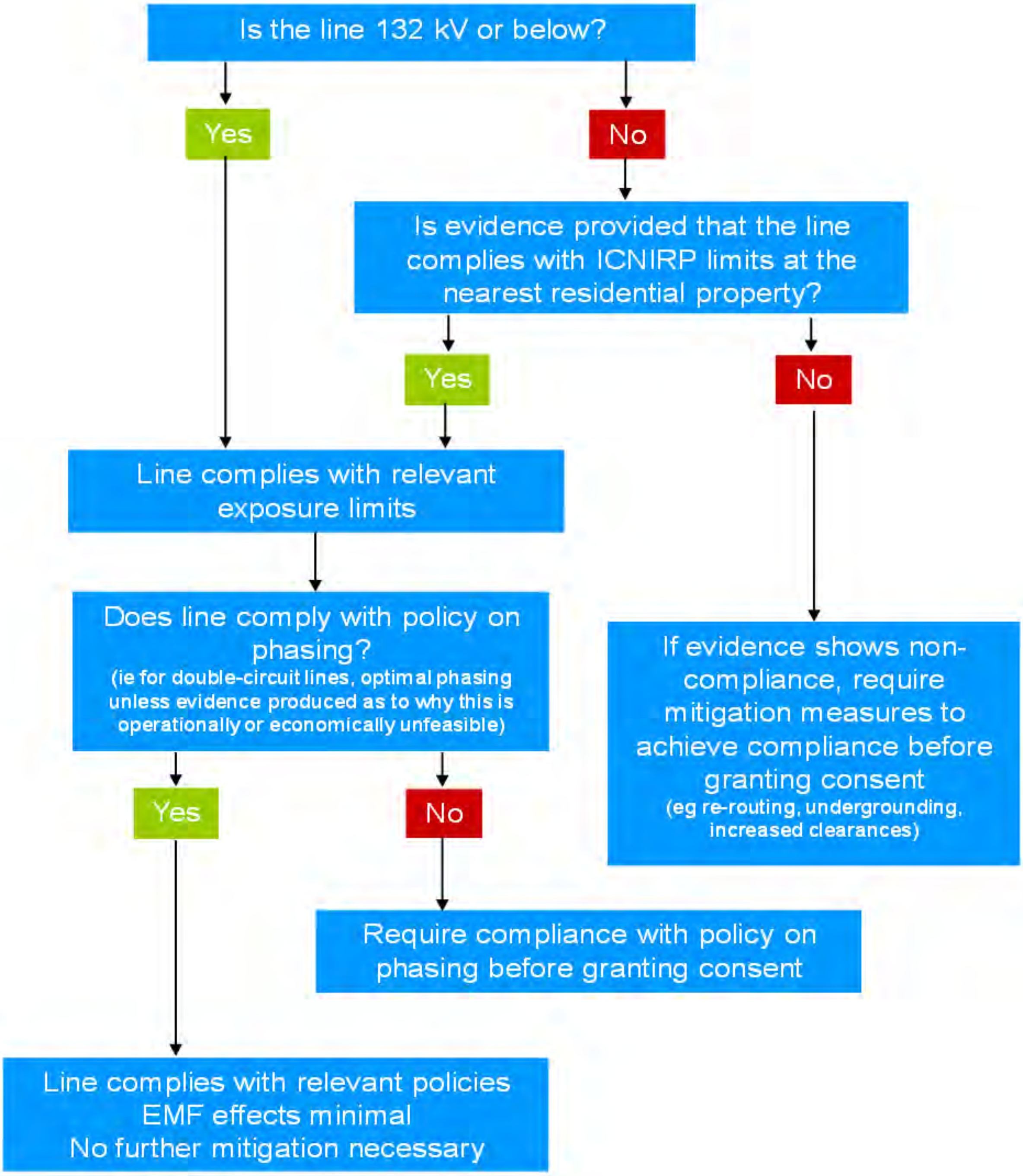
Department for
Energy Security
& Net Zero

at


Is the line 132 kV or below?
Yes
No
Is evidence provided that the line complies with ICNIRP limits at the nearest residential property?
Yes
No
Line complies with relevant exposure limits
If evidence shows non-compliance, require mitigation measures to achieve compliance before granting consent
(eg re-routing, undergrounding, increased clearances)
Does line comply with policy on phasing?
(ie for double-circuit lines, optimal phasing unless evidence produced as to why this is operationally or economically unfeasible)
Yes
No
Require compliance with policy on phasing before granting consent
Line complies with relevant policies
EMF effects minimal
No further mitigation necessary

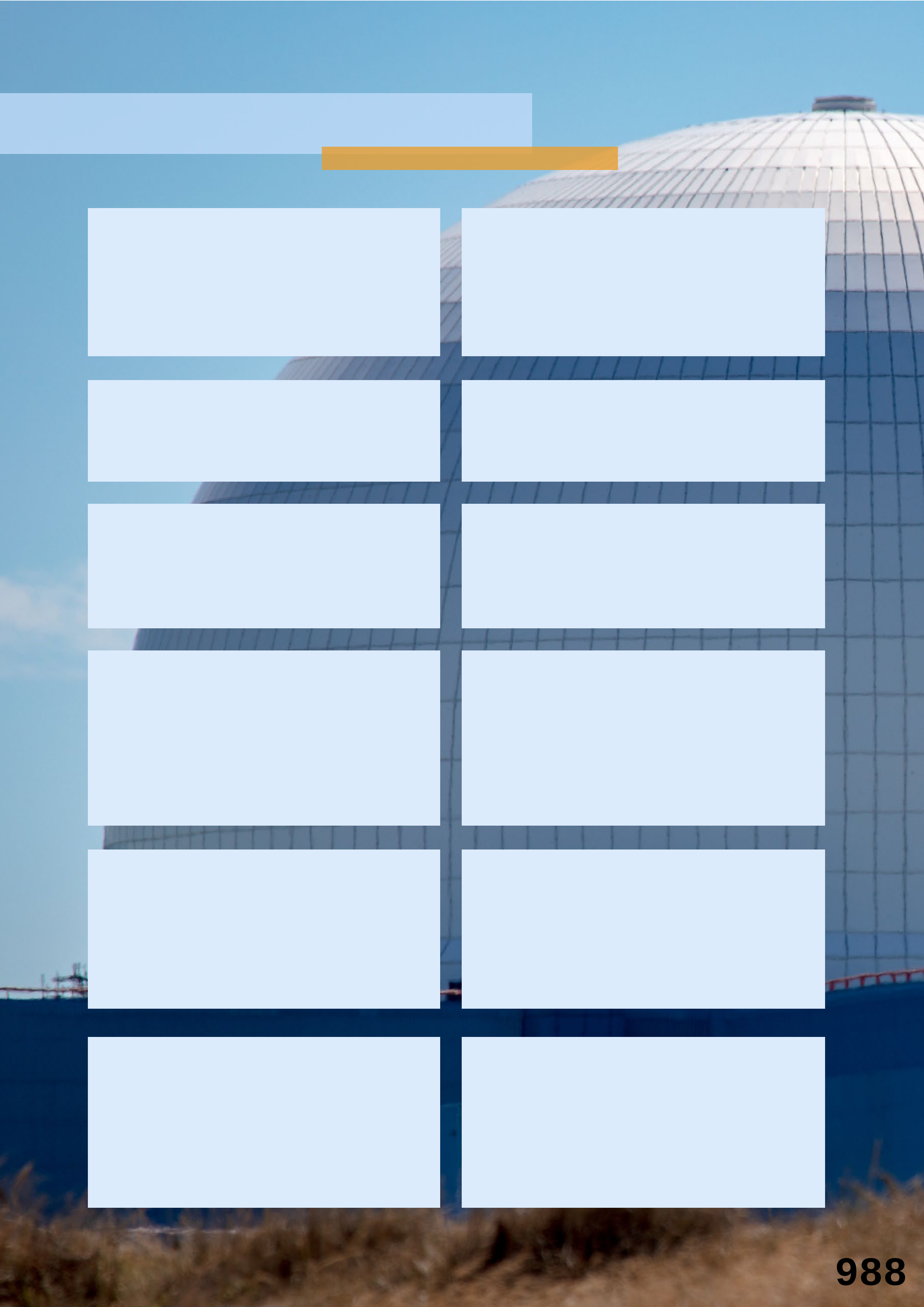
HM Government

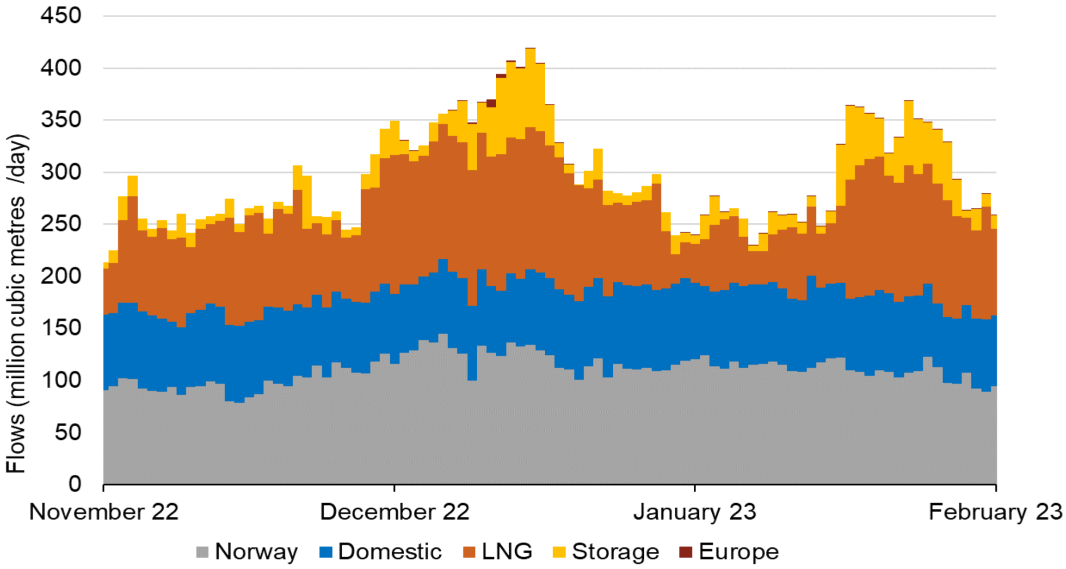
POWERING UP BRITAIN

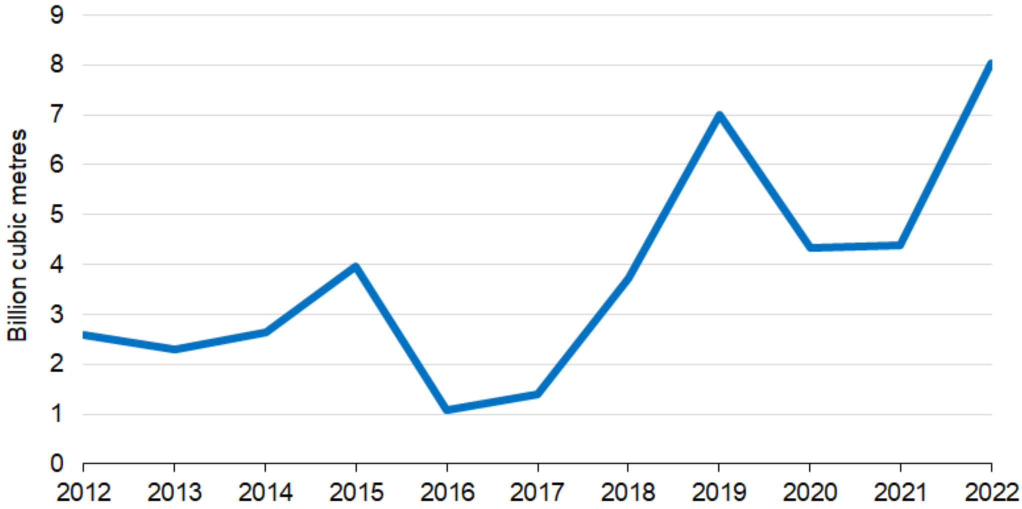
ENERGY SECURITY PLAN

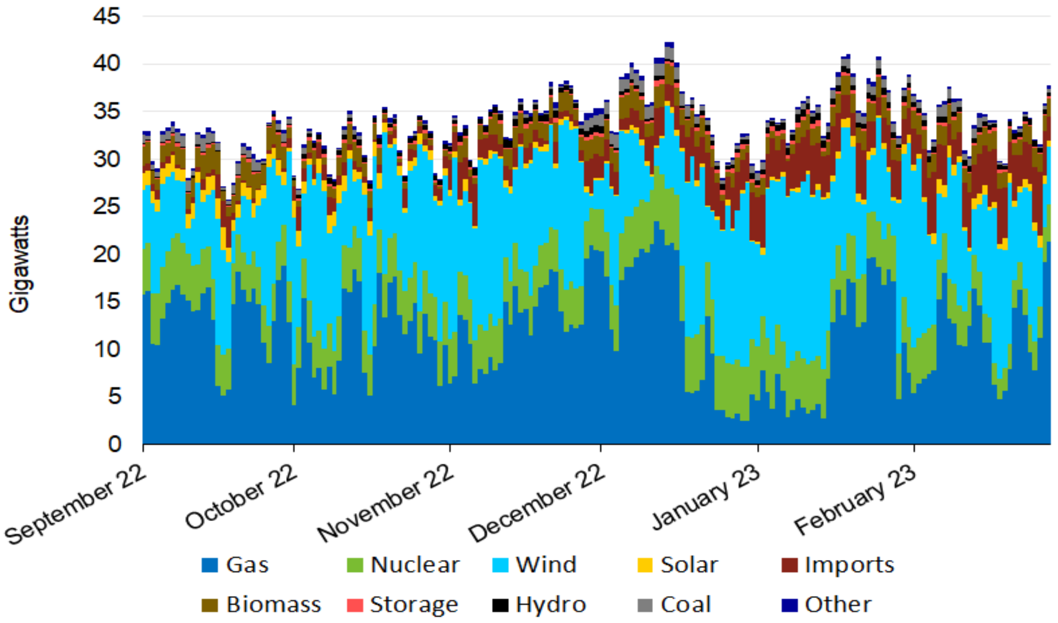
March 2023

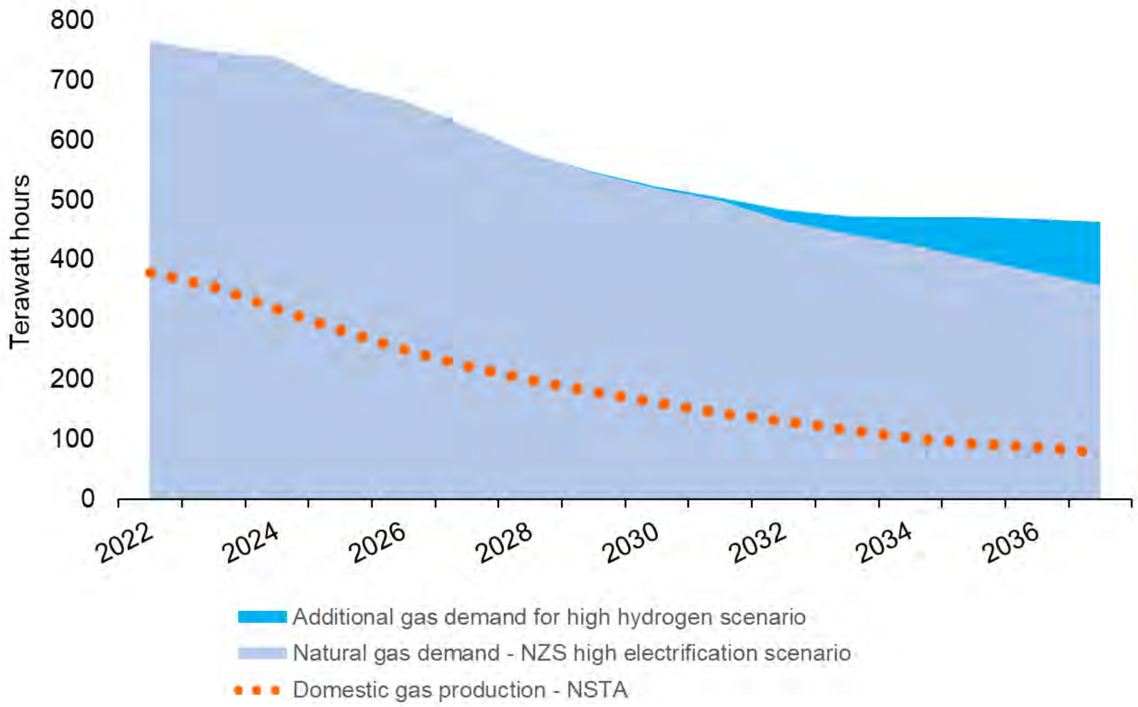

11:53
£61.72
£148
£0.09/hr
So far this month




Flows (million cubic metres /day)
450
400
350
300
250
200
150
100
50
0
November 22
December 22
January 23
February 23
Norway
Domestic
LNG
Storage
Europe


Billion cubic metres
9
8
7
6
5
4
3
2
1
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022


Gigawatts
45
40
35
30
25
20
15
10
5
0
September 22
October 22
November 22
December 22
January 23
February 23
Gas
Nuclear
Wind
Solar
Imports
Biomass
Storage
Hydro
Coal
Other



Terawatt hours
800
700
600
500
400
300
200
100
0
2022
2024
2026
2028
2030
2032
2034
2036
Additional gas demand for high hydrogen scenario
Natural gas demand - NZS high electrification scenario
Domestic gas production - NSTA

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HM Government

POWERING UP BRITAIN

March 2023

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- A strategic framework and delivery plan for the critical networks of the future to turbocharge onshore and offshore development

1. Grid and Infrastructure

- Full-scale deployment of solar including a rooftop revolution to harness one of the cheapest forms of energy, increase our energy independence and deliver up to 70GW of British solar generation by 2035

2. Solar

- Pave the way for onshore deployment, working closely with communities to deliver local benefits

3. Onshore Wind

- A programmatic approach for a next generation fleet of nuclear, supporting a high-tech British industry covering the whole supply chain

4. Nuclear

- Setting a clear plan for industry decarbonisation built around long term investment in CCUS and hydrogen networks and technologies

5. Energy Intensives and Industry

- Stimulate the efficient and circular use of resources across the economy, galvanising action on recycling and the reuse of critical materials

6. Circular Economy and Waste

- Unblocking the planning system and reforming the relationship between central and local government to give local authorities and communities the power they need to act on net zero

7. Net Zero Local Big Bang

- Working towards gas free homes by 2035 and giving consumers greater understanding of their household through a new Net Zero Performance Certificate

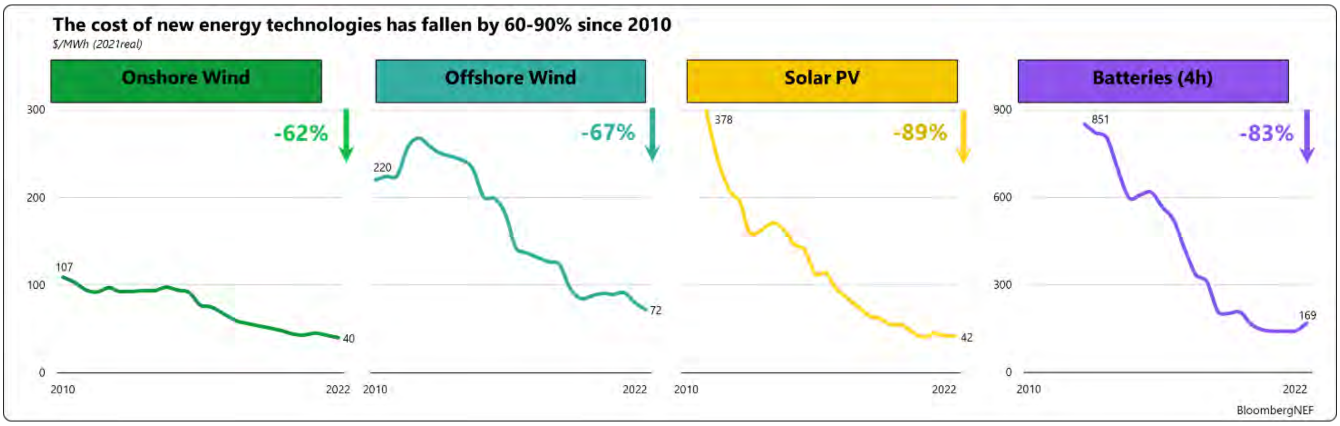
8. Energy Efficiency For Households

- Embed nature and habitat restoration throughout transition plans, maximising co-benefits for climate and nature wherever possible

9. Net Zero Nature

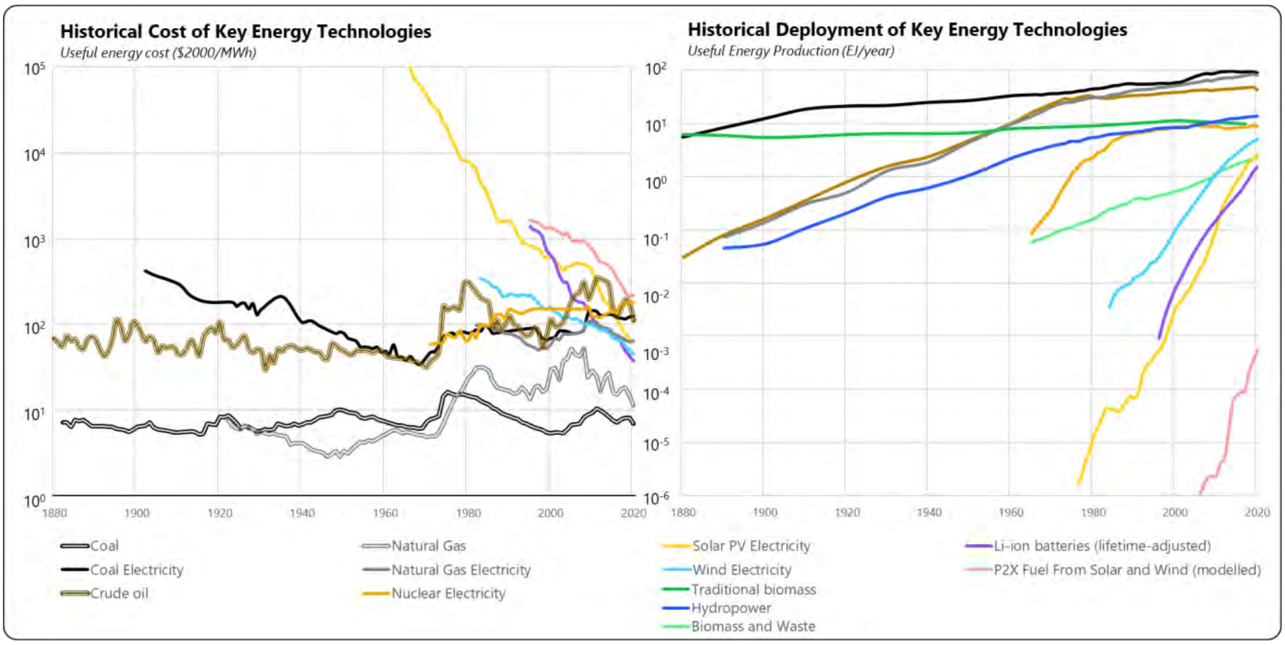
- Catalyse decisions and action with an R&D and technology roadmap to 2050, pushing for more agile regulation, and supporting up to three 10-year demonstrators

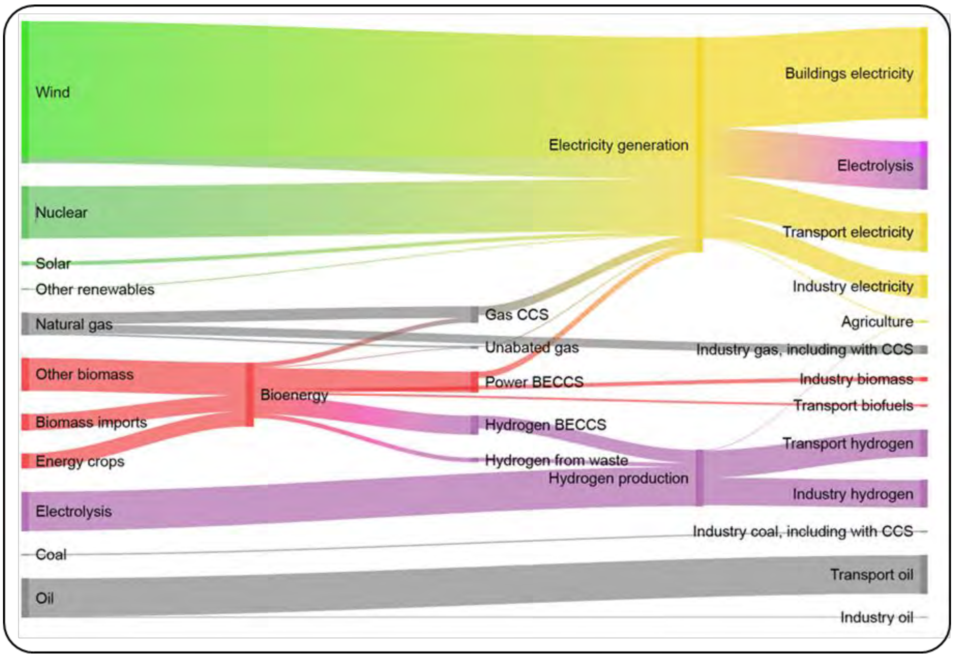
10. R&D And Innovation


The cost of new energy technologies has fallen by 60-90% since 2010

$/MWh (2021real)

BloombergNEF


Historical Cost of Key Energy Technologies
Useful energy cost ($2000/MWh)
10^5
10^4
10^3
10^2
10^1
10^0
1880
1900
1920
1940
1960
1980
2000
2020
Historical Deployment of Key Energy Technologies
Useful Energy Production (EJ/year)
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
1880
1900
1920
1940
1960
1980
2000
2020
Coal
Coal Electricity
Crude oil
Natural Gas
Natural Gas Electricity
Nuclear Electricity
Solar PV Electricity
Wind Electricity
Traditional biomass
Hydropower
Biomass and Waste
Li-ion batteries (lifetime-adjusted)
P2X Fuel From Solar and Wind (modelled)


Wind
Electricity generation
Buildings electricity
Electrolysis
Nuclear
Transport electricity
Solar
Other renewables
Industry electricity
Agriculture
Natural gas
Gas CCS
Unabated gas
Industry gas, including with CCS
Other biomass
Bioenergy
Power BECCS
Industry biomass
Transport biofuels
Biomass imports
Hydrogen BECCS
Transport hydrogen
Energy crops
Hydrogen from waste
Hydrogen production
Industry hydrogen
Electrolysis
Industry coal, including with CCS
Coal
Transport oil
Oil
Industry oil

o

o

o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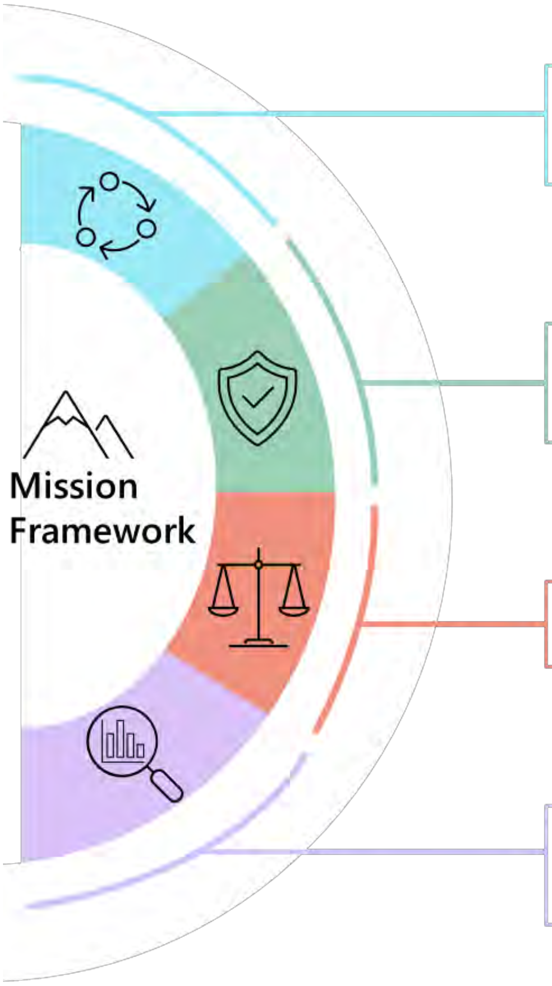


Continuity

Across people, policy areas and time.

Certainty

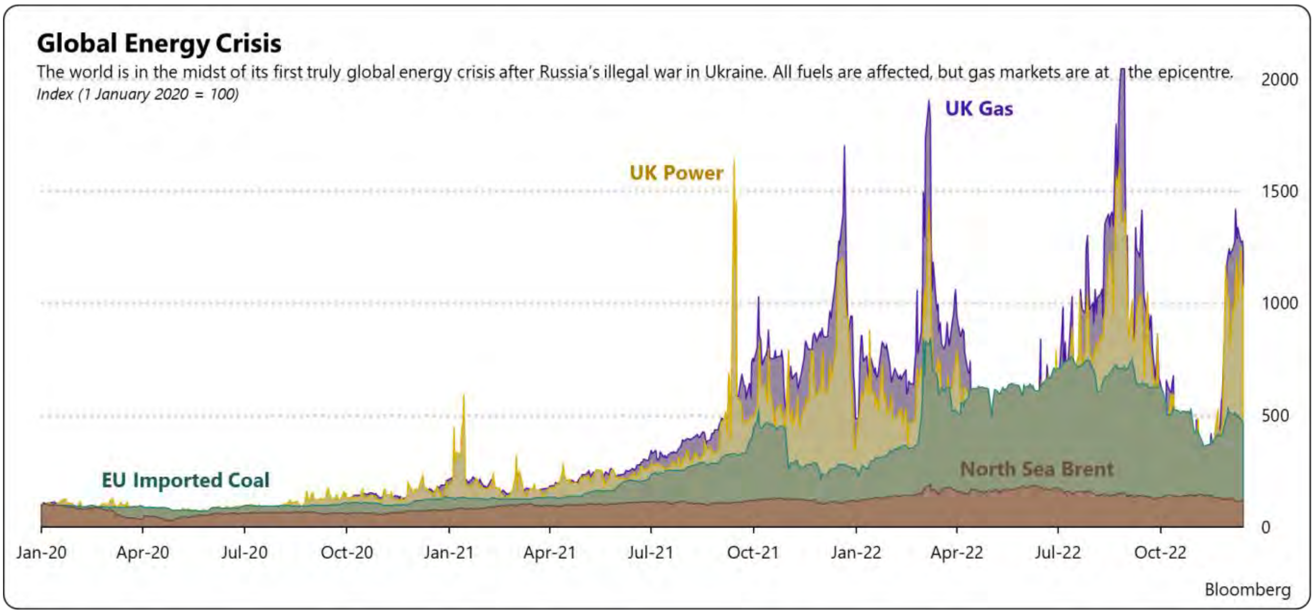
On funding, business environment and regulation.

Consistency

Creating a level playing field.

Clarity

Data to inform future decision making.



Global Energy Crisis

The world is in the midst of its first truly global energy crisis after Russia's illegal war in Ukraine. All fuels are affected, but gas markets are at the epicentre.

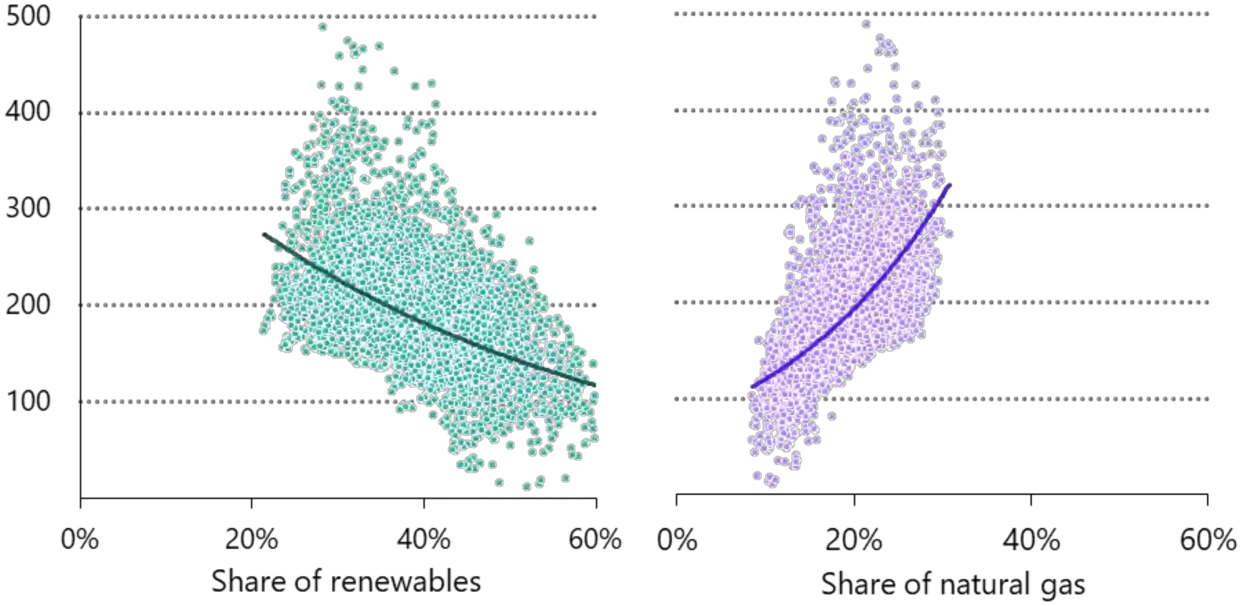
Index (1 January 2020 = 100)

Bloomberg

Hourly Wholesale Electricity Prices in the EU in the First Half of 2022

High shares of renewables in electricity supply drove down wholesale electricity, while high shares of natural gas pushed them up.

€ per MWh

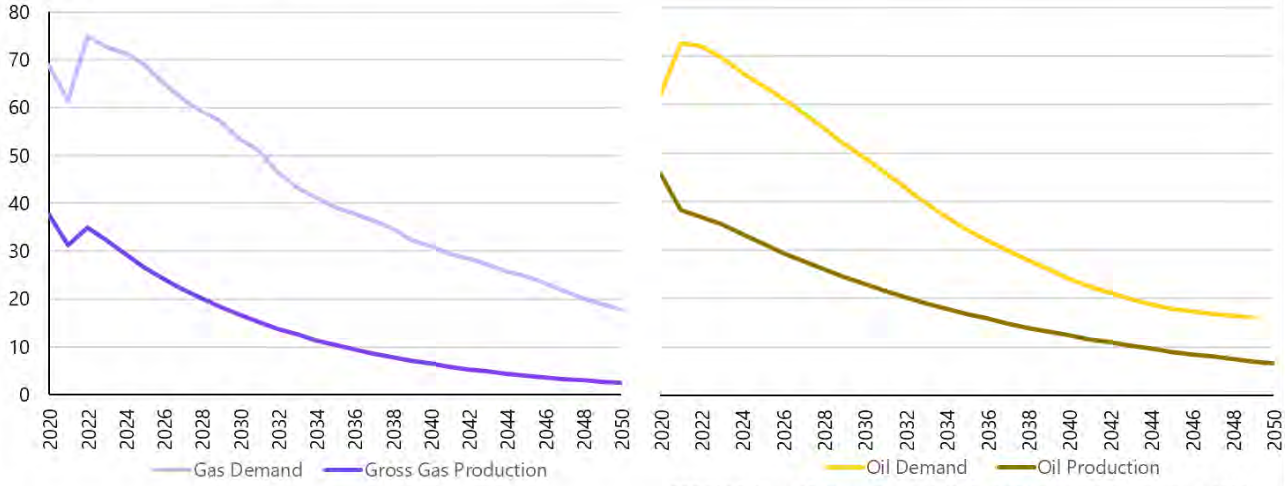


IEA analysis based on data from the ENTSO-E Transparency Platform

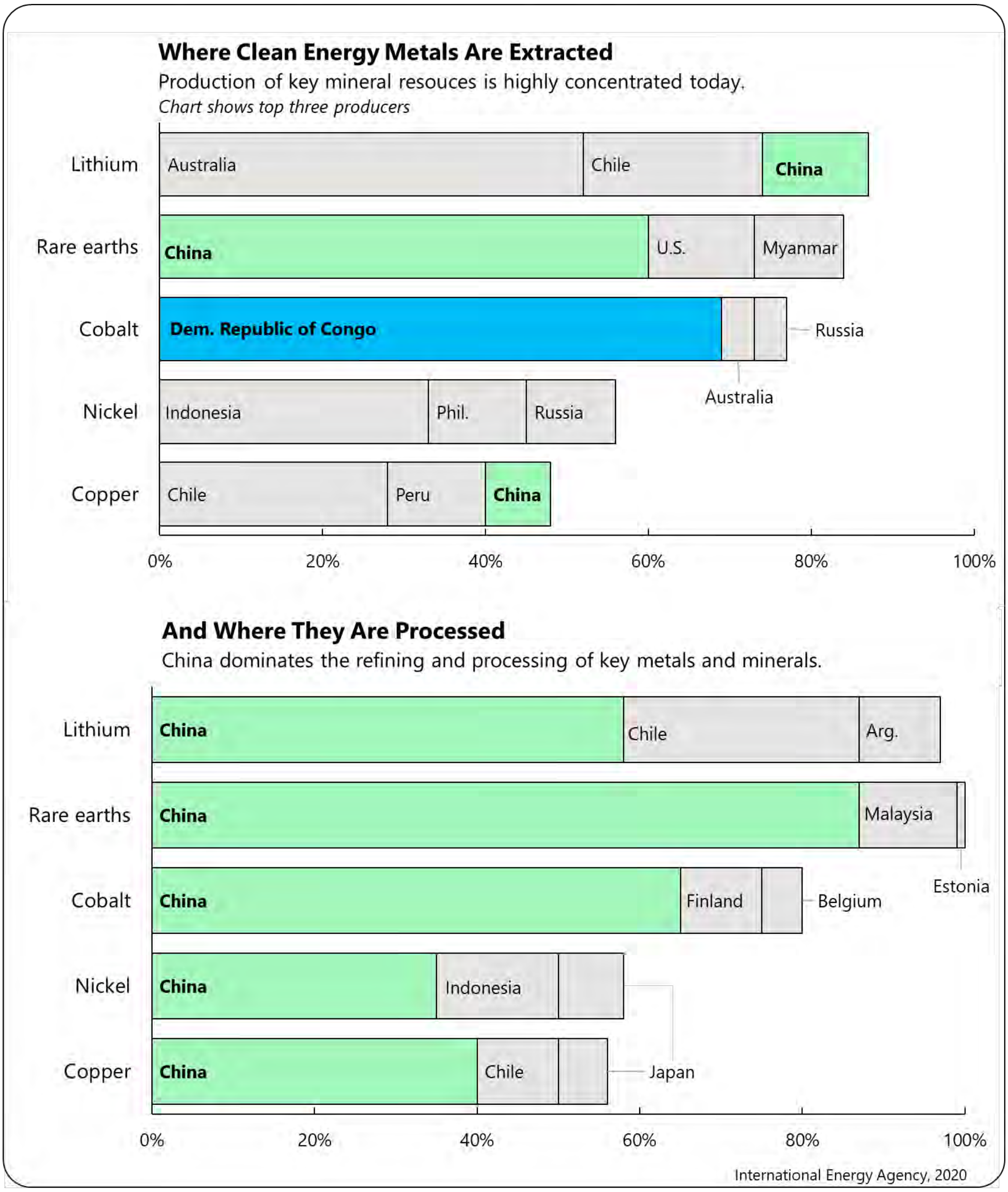
Longevity of Hydrocarbons

CCC's *balanced pathway* demand scenario for oil and gas never falls below NSTA's production projections

Mtoe



CCC CB6 Balanced Pathway Demand, 2020 • NSTA Production Projections, 2022



Where Clean Energy Metals Are Extracted

Production of key mineral resouces is highly concentrated today.

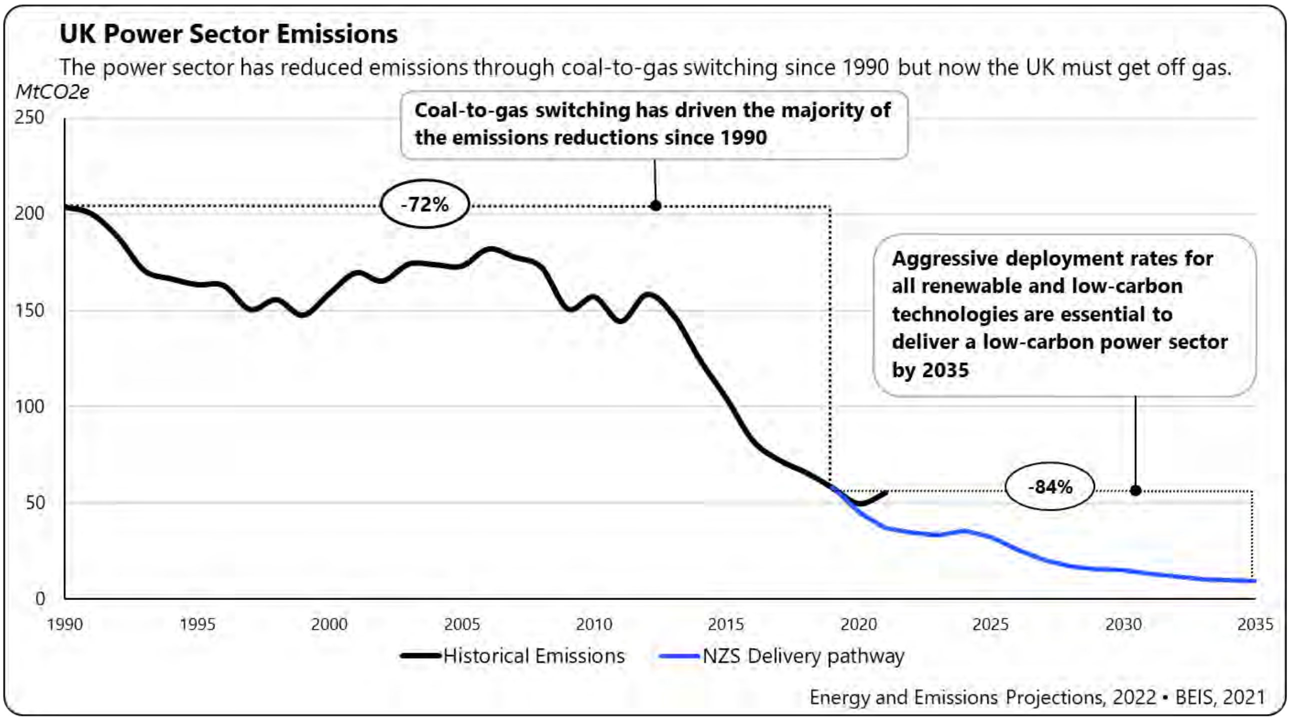
Chart shows top three producers

And Where They Are Processed

China dominates the refining and processing of key metals and minerals.

International Energy Agency, 2020

Option	Description	Examples	Advantages	Disadvantages	Key considerations
Lower tax on electricity for heating	Lowering the tax rate applied to electricity that is used for heating	Denmark	Simplicity No negative impact on low-income customers	Loss in revenue If tax rate is low to start with, impact is limited	Potential for incentivising excessive electric resistive heating
Shift levies to fossil fuels	Levies are shifted from electricity to fossil fuels	Netherlands	Simultaneously lowers cost of clean heating and increases cost of fossil heating	Impact on low-income customers using fossil fuels	Need to ensure low-income customers are not disadvantaged, and protected from impact
Shift levies to public budget	Levies are shifted to the public budget	Germany	No negative impact on low-income customers	Additional cost item in public budget	Potentially less stable funding for clean energy programmes previously funded through levies
Environmental taxation	Fossil fuels are taxed based on environmental impacts	Swedish carbon tax	Simplicity Source of additional revenue to support heat decarbonisation	Impact on low-income customers using fossil fuels	Need to ensure low-income customers are not disadvantaged, and protected from impact



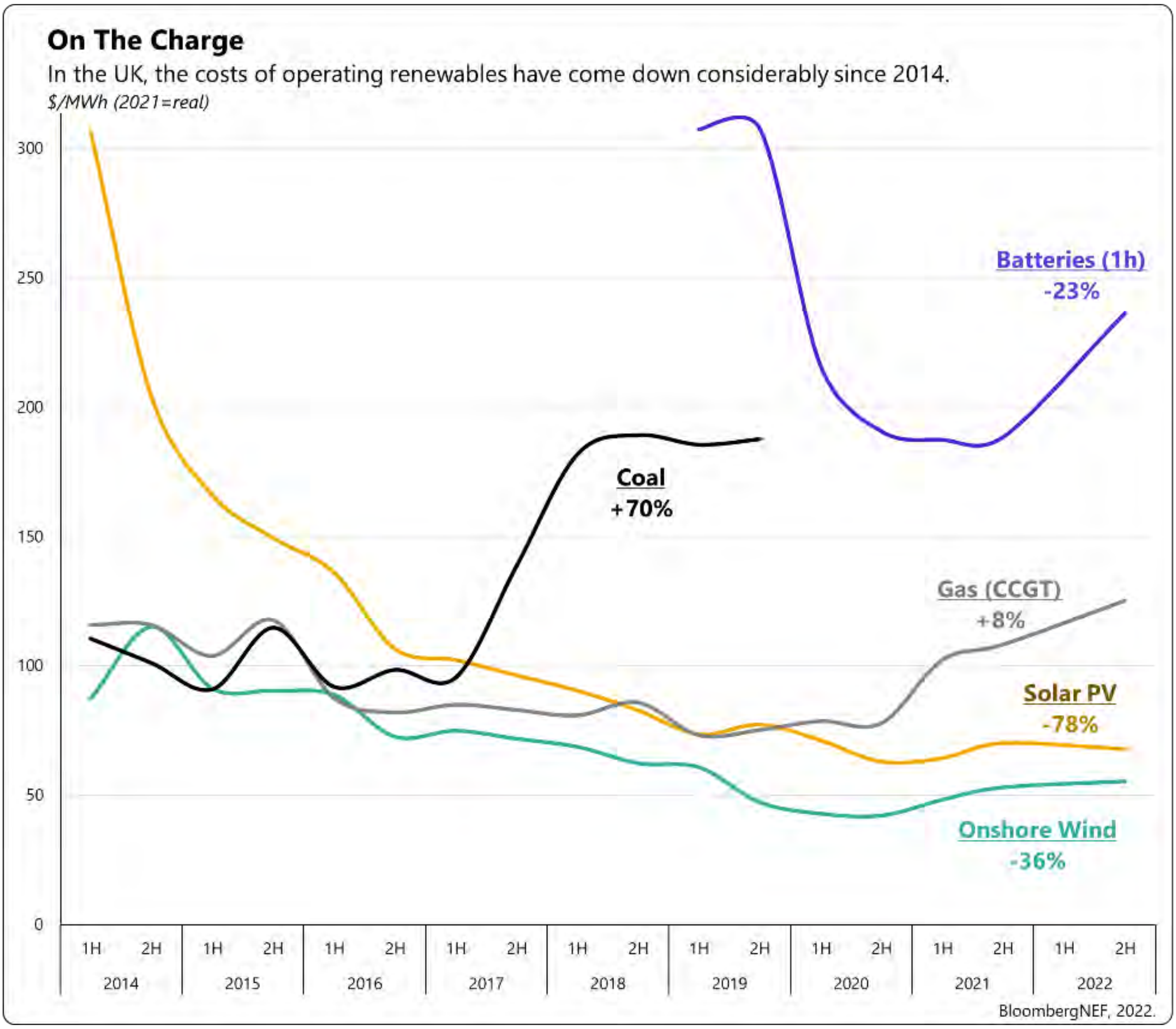
UK Power Sector Emissions

The power sector has reduced emissions through coal-to-gas switching since 1990 but now the UK must get off gas.

Coal-to-gas switching has driven the majority of the emissions reductions since 1990

Aggressive deployment rates for all renewable and low-carbon technologies are essential to deliver a low-carbon power sector by 2035

Energy and Emissions Projections, 2022 • BEIS, 2021


On The Charge

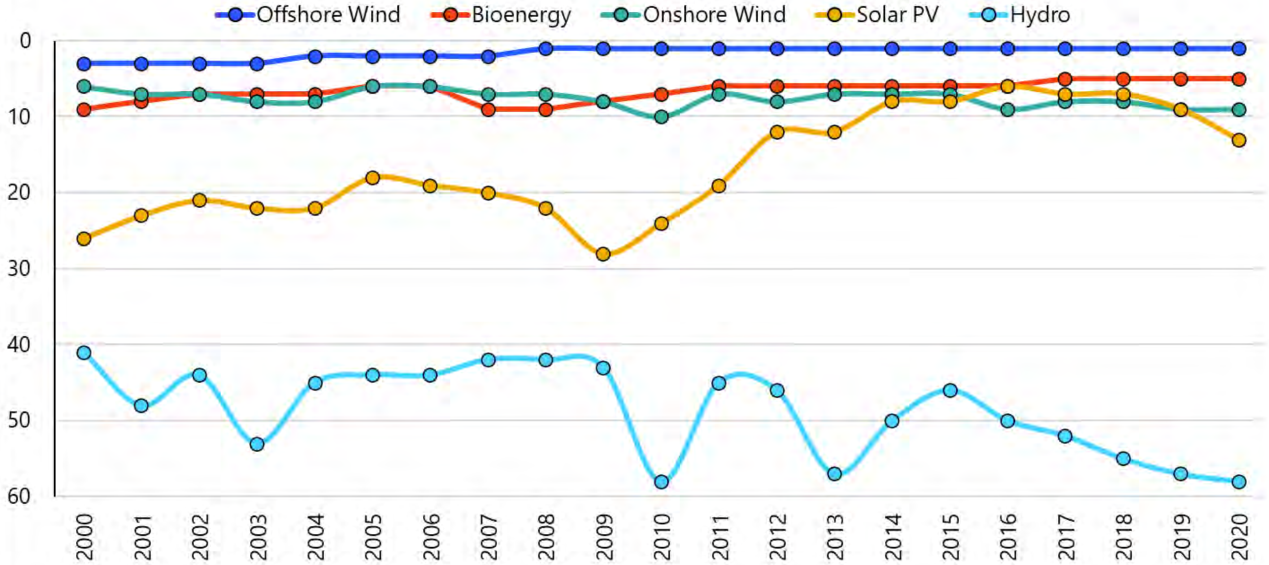
In the UK, the costs of operating renewables have come down considerably since 2014.

BloombergNEF, 2022.

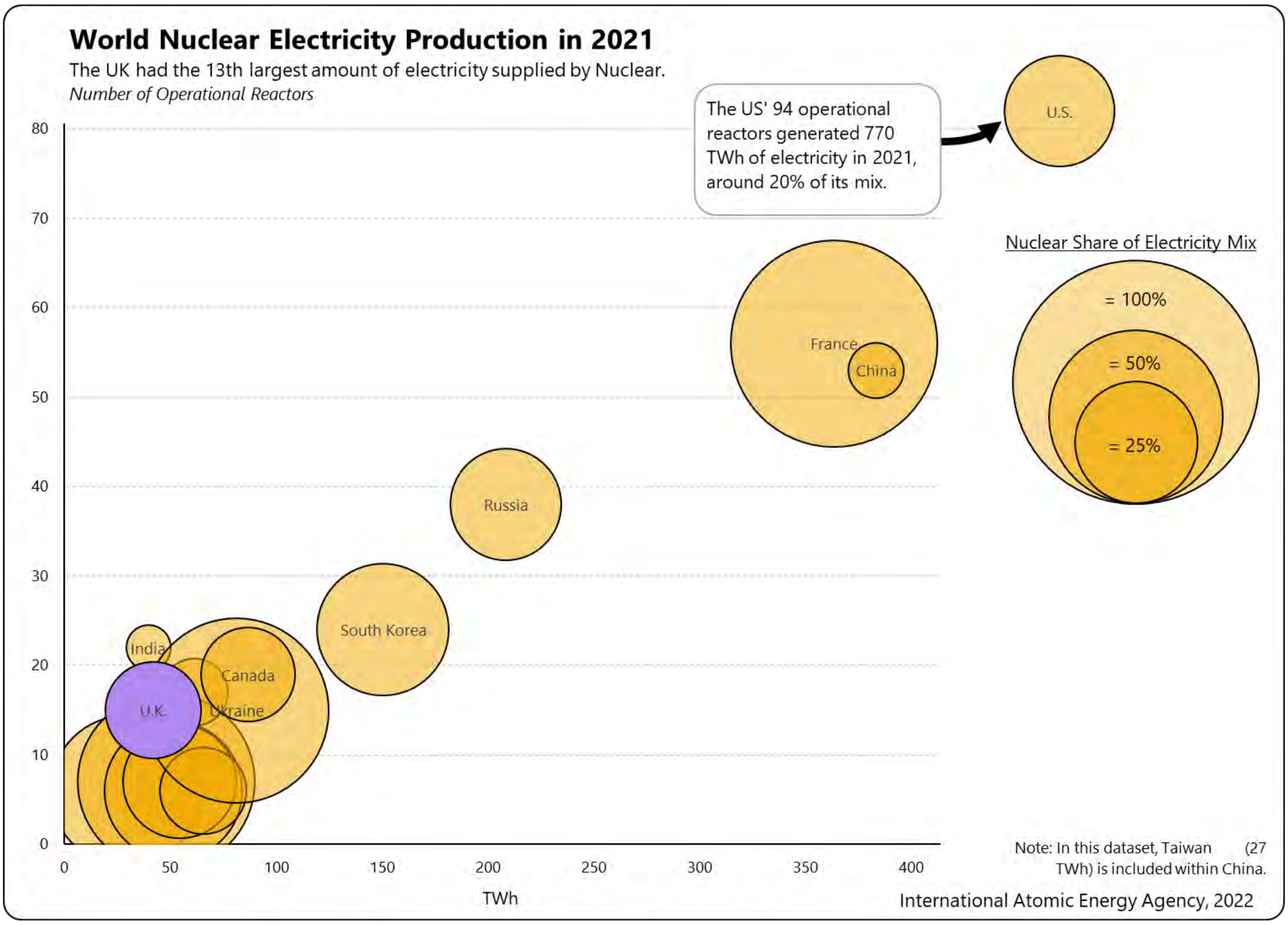
Tailwinds

While the UK is a world-leader in wind technology, there are other opportunities to go further, faster.

UK world ranking for key renewable technologies electricity generation (GWh)



IRENA, 2021



World Nuclear Electricity Production in 2021

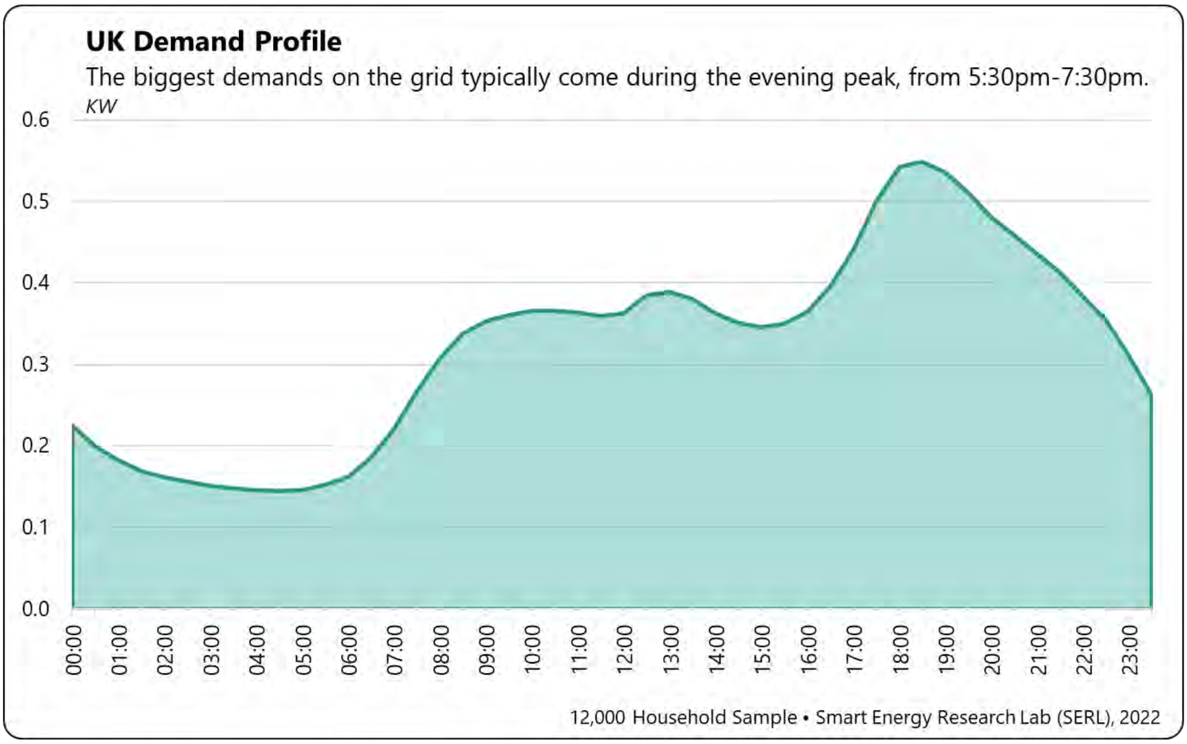
The UK had the 13th largest amount of electricity supplied by Nuclear.

Number of Operational Reactors

The US' 94 operational reactors generated 770 TWh of electricity in 2021, around 20% of its mix.

Note: In this dataset, Taiwan (27 TWh) is included within China.

International Atomic Energy Agency, 2022

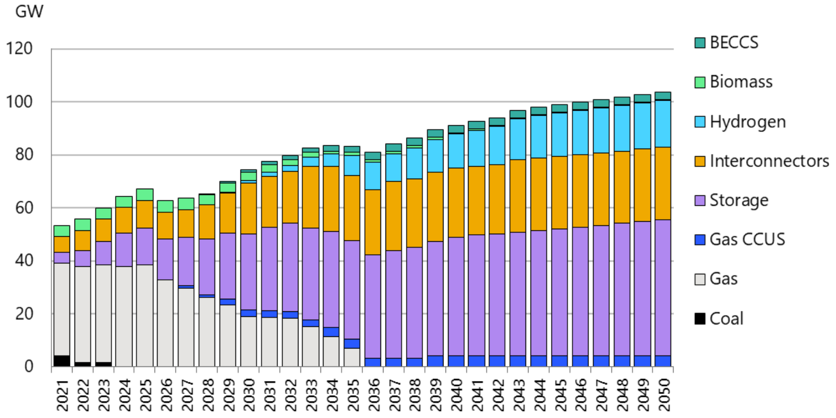


UK Demand Profile

The biggest demands on the grid typically come during the evening peak, from 5:30pm-7:30pm.

12,000 Household Sample • Smart Energy Research Lab (SERL), 2022

Dispatchable Electricity Supply Sources in *Leading the Way* Scenario

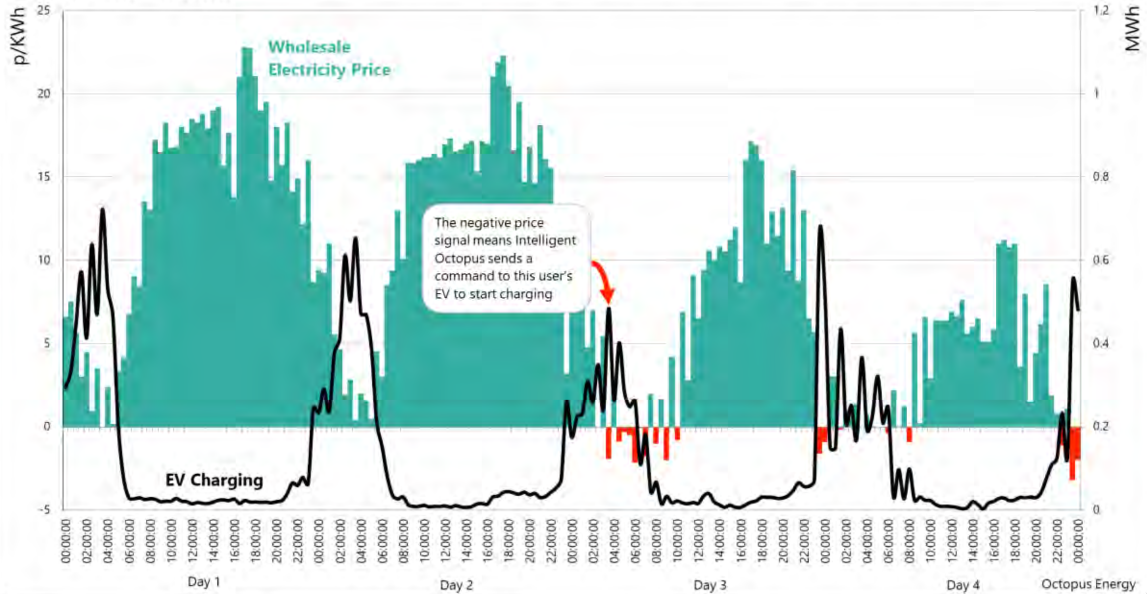


National Grid ESO's Future Energy Scenarios, 2022

Flexible Charging

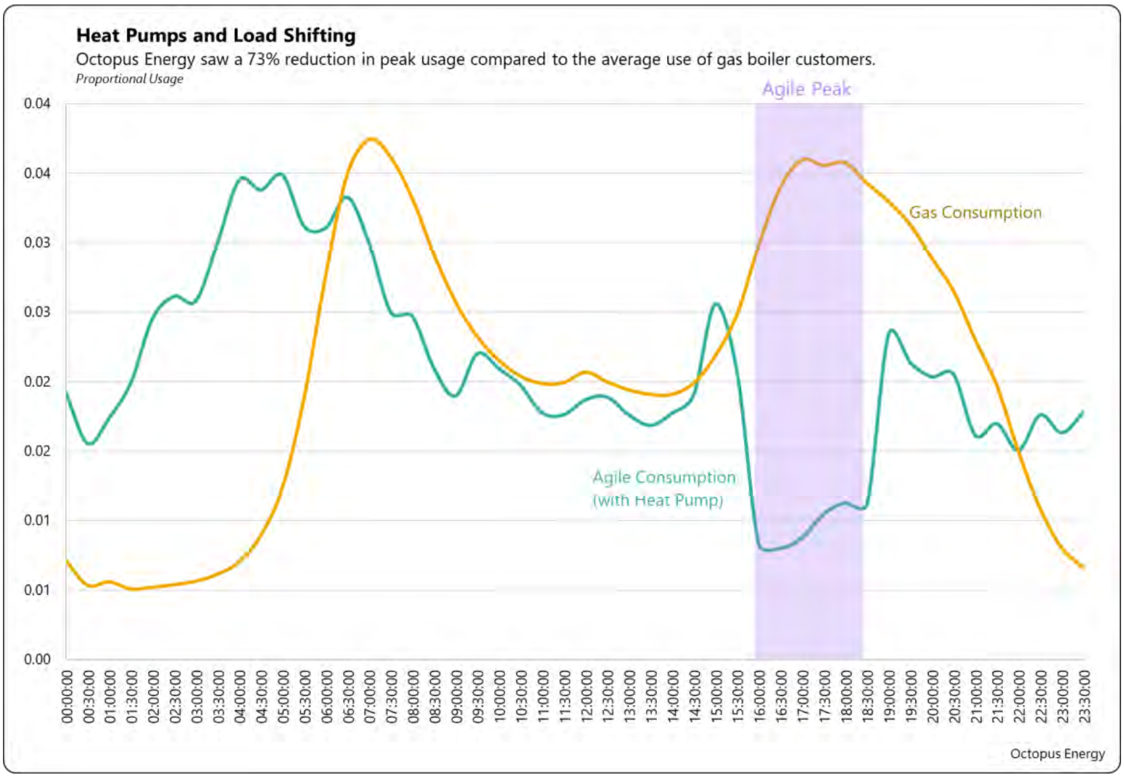
In this user's demand profile, their EV is being charged overnight when wholesale prices are low or negative

30/12/2021 - 03/01/2022



The negative price signal means Intelligent Octopus sends a command to this user's EV to start charging

Octopus Energy

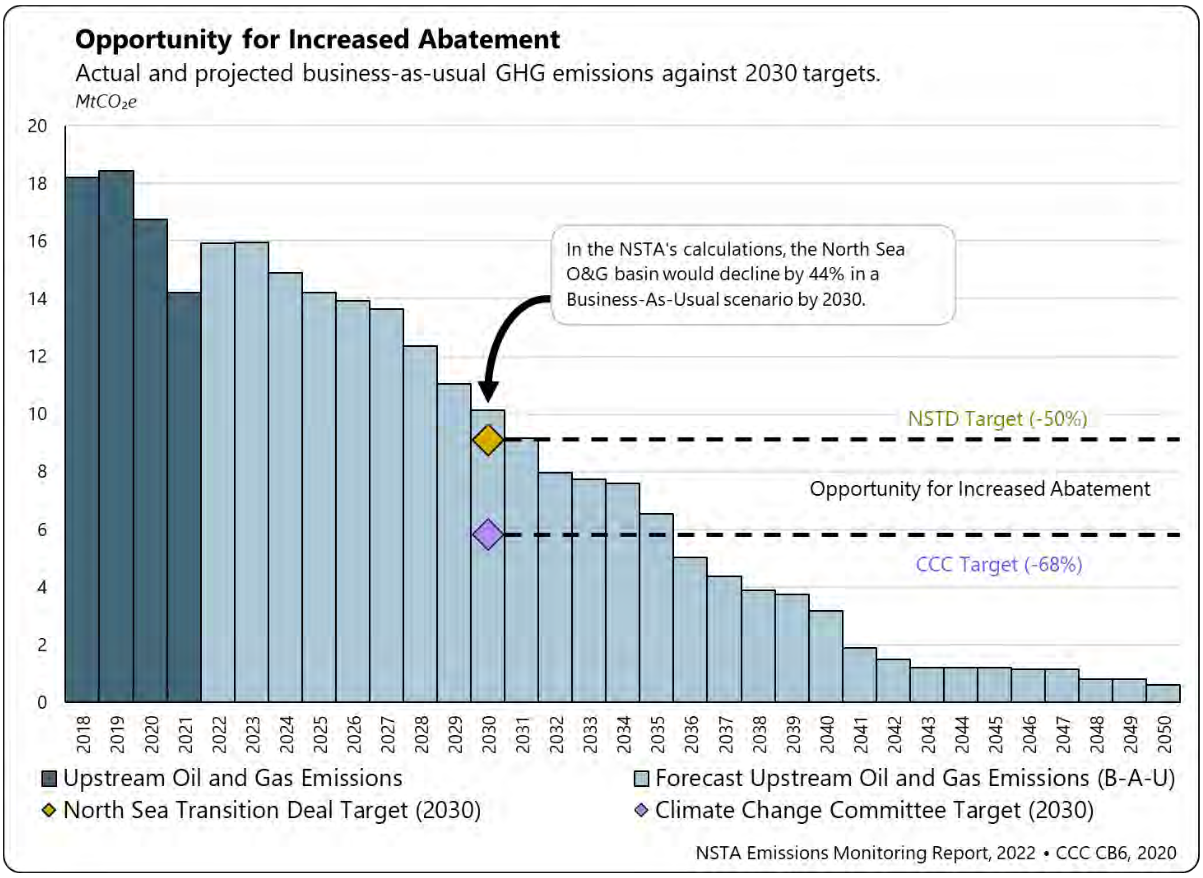


Heat Pumps and Load Shifting

Octopus Energy saw a 73% reduction in peak usage compared to the average use of gas boiler customers.

Octopus Energy

A



Opportunity for Increased Abatement

Actual and projected business-as-usual GHG emissions against 2030 targets.

In the NSTA's calculations, the North Sea O&G basin would decline by 44% in a Business-As-Usual scenario by 2030.

NSTA Emissions Monitoring Report, 2022 • CCC CB6, 2020

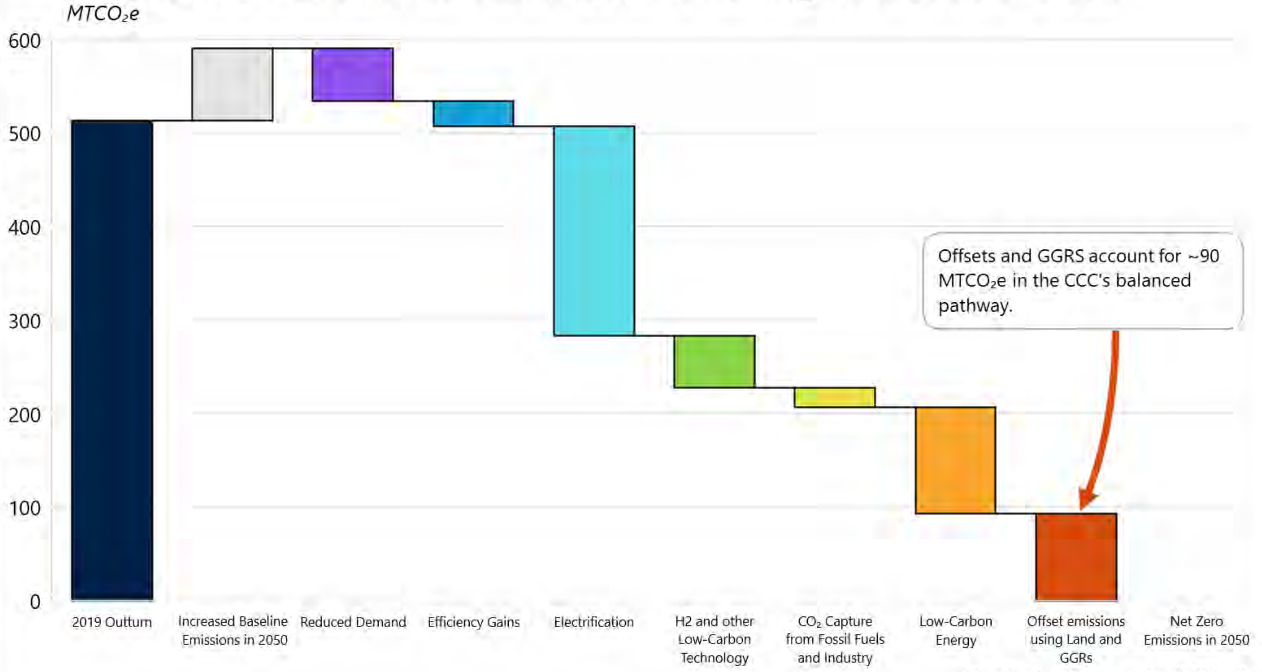
2

2

2

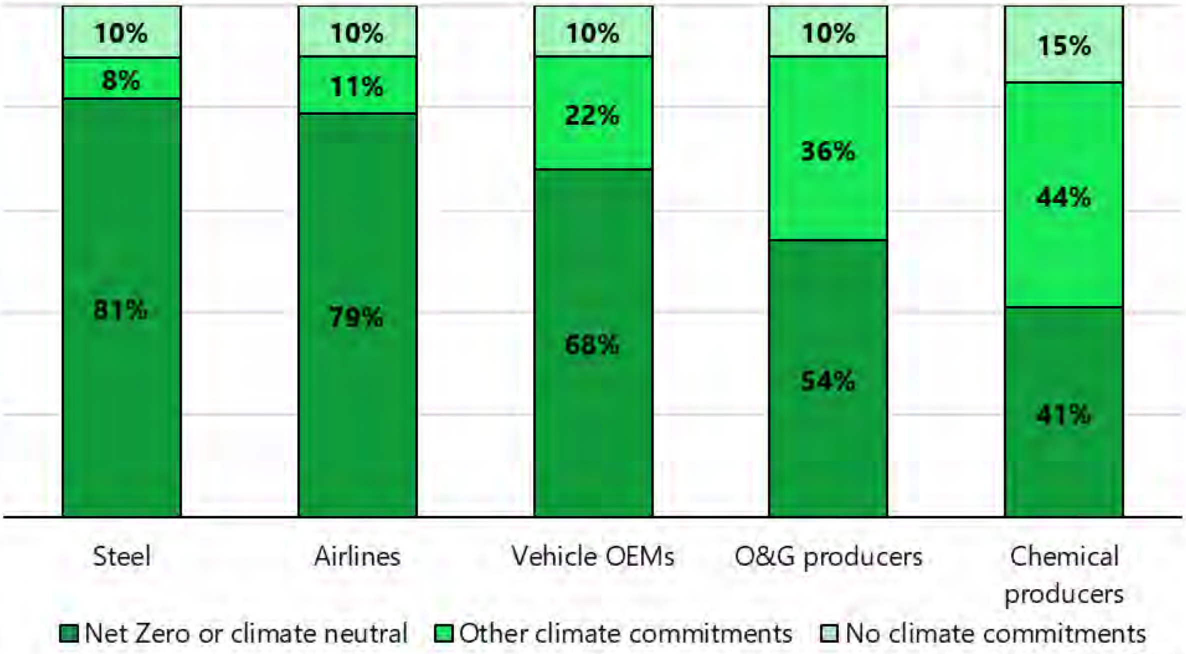
Removals will be needed to acheive net zero

Outturn 2019 emissions and how those emissions can be mitigated to acheieve net zero.



Offsets and GGRS account for ~90 $MTCO_2e$ in the CCC's balanced pathway.

Climate Change Committee CB6, 2020

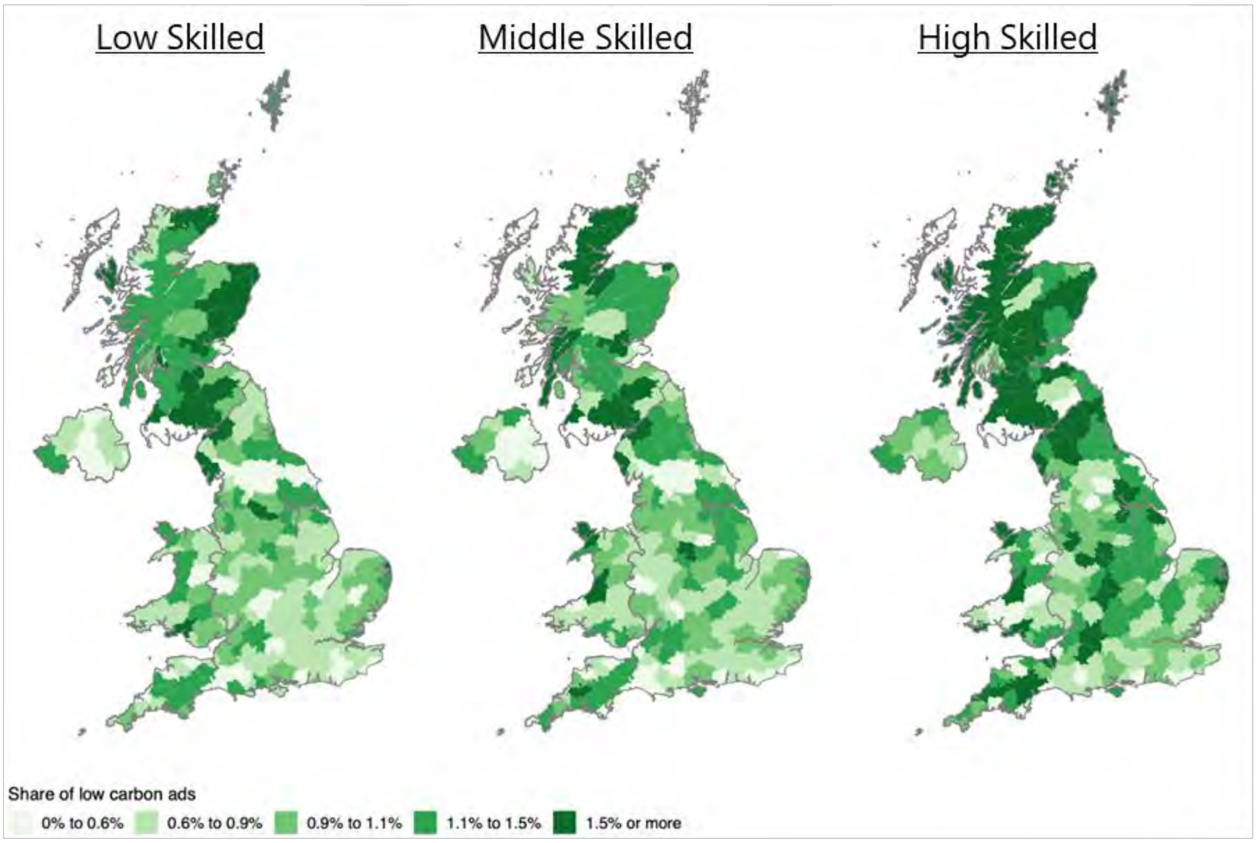


Climate Commitments of the Top 20 Corporations

Even in heavy fossil fuel usage sectors, companies are pledging to get to net zero.

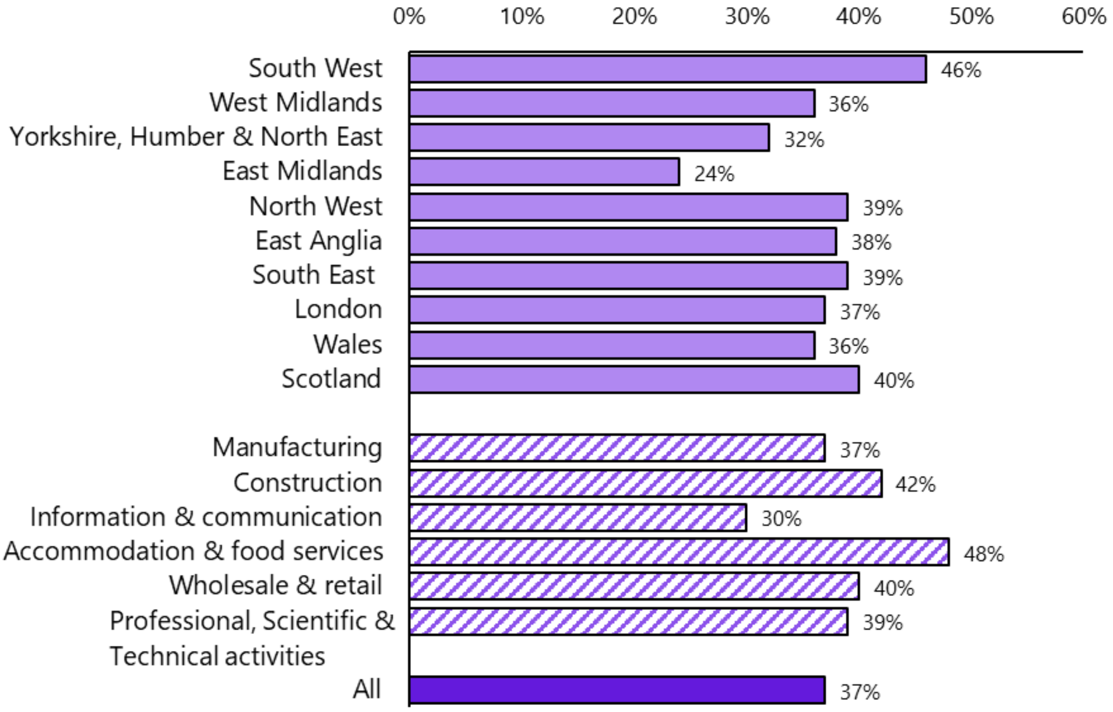
% of total

RMI, McKinsey (2022)

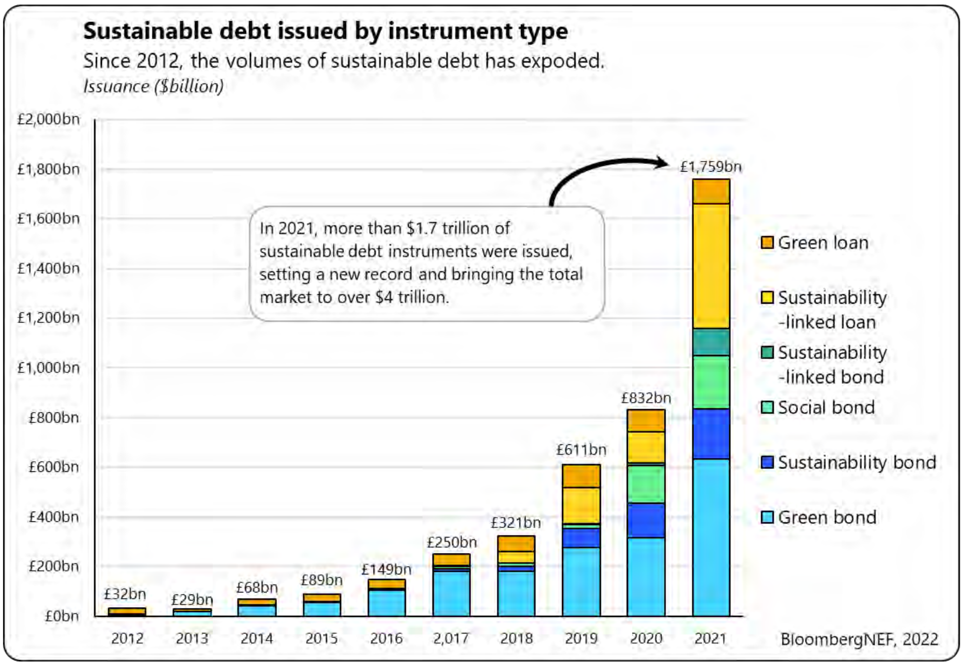

Low Skilled
Middle Skilled
High Skilled
Share of low carbon ads
0% to 0.6%
0.6% to 0.9%
0.9% to 1.1%
1.1% to 1.5%
1.5% or more

Proportion of small businesses that want to do more to achieve net zero and sustainability for their business: UK region and sector, 2021

% of small businesses



FSB Tax Survey, 2021



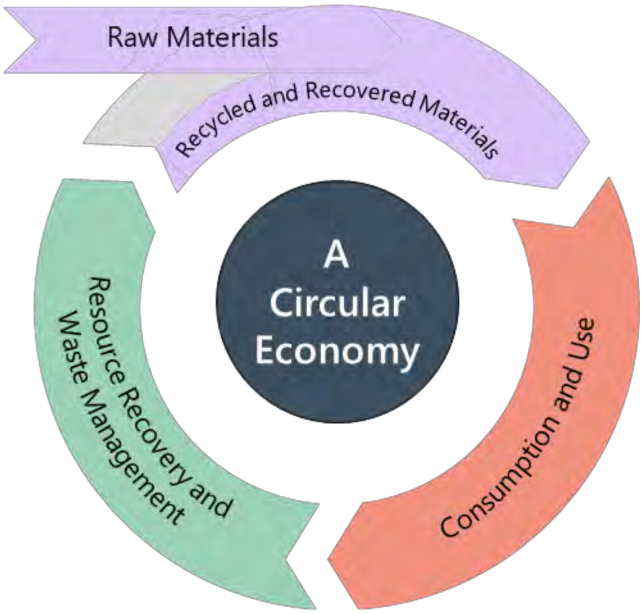
Sustainable debt issued by instrument type

Since 2012, the volumes of sustainable debt has expoded.

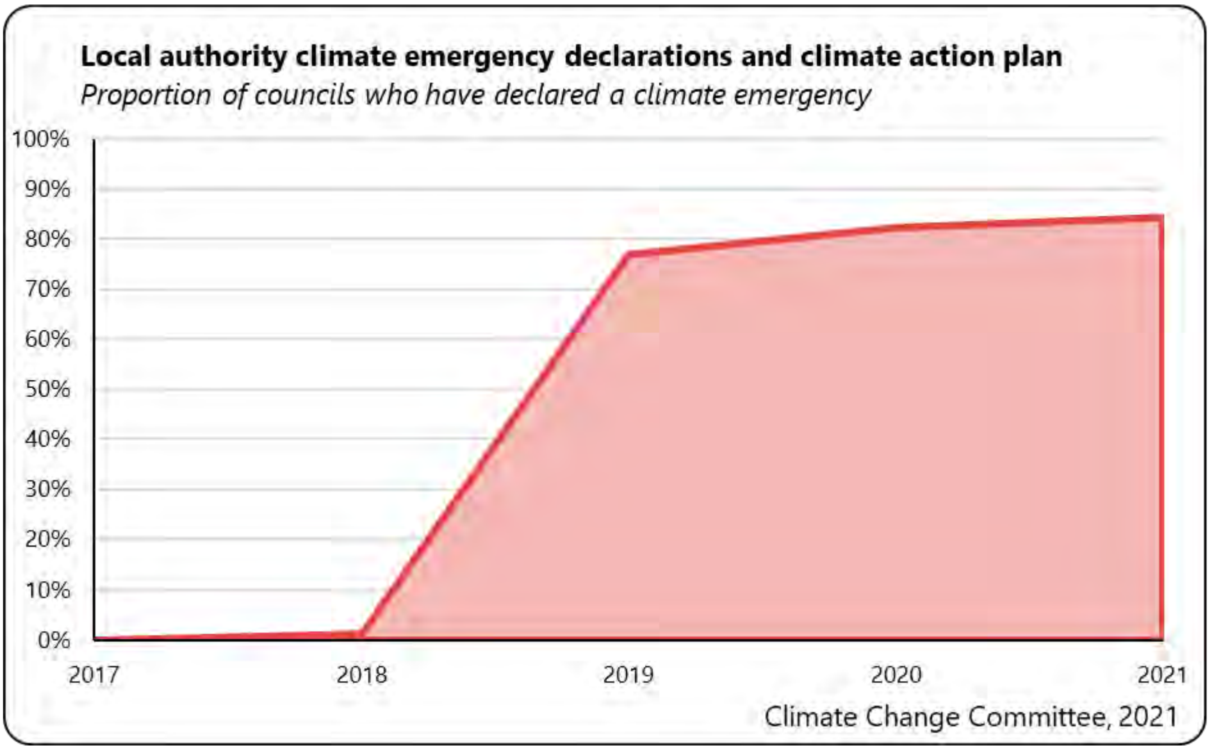
Issuance ($billion)

In 2021, more than $1.7 trillion of sustainable debt instruments were issued, setting a new record and bringing the total market to over $4 trillion.

BloombergNEF, 2022


Raw Materials
Recycled and Recovered Materials
A Circular Economy
Consumption and Use
Resource Recovery and Waste Management

“



Local authority climate emergency declarations and climate action plan

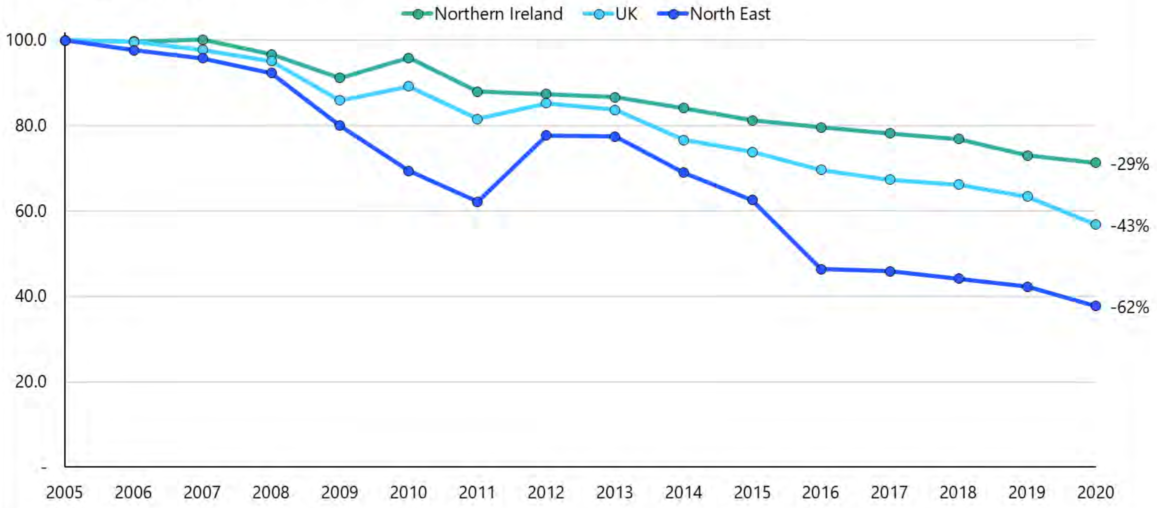
Proportion of councils who have declared a climate emergency

Climate Change Committee, 2021

CO_2 emissions: UK, Northern Ireland and North East England, 2015-2020

While all regions have seen falls, the North East experienced the largest reduction in CO_2 emissions from 2005 to 2020, in part due to industrial closures.

Index (2005=100)

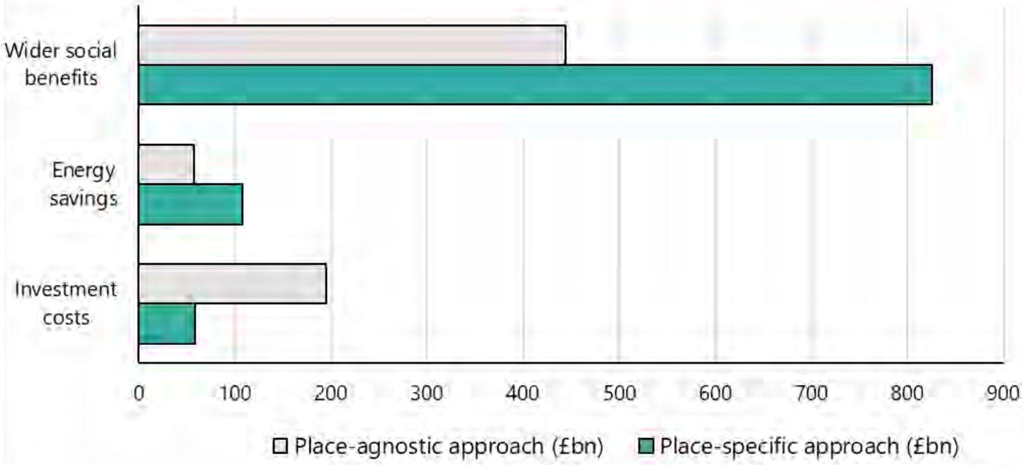


BEIS: Local Authority Greenhouse Gas Emissions, 2021

Benefits of a place-specific approach to net zero

Adopting a place specific approach could generate greater benefits and lower costs.

£bn



UKRI, 2022

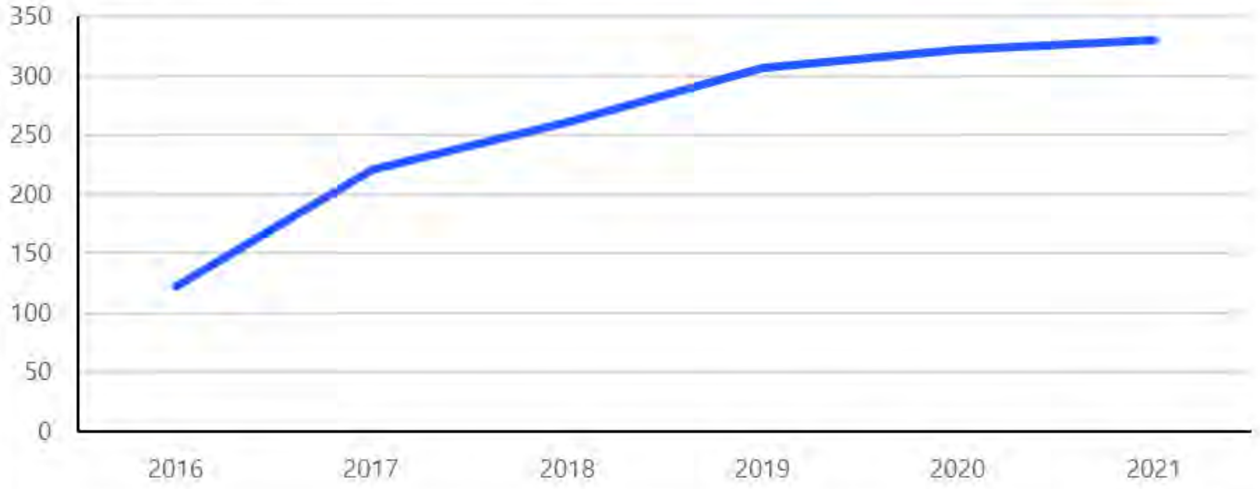
Procurement spend retained locally, 2012/13 and 2016/17

Adopting a community wealth building approach to procurement can boost local economies.

CLES and Preston City Council, 2021

Community-owned electricity capacity in the UK, 2016-2021

MW



Community Energy, 2021

Transport

Adopt low carbon technologies:
- Use an electric vehicle
- Install an electric vehicle charger
- Use an e-bike

Use technology and resources more efficiently:
- Use smart charging for electric vehicles

Day to day choices:
- Use public transport or active travel over cars
- Ride-share

Products and Waste

Use technology and resources more efficiently:
- Repair products where possible
- Use products for longer

Day to day choices:
- Choose environmentally friendly products
- Recycle
- Separate food waste
- Reduce food waste

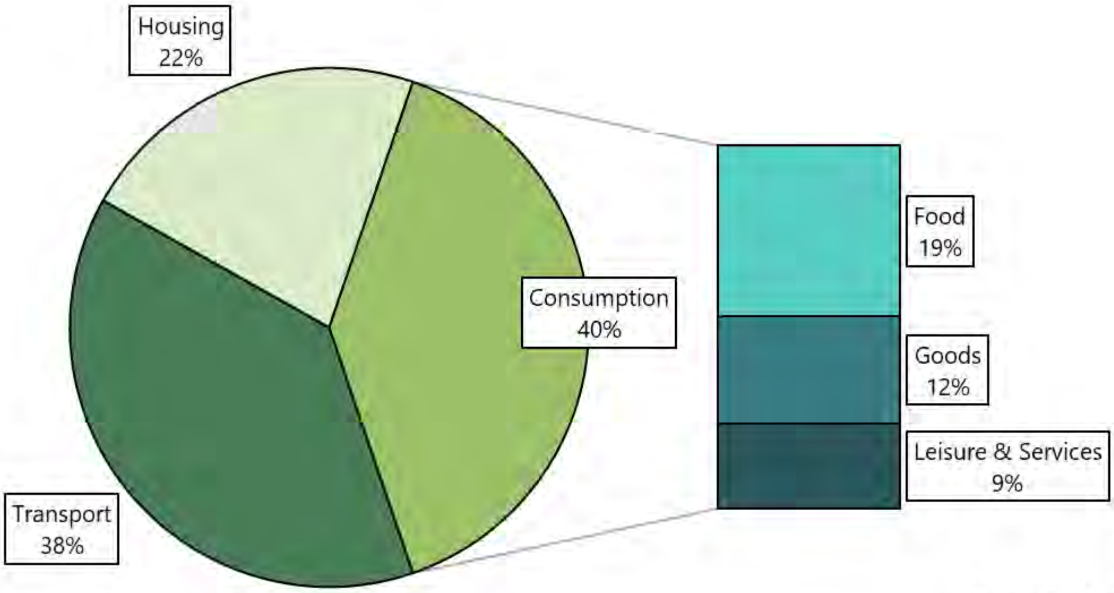
Homes

Adopt low carbon technologies:
- Install energy efficiency measures (e.g. insulation, solar, etc.)
- Install low carbon heating
- Install smart heating controls

Use technology and resources more efficiently:
- Switch to time-of-use tariff
- Use electricity/smart appliances at off-peak times

Emissions Split

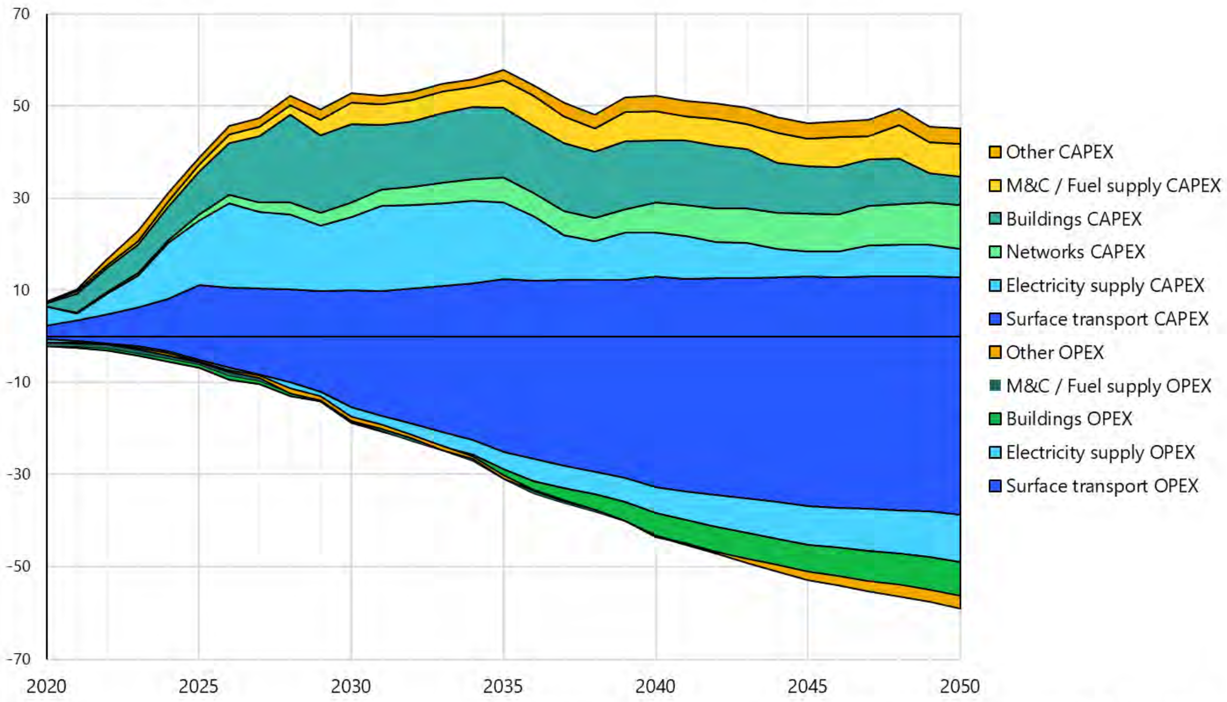
Studies show the average Brit contributes around 8.5 tonnes CO2e per year in emissions



Akenji et al., 2022

Pay now, save later

While the aggregate cost of reaching Net Zero is low, the costs predate the savings by years, or even decades.



CCC CB6 Analysis • Capital investment costs and operating cost savings in the Balanced Pathway

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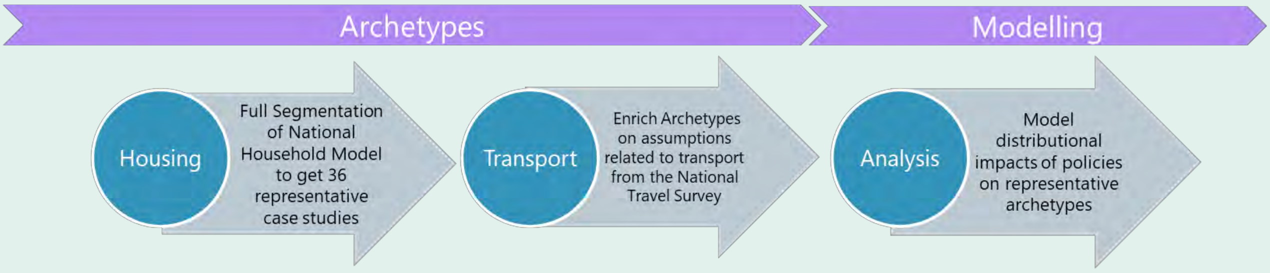


Archetypes

Modelling

Housing

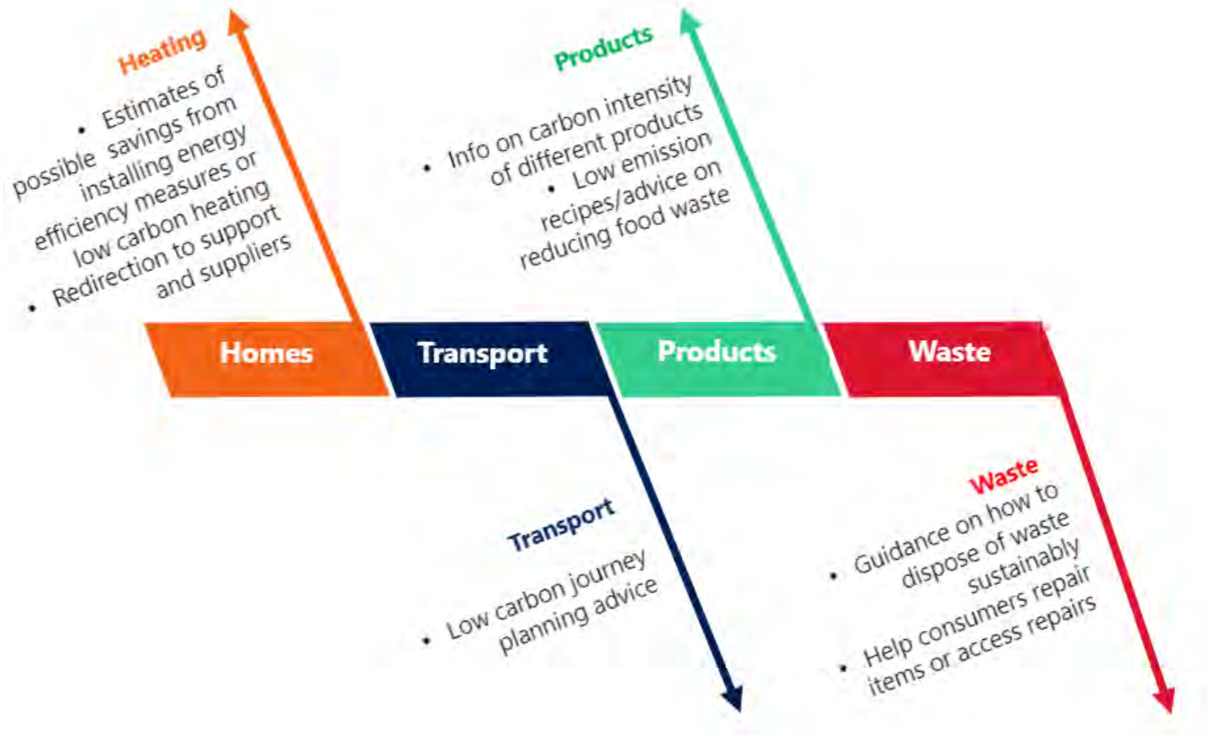
Full Segmentation of National Household Model to get 36 representative case studies

Transport

Enrich Archetypes on assumptions related to transport from the National Travel Survey

Analysis

Model distributional impacts of policies on representative archetypes



Heating

- Estimates of possible savings from installing energy efficiency measures or low carbon heating
- Redirection to support and suppliers

Products

- Info on carbon intensity of different products
- Low emission recipes/advice on reducing food waste

Transport

- Low carbon journey planning advice

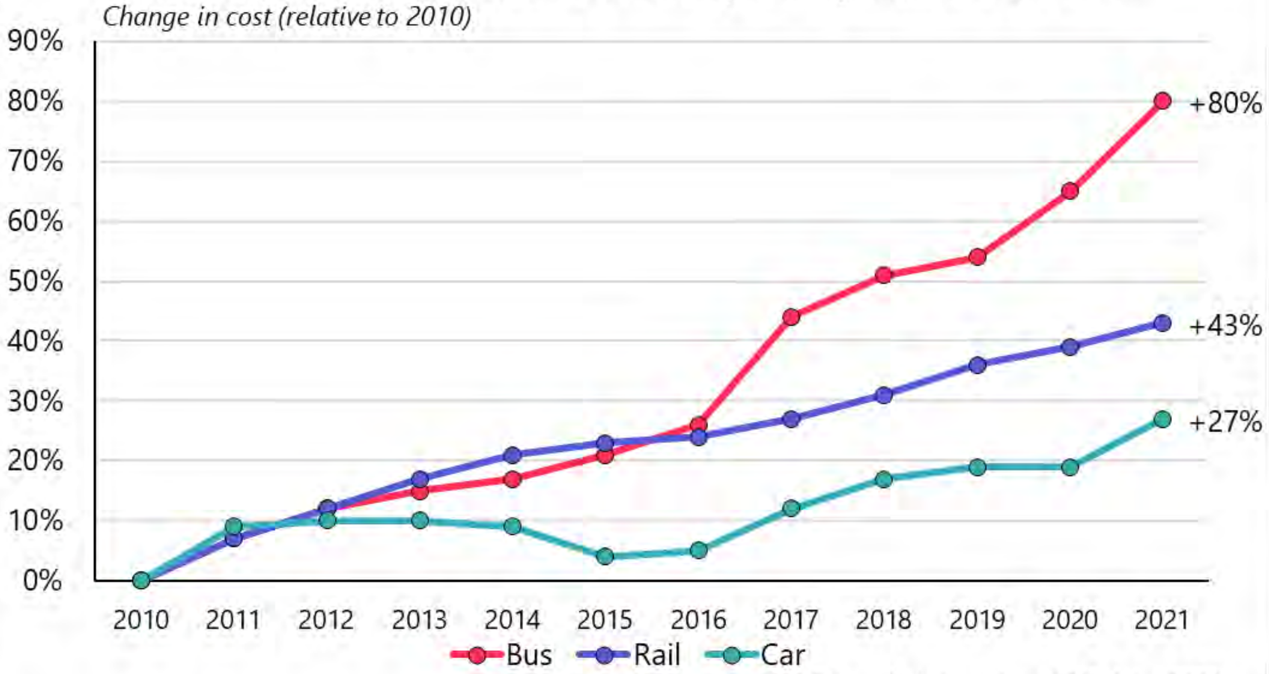
Waste

- Guidance on how to dispose of waste sustainably
- Help consumers repair items or access repairs

Discouraging Modal Shift

Since 2010, public transport costs have risen significantly faster than car travel.

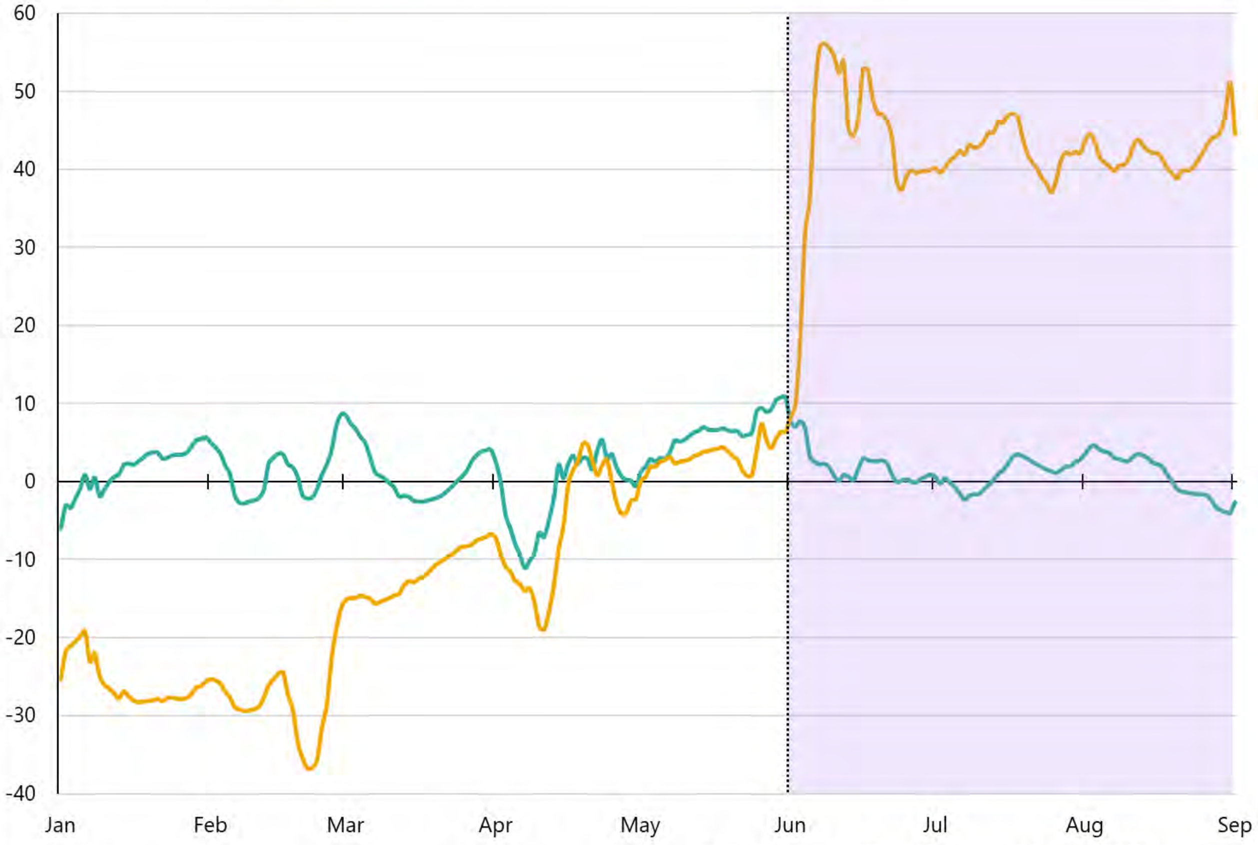
Change in cost (relative to 2010)



CCC analysis based on ONS data, 2022

German rail travel was buoyed during the 9-Euro transport ticket

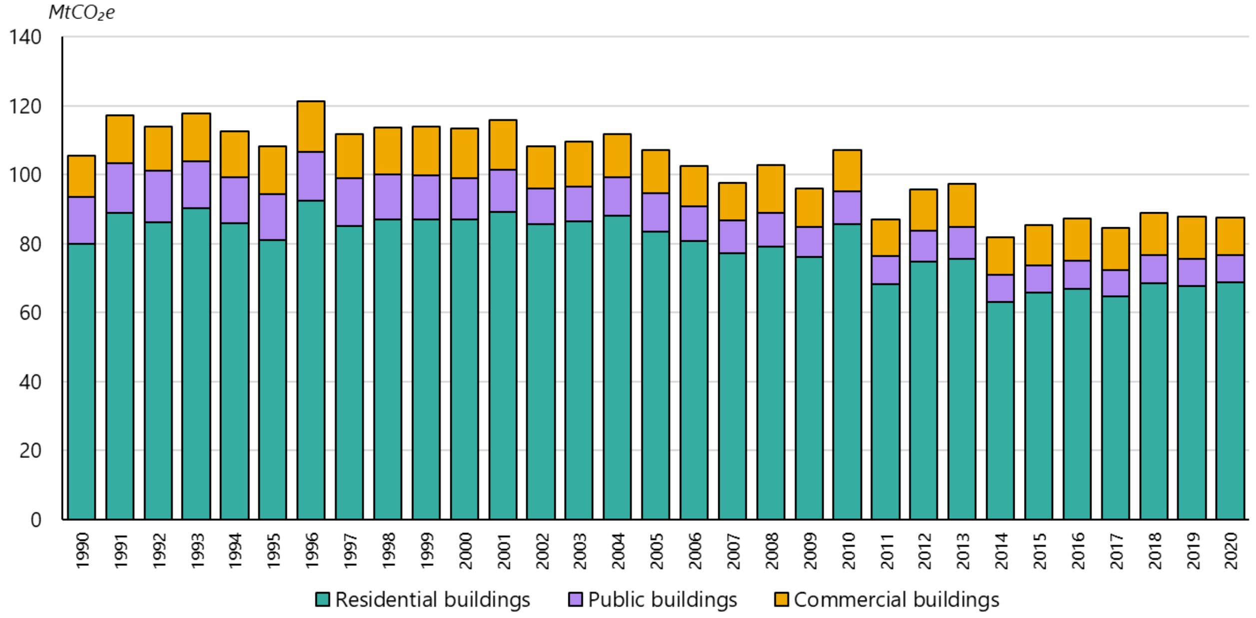
Change in mobility (%), by rail and road, on 2019 levels



Federal Statistical Office of Germany • Distances of 30km or more

Stalling Progress

After decades of progress, direct emissions from buildings have not changed significantly since 2015.



BEIS, 2022

Energy Savings

- In the UK, total residential energy consumption from 2000 to 2019 fell by 15%, even as 500 million m2 of floor area was added. This is equivalent to an extra 5.3 million homes, or about 260,000 new homes being added every year (IEA).

Energy Security

- By reducing overall energy demand, efficiency can reduce reliance on imports.
- Analysis shows that UK gas imports would be 13% lower if high levels of government support for energy efficiency and renewables had continued post-2013 (Carbon Brief).

Employment Opportunities

- Increasing energy efficiency in buildings and homes will support up to 175,000 jobs by 2030 (BEIS).

Health & Wellbeing

- On average, more than 10,000 people die each year due to living in a cold home (NEA).
- Research also highlights the detrimental affect poor housing has on mental health, anxiety and depression (Shelter).

Emissions Savings

- Across both Energy Company Obligation (ECO) and Green Deal (GD) schemes, from quarter 1 2013 to the end of quarter 1 2022, the provisional estimated lifetime carbon saving was 60 MtCO2 (BEIS).

Household Savings

- Estimates suggest the increasing the energy efficiency of homes would save those in the least efficient properties over £950 per year (Citizen's Advice).

Asset Values

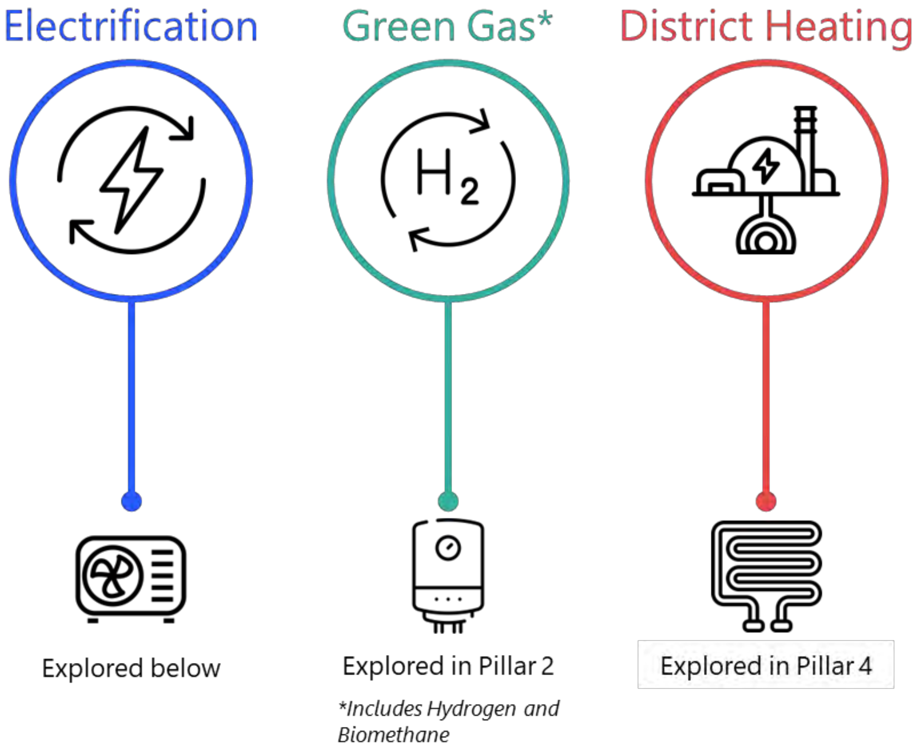
- Recent reports suggest that homebuyers are willing to pay almost 10% more for energy efficient properties. This equates to an average increase of £26,600 based on the average UK house price (Santander).

Productivity

- By 2040, manufacturing industries could produce nearly twice as much gross value-added from each unit of energy use in an efficient scenario (IEA).

Public Budgets

- The government's Energy Price Guarantee is expected to cost the Treasury £16 billion this winter (Resolution Foundation).
- An unseasonably warm October, which reduced gas demand by 19%, saved the Treasury £260mn. This shows the scale of savings that could be made with energy efficiency measures (Bloomberg).



Electrification	Green Gas*	District Heating
Explored below	Explored in Pillar 2	Explored in Pillar 4

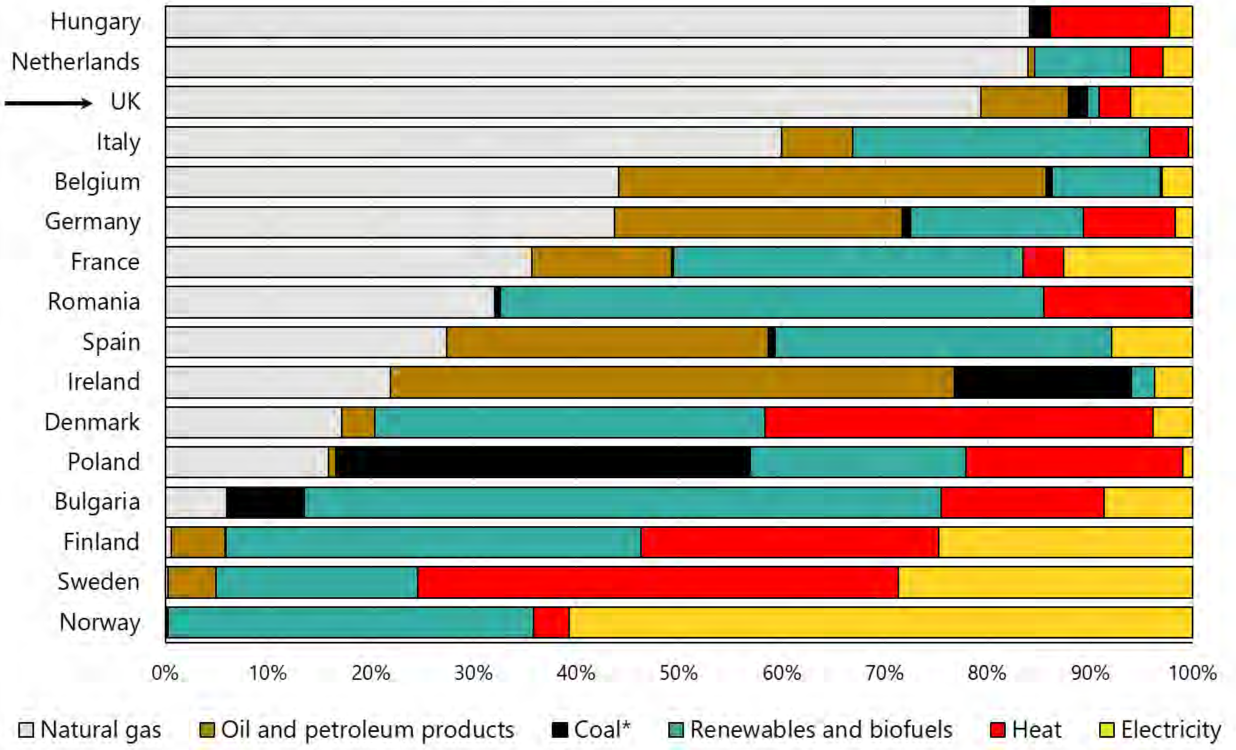
**Includes Hydrogen and Biomethane*

-

Hooked on Gas

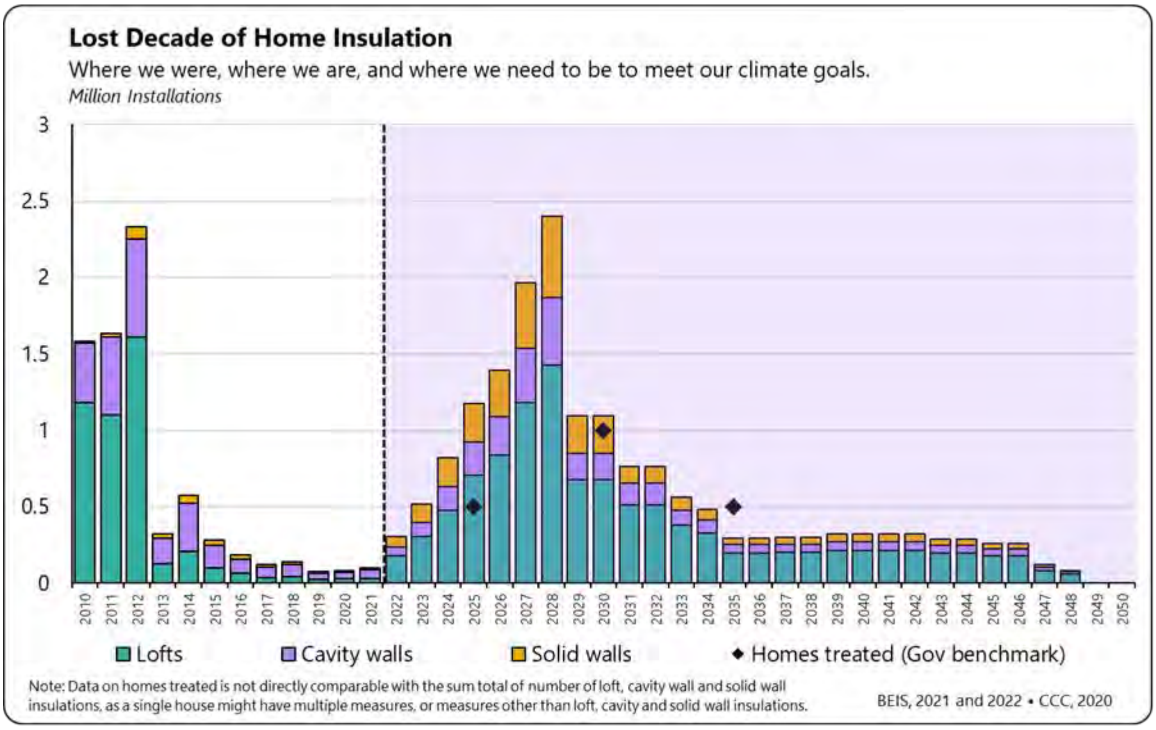
The UK is dependent on gas for 80% of its residential heating — the EU average is 38%.

Energy used for residential heating, by fuel type (%)



*Includes all solid fossil fuels, peat, peat products, oil shale and oil sands

Eurostat, 2021 • BEIS, 2021

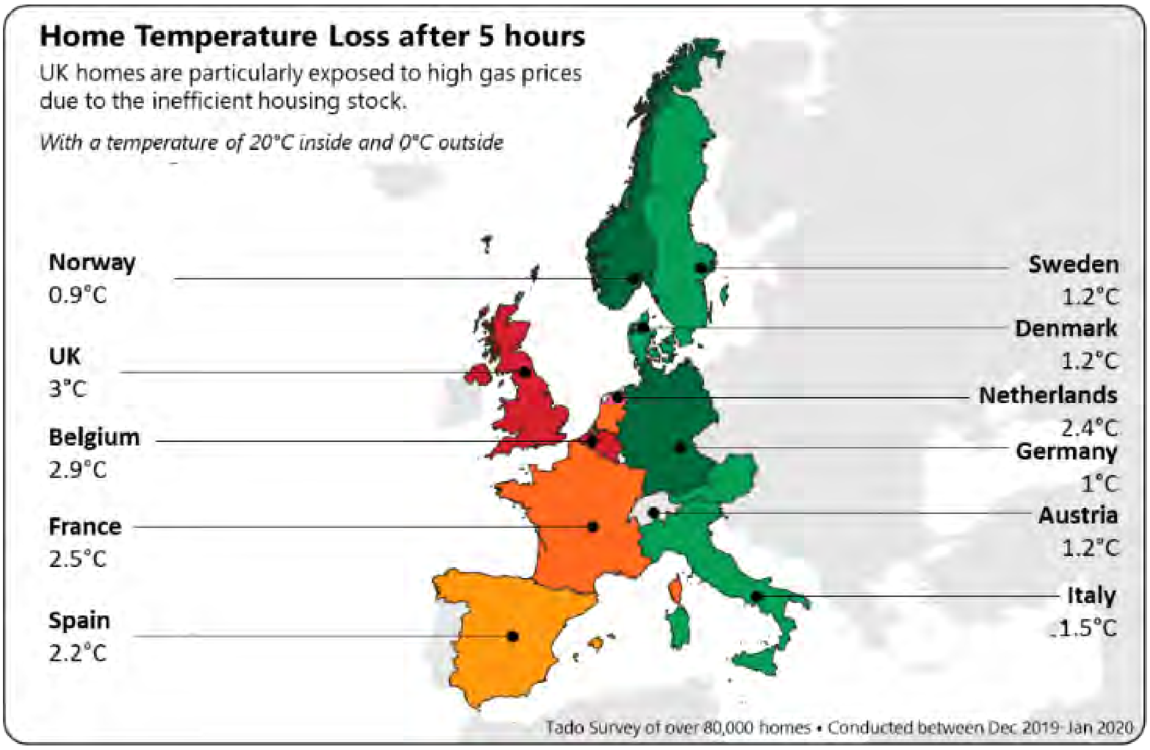


Lost Decade of Home Insulation

Where we were, where we are, and where we need to be to meet our climate goals.

Note: Data on homes treated is not directly comparable with the sum total of number of loft, cavity wall and solid wall insulations, as a single house might have multiple measures, or measures other than loft, cavity and solid wall insulations.

BEIS, 2021 and 2022 • CCC, 2020

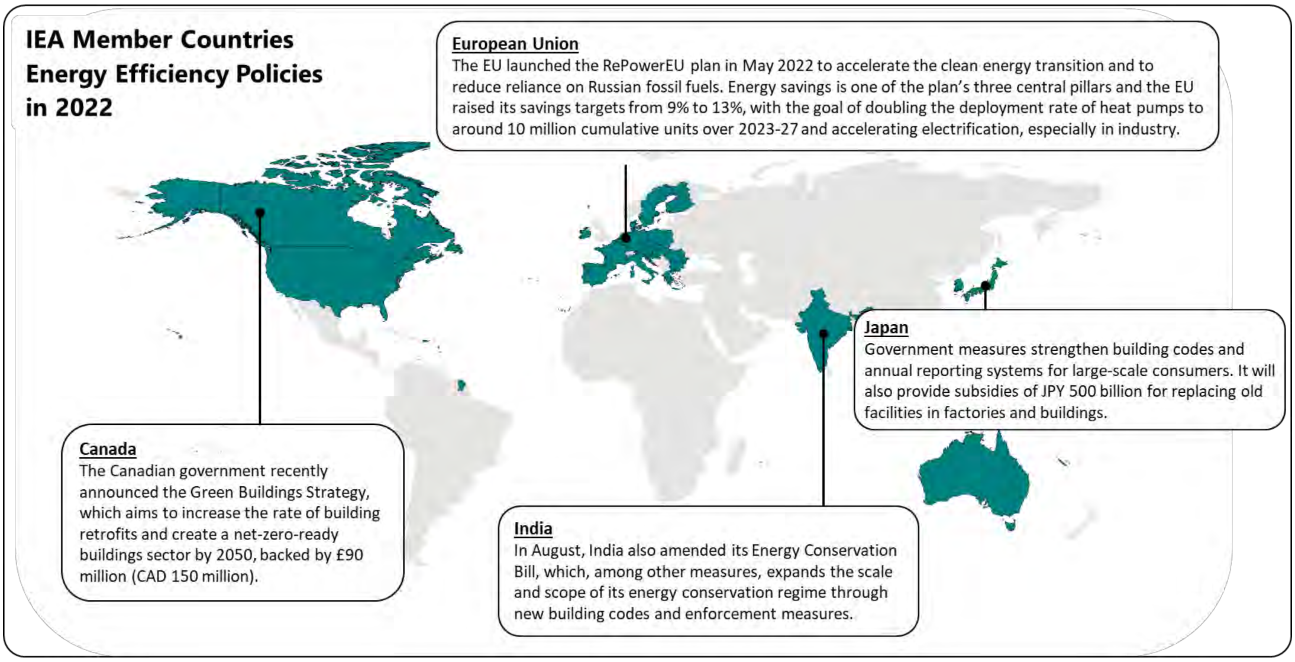


Home Temperature Loss after 5 hours

UK homes are particularly exposed to high gas prices due to the inefficient housing stock.

With a temperature of 20°C inside and 0°C outside

Tado Survey of over 80,000 homes • Conducted between Dec 2019-Jan 2020



IEA Member Countries Energy Efficiency Policies in 2022

European Union
The EU launched the RePowerEU plan in May 2022 to accelerate the clean energy transition and to reduce reliance on Russian fossil fuels. Energy savings is one of the plan's three central pillars and the EU raised its savings targets from 9% to 13%, with the goal of doubling the deployment rate of heat pumps to around 10 million cumulative units over 2023-27 and accelerating electrification, especially in industry.

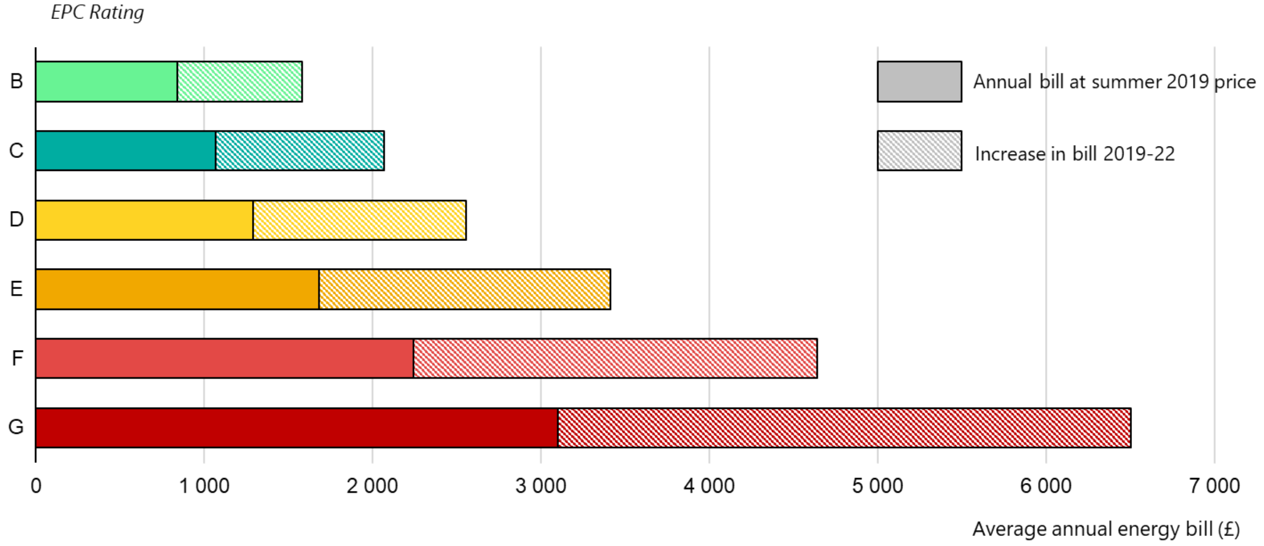
Japan
Government measures strengthen building codes and annual reporting systems for large-scale consumers. It will also provide subsidies of JPY 500 billion for replacing old facilities in factories and buildings.

Canada
The Canadian government recently announced the Green Buildings Strategy, which aims to increase the rate of building retrofits and create a net-zero-ready buildings sector by 2050, backed by £90 million (CAD 150 million).

India
In August, India also amended its Energy Conservation Bill, which, among other measures, expands the scale and scope of its energy conservation regime through new building codes and enforcement measures.

Doubling Bills

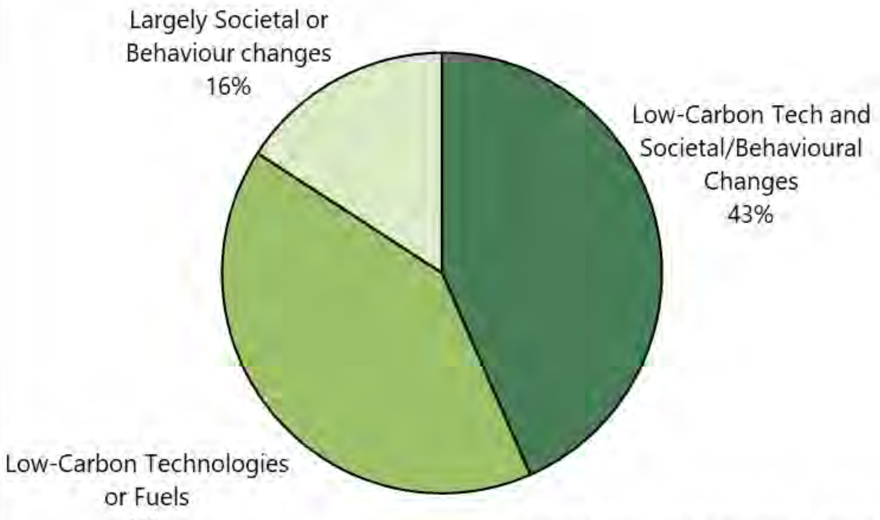
With recent energy price rises, annual UK household energy bills are estimated to be around double the level of 2019.



IEA analysis of data from BEIS, 2022

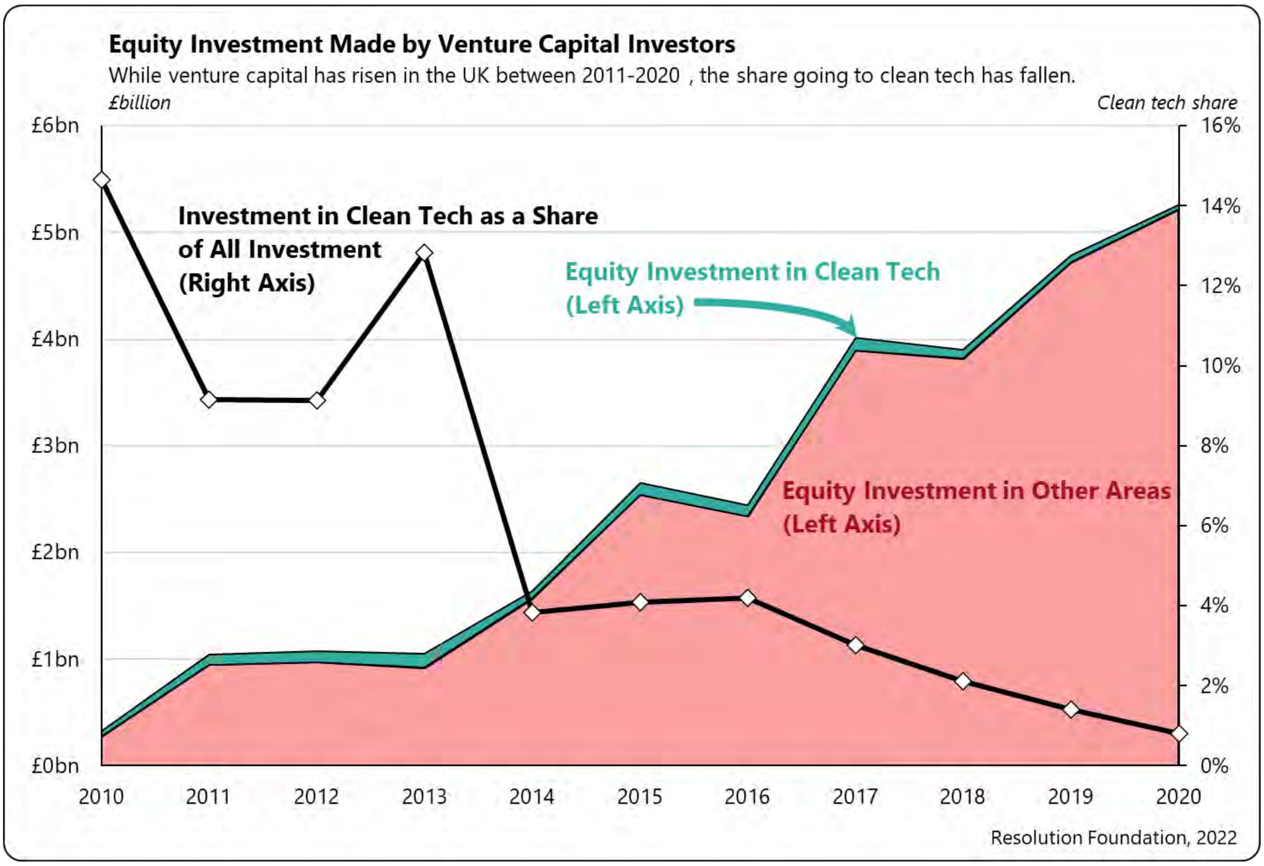
Role of Technologies and Behavioural Change in Decarbonisation

In 2035, 84% of the CCC's *Balanced Net Zero Pathway* involves low-carbon technologies or fuels.



Climate Change Committee, 2020

Maturity	Area
Success – TRL9 achieved	• Battery-electric passenger cars • Hydrogen/fuel cell passenger cars • Wind power • Solar PV • Large scale (>1GW) nuclear power • Electricity HVDC inter-connectors and HV transmission systems
Ripe for Development – Currently at c. TRL7	• Carbon capture, utilisation and storage • Battery-electric and/or hydrogen fuel cells for heavy vehicles, buses and trains • Bio-energy with carbon capture & storage • Small, modular nuclear power • Domestic heat pumps in substantial quantities • Flow batteries • Direct reduced iron
More work Required – Lower TRL's	• Domestic retrofit insulation & heating in quantity • Direct air capture of CO_2 • Compressed air, liquid air, and gravity energy storage • Nuclear fusion • Space-based solar power



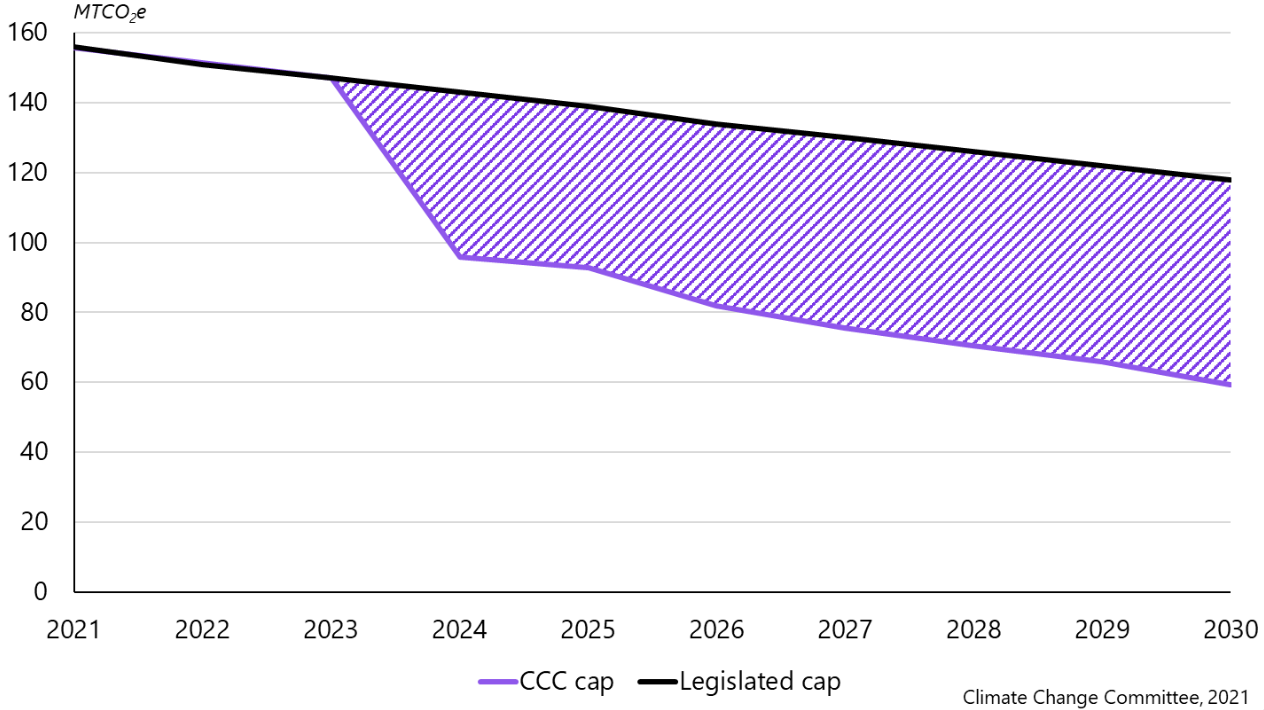
Equity Investment Made by Venture Capital Investors

While venture capital has risen in the UK between 2011-2020 , the share going to clean tech has fallen.

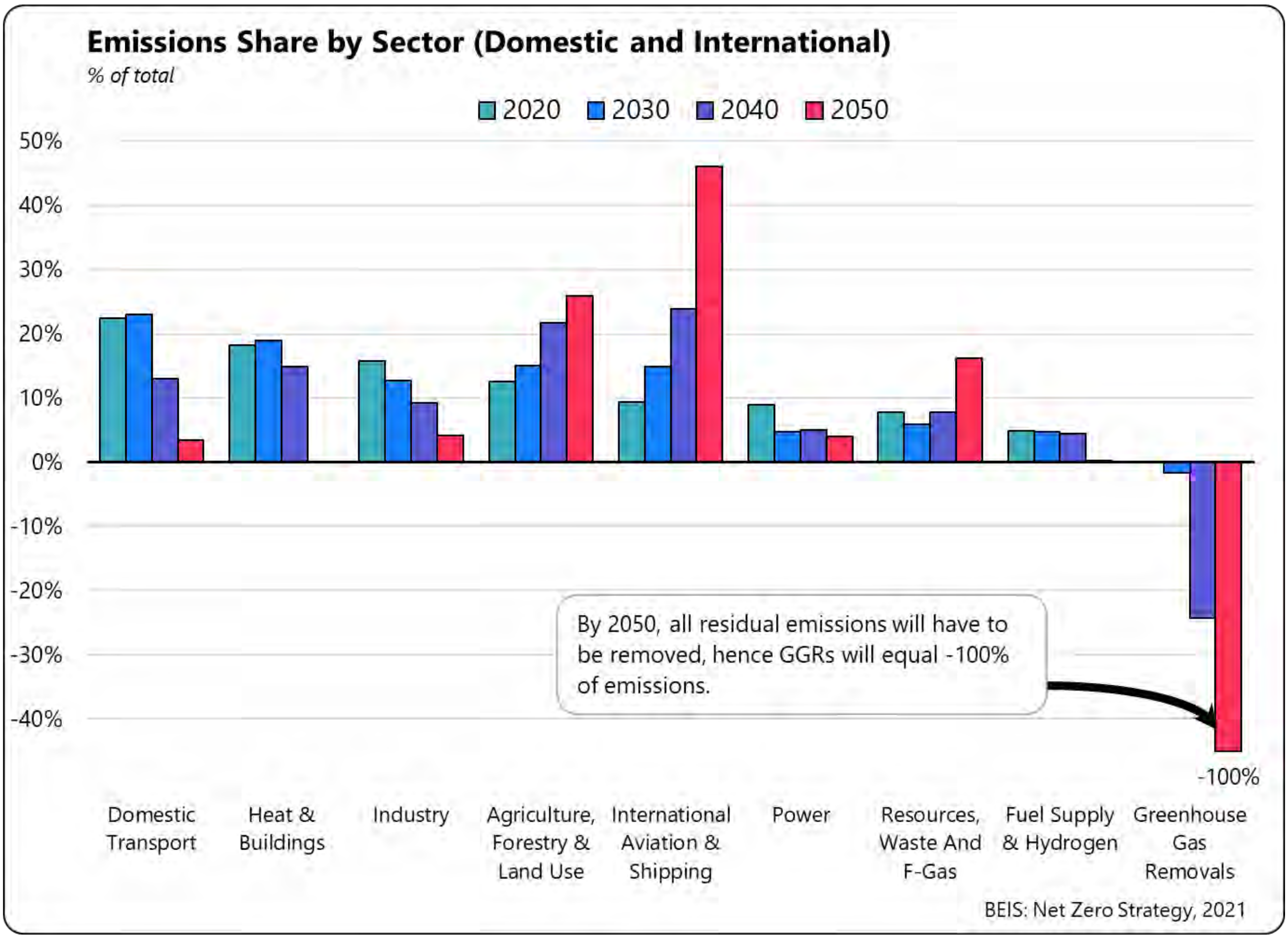
Resolution Foundation, 2022

ETS Within Scope

CCC's proposed path for sectors covered by the UK ETS compared to the currently legislated cap.



Climate Change Committee, 2021



By 2050, all residual emissions will have to be removed, hence GGRs will equal -100% of emissions.

BEIS: Net Zero Strategy, 2021

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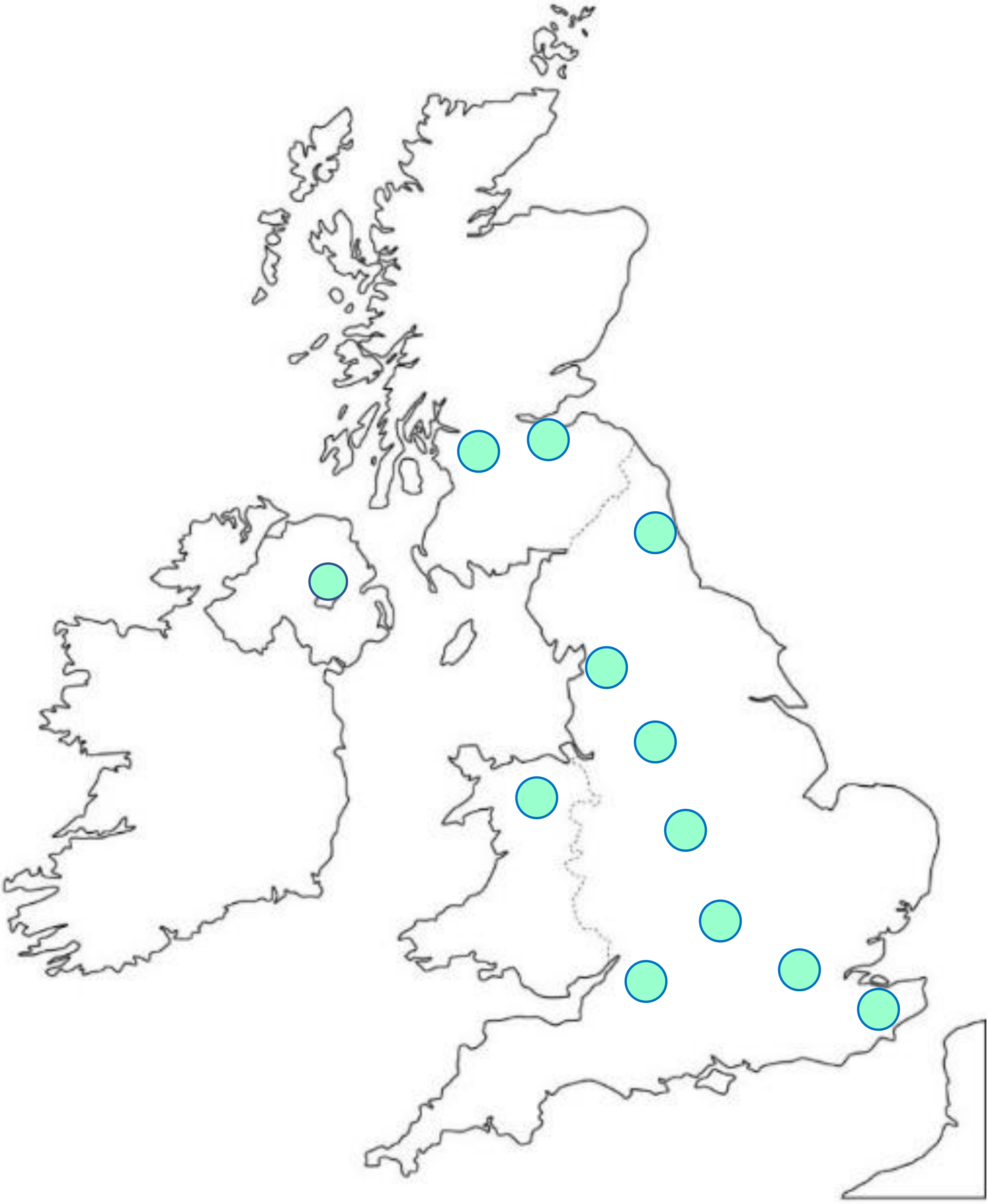

https://www.nstauthority.co.uk/data-centre/data-downloads-and-publications/production-projections/

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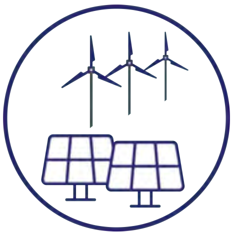

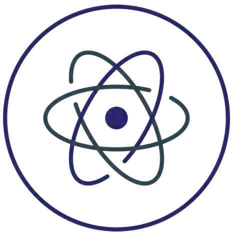

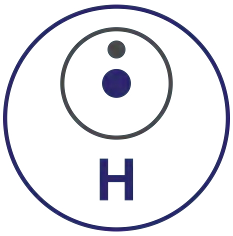
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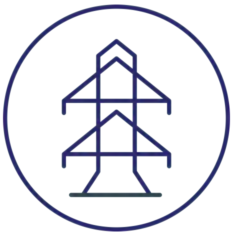

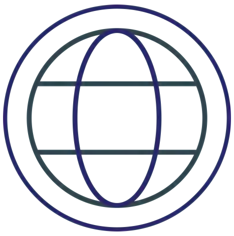

HM Government

TOGETHER
FOR OUR
PLANET

Net Zero Strategy: Build Back Greener

October 2021

Net Zero Strategy: Build Back Greener

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of the Climate Change Act 2008

This publication is available at www.gov.uk/official-documents.

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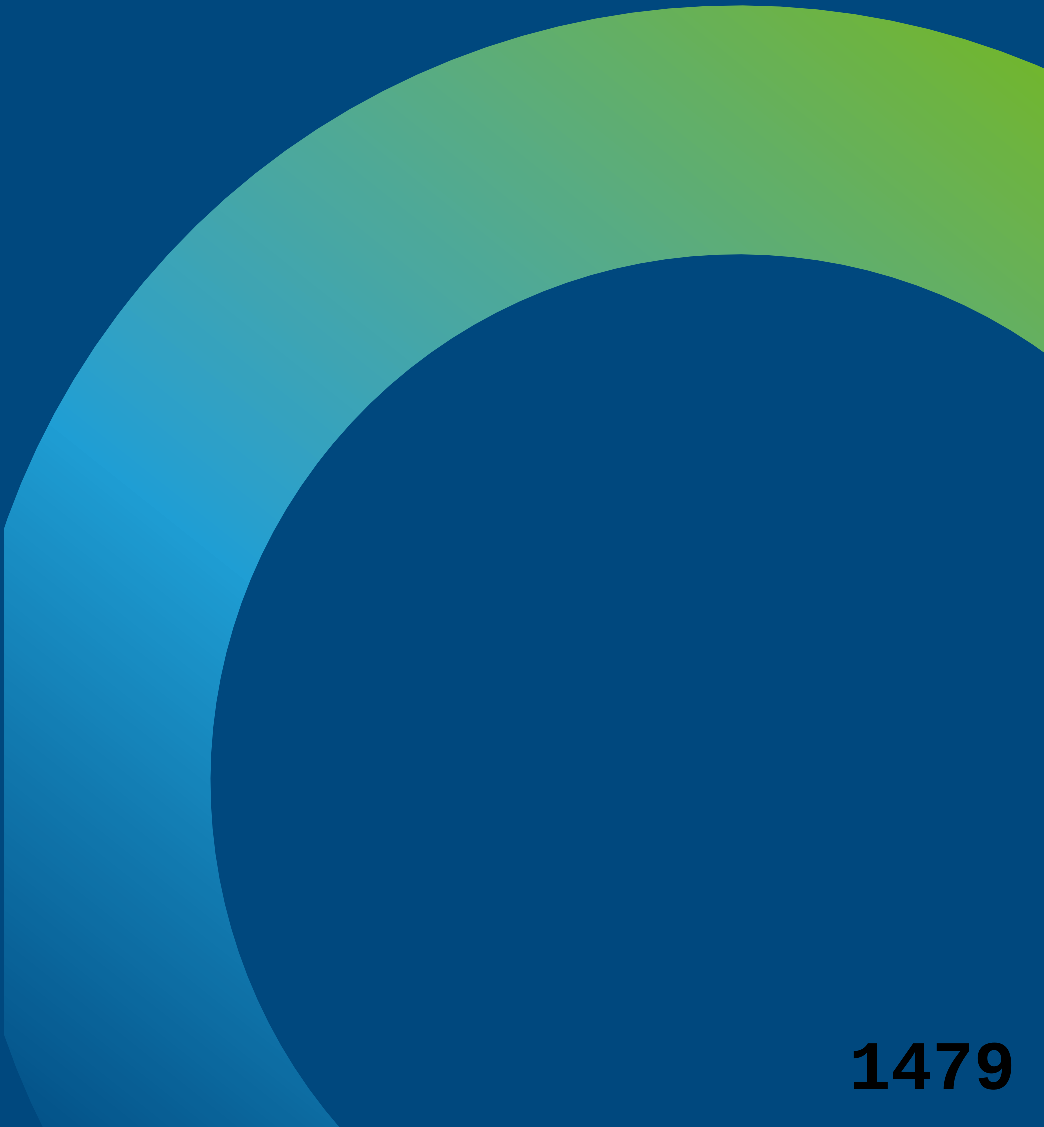


Foreword from the Prime Minister

Our strategy for net zero is to lead the world in ending our contribution to climate change, while turning this mission into the greatest opportunity for jobs and prosperity for our country since the industrial revolution.

Removing dirty fossil fuels from the global economy will lead to the creation of vast new global industries from offshore wind to electric vehicles and carbon capture and storage. By moving first and making the United Kingdom the birthplace of the Green Industrial Revolution we are building a defining competitive edge. Through our Ten Point Plan we have already attracted over £5.8 billion of new inward investment in just over ten months, and will create and support hundreds of thousands of new high skilled, high wage green jobs.

Over the last three decades we have already reduced our emissions by 44 per cent - while growing our economy by over 75 per cent – and this strategy sets out our plan for going the rest of the way. We will meet the global climate emergency but not with panicked, short-term or self-destructive measures as some have urged. Instead we will unleash the unique creative power of capitalism to drive the innovation that will bring down the costs of going green, so we make net zero a net win for people, for industry, for the UK and for the planet.

This strategy sets out how we will make historic transitions to remove carbon from our power, retire the internal combustion engine from our vehicles and start to phase out gas boilers from our homes. But it also shows how we will do this fairly by making carbon-free alternatives cheaper. We will make sure what you pay for green, clean electricity is competitive with carbon-laden gas, and with most of our electricity coming from the wind farms of the North Sea or state-of-the-art British nuclear reactors we will reduce our vulnerability to sudden price rises caused by fluctuating international fossil fuel markets.

The United Kingdom is not afraid to lead the charge towards global net zero at COP26, because history has never been made by those who sit at the back of the class hoping not to be called on. Indeed, as we set an example to the world by showing that reaching Net Zero is entirely possible, so the likes of China and Russia are following our lead with their own net zero targets, as prices tumble and green tech becomes the global norm.

For years, going green was inextricably bound up with a sense that we have to sacrifice the things we love. But this strategy shows how we can build back greener, without so much as a hair shirt in sight. In 2050, we will still be driving cars, flying planes and heating our homes, but our cars will be electric gliding silently around our cities, our planes will be zero emission allowing us to fly guilt-free, and our homes will be heated by cheap reliable power drawn from the winds of the North Sea. And everywhere you look, in every part of our United Kingdom, there will be jobs. Good jobs, green jobs, well-paid jobs, levelling up our country while squashing down our carbon emissions.

That is the clean and prosperous future that awaits every one of us as the UK leads the world in the race to net zero.

The Rt Hon Boris Johnson MP

Prime Minister

Foreword from the Secretary of State for Business, Energy & Industrial Strategy

Now is the time the world needs to go further and faster to tackle climate change. The UK is stepping up to that challenge. Here we set out our ambitious strategy – the first of its kind in the world of a major economy - to create new jobs, develop new industries with innovative new technologies and become a more energy secure nation with clean green British energy. At the same time we will reduce greenhouse gas emissions across the economy to reach net zero by 2050.

The UK has already taken bold steps towards net zero, including bringing forward the end of sales of new petrol and diesel cars to 2030. We have committed over £12 billion of domestic green investment since March 2020, and have doubled our International Climate Finance commitment to £11.6 billion between 2021-2025.

This Strategy sets out the next steps we will take to cut our emissions, seize green economic opportunities, and leverage further private investment into net zero. The policies and spending brought forward in the Net Zero Strategy mean that since the *Ten Point Plan* we have mobilised over £26 billion of government capital investment for the green industrial revolution. Along with regulations, this will support 190,000 jobs by 2025, and 440,000 jobs by 2030, and leverage up to £90 billion of private investment by 2030. This will put us on an ambitious path to meet our Sixth Carbon Budget and our Nationally Determined Contribution, cutting emissions by at least 68% by 2030 on 1990 levels, and reaching net zero by 2050.

We know economic growth and reducing emissions can go hand-in-hand. As we continue to build back better from the COVID-19 pandemic, we will fuel a Green Industrial Revolution, creating jobs and business growth opportunities, and establishing the UK as a global leader in the technologies to tackle climate change. We will deliver the commitments in the Prime Minister's *Ten Point Plan* and *Build Back Better: our plan for growth*, and go further to build a resilient economy and level up the UK.

The changes will have wider benefits for the public and businesses alike. We will all enjoy cleaner air, increased biodiversity and improved access to green spaces. We will see greater efficiency in the way we travel and heat our buildings, which will be better protected from more extreme weather events. We will also put consumers at the heart of this transition, helping them make their homes warmer, more efficient, and ensure that they pay a fair, affordable prices for their energy.

But we cannot tackle climate change alone. We will take a coordinated approach, working across local and national government, the Devolved Administrations, and with businesses and civil society organisations. And we will make it easier and fairer for individuals, businesses and households to decarbonise, so that our whole society can work together to reduce emissions. This strategy demonstrates how the UK is leading by example, with a clear plan for the future.

The Rt Hon Kwasi Kwarteng
Secretary of State for Business, Energy & Industrial Strategy

Executive Summary

What is net zero and why do we need to act?

From heating our homes to filling up our cars, burning fossil fuels releases the greenhouses gases that increase global temperatures. We are already seeing the effects here in the UK, with devastating floods in the West Midlands in January and torrential downpours submerging London Underground stations earlier this summer.

People are rightly concerned, with the latest IPCC report showing that if we fail to limit global warming to 1.5°C above pre-industrial levels, the floods and fires we have seen around the world this year will get more frequent and more fierce, crops will be more likely to fail, and sea levels will rise driving mass migration as millions are forced from their homes. Above 1.5°C we risk reaching climatic tipping points like the melting of arctic permafrost – releasing millennia of stored greenhouse gases – meaning we could lose control of our climate for good.

But the good news is that there is, still, a path to avoid catastrophic climate change. The science could not be clearer: by the middle of this century the world has to reduce emissions to as close to zero as possible, with the small amount of remaining emissions absorbed through natural carbon sinks like forests, and new technologies like carbon capture. If we can achieve this, global emissions of greenhouse gases will be ‘net zero’.

Delivering this requires urgent global action, including ending coal fired power generation, retiring petrol and diesel engines from all cars, and halting deforestation. These are the steps that the UK is calling for at COP26, the global climate change talks in Glasgow next month.

Why should the UK act first?

Since 1990 the UK has almost halved our greenhouse gas emissions. Thanks to the efforts of successive governments, we are almost half-way to ending the UK's domestic contribution to man-made climate change, and in 2019 the UK became the first major economy in the world to legislate to finish the job with a binding target to reach net zero emissions by 2050.

We are proud to lead the world in ending our own contribution to climate change, not just because it is the right thing to do, but because we are determined to seize the unprecedented economic opportunity it brings. We want to build back better from the pandemic by building back greener and levelling up our country with new high skilled, high wage, sustainable jobs in every part of our United Kingdom.

Removing dirty fossil fuels will require the transformation of every sector of the global economy. It means no longer burning fossil fuels for power or heating; it means new ways of making concrete, cement, steel; it means the end of the petrol and diesel engine. These changes are already beginning to happen. Renewable energy is now the cheapest source of power across two-thirds of the globe. Clean, cheap power is already driving the decarbonisation of heavy industry around the world. Almost all major car companies are now developing or producing zero emissions vehicles as battery technology improves and costs reduce.

The question is whether the new clean machinery of the net zero future will be "made elsewhere" or "made in Britain". By moving first, the UK can get ahead of the pack and make the birthplace of the industrial revolution the home of the new Green Industrial Revolution.

Indeed, as we produce more of our own electricity – from wind farms in the North Sea and state-of-the-art British nuclear reactors – families will be much better protected from energy price spikes caused by volatile international fossil fuel markets. At the same time, by getting ahead of the curve in driving down the costs of the latest clean technology, more consumers will enjoy more efficient cars and heating systems sooner. Furthermore, by accelerating the deployment of cheap renewable power, and rolling out further energy efficiency measures, government decarbonisation policies mean that the average consumer energy bill in 2024 will likely be cheaper than it would otherwise have been.

We have shown the world that green and growth go hand in hand, and as a result other countries are already following our lead with their own net zero targets. When the UK was confirmed as host of COP26, less than 30% of global GDP was signed up to net zero or carbon neutrality targets. Today, in part again because of UK leadership, that figure is now over 80% – and rising.

The Ten Point Plan for a Green Industrial Revolution

Last year, the government kick-started its mission to get ahead of the pack, by setting out a *Ten Point Plan for a Green Industrial Revolution*. Our ambition was to create the conditions for the private sector to invest with confidence, unleashing the unique creativity of capitalism to generate and grow new green industries.

We mobilised £12 billion of government investment, shared some of the risks of pioneering new industries, and began to introduce regulations to assure industry of the future demand for green products – such as through our decision to end the sale of new petrol and diesel cars by 2030. We have also invested in the skills the British workforce will need for these new high wage green jobs, though our Lifetime Skills Guarantee, and we are helping investors to access capital for green projects by making the City of London the global centre of Green Finance.

At the Global Investment Summit in October 2021, the Prime Minister announced a package of 18 deals worth £9.7 billion that will support green growth and create an estimated 30,000 UK jobs. This is on top of the £5.8 billion already committed for sustainable projects since the Prime Minister launched his *Ten Point Plan* in November 2020. Now we need to build on this progress with a strategy to take us to net zero by 2050.

Our Strategy for Net Zero

Since 1990 the UK has reduced our greenhouse gas emissions by 44%, while growing our economy by over 75%. This strategy sets out this Government's long-term plan to finish the job and end the UK's domestic contribution to man-made climate change by 2050.

Although every study shows that the costs of inaction on climate are far greater, there will, of course, be costs to the investments needed to make this transition happen. So we will approach these with four key principles:

1. **We will work with the grain of consumer choice:** no one will be required to rip out their existing boiler or scrap their current car

2. **We will ensure the biggest polluters pay the most for the transition** through fair carbon pricing

3. **We will ensure that the most vulnerable are protected through Government support** in the form of energy bill discounts, energy efficiency upgrades, and more

4. **We will work with businesses to continue delivering deep cost reductions in low carbon tech** through support for the latest state of the art kit to bring down costs for consumers and deliver benefits for businesses.

This strategy is a long-term plan for a transition that will take place over the next three decades. Many of the policies in the strategy will be phased in over the next decade or longer. Given our success in decarbonisation to date we are confident in our approach, but this strategy does not intend to predict the exact shape of the British economy in 2050 and neither should it.

We are making the decisions that are needed now to drive investment into new low carbon technologies and as these develop and we test our approach, we will make informed decisions over how we scale to reach net zero by 2050.

We have consistently underestimated how quickly the costs of clean technology would fall to date. There will be many more decisions to take, and many more steps on the journey to the finish line. But this strategy marks the beginning of the end of the UK's domestic contribution to climate change.

What is in the Strategy?

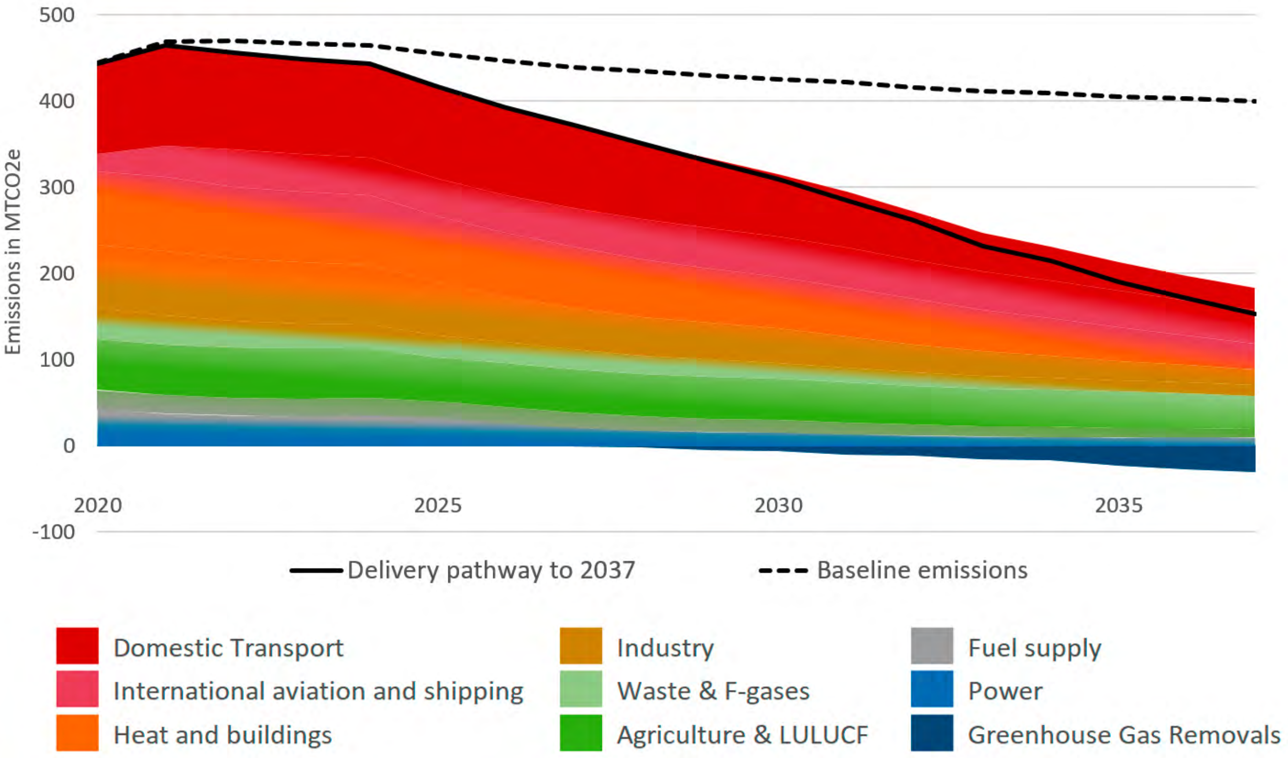
Ending the UK's contribution to climate change is a long-term shift, and the Climate Change Act breaks up this challenge into bitesize chunks – five-year long carbon budgets.

We have hit all of our carbon budgets to date. **This document sets out clear policies and proposals for keeping us on track for our coming carbon budgets, our ambitious Nationally Determined Contribution (NDC), and then sets out our vision for a decarbonised economy in 2050.**

Whilst there are a range of ways in which net zero could be achieved in the UK, we set out a delivery pathway showing indicative emissions reductions across sectors to meet our targets up to the sixth carbon budget (2033-2037). This is based on our current understanding of each sector's potential, and a whole system view of where abatement is most effective. But we must be adaptable over time, as innovation will increase our understanding of the challenges, bring forward new technologies and drive down the costs of existing ones.

The policies and spending brought forward in the Net Zero Strategy mean that since the *Ten Point Plan*, HMG has mobilised £26 billion of government capital investment for the green industrial revolution. Along with regulations, this will support up to 190,000 jobs by 2025, and up to 440,000 jobs by 2030, and leverage up to £90 billion of private investment by 2030.

Figure 1: Indicative delivery pathway to 2037 by sector



Source: BEIS Analysis (2021)

So this strategy sets out our plans for reducing emissions from each sector of our economy, while hoovering up any remaining emissions with greenhouse gas removals – either natural, like trees, or technological, using carbon capture. This is an historic plan. Taken together the transitions set out below for every sector of the UK economy meets Carbon Budgets 4 and 5, and puts us on the path for Carbon Budget 6 – and ultimately on course for net zero by 2050.

Power

The policies and proposals for power in the Net Zero Strategy will …

Support for up to 59,000 jobs in 2024 and up to 120,000 jobs in 2030

Start to mobilise additional public and private investment of £150-270 billion, in line with our 2037 delivery pathway

Fully decarbonise our power system by 2035

The net zero economy will be underpinned by cheap clean electricity, made in Britain. A clean, reliable power system is the foundation of a productive net zero economy as we electrify other sectors – so **we will fully decarbonise our power system by 2035**, subject to security of supply. Our power system will consist of abundant, cheap British renewables, cutting edge new nuclear power stations, and be underpinned by flexibility including storage, gas with CCS, hydrogen and ensure reliable power is always there at the flick of a switch. The transformation of the power sector will bring high skill, high wage job opportunities right across the UK.

Key policies:

- By 2035 the UK will be powered entirely by clean electricity, subject to security of supply.
- Secure a final investment decision on a large-scale nuclear plant by the end of this Parliament, and launch a new £120 million Future Nuclear Enabling Fund, retaining options for future nuclear technologies, including Small Modular Reactors, with a number of potential sites including Wylfa in North Wales.
- 40GW of offshore wind by 2030, with more onshore, solar, and other renewables – with a new approach to onshore and offshore electricity networks to incorporate new low carbon generation and demand in the most efficient manner that takes account of the needs of local communities like those in East Anglia.
- Moving towards 1GW of floating offshore wind by 2030 to put us at the forefront of this new technology that can utilise our North and Celtic Seas – backed by £380 million overall funding for our world-leading offshore wind sector.
- Deployment of new flexibility measures including storage to help smooth out future price spikes.

Fuel Supply & Hydrogen

The policies and proposals for fuel supply and hydrogen in the Net Zero Strategy will…

Support up to 10,000 jobs in 2030 in fuel supply	Start to mobilise additional public and private investment of £20-30 billion, in line with our 2037 delivery pathway	Deliver 5 GW of hydrogen production capacity by 2030, whilst halving emissions from oil and gas

While electricity will be the primary source of energy, we cannot rely on it alone. Many sectors require low carbon energy, including those where electrification is not a viable option, making the supply of cleaner fuels essential to achieving net zero. Building on commitments in the *North Sea Transition Deal*, we will significantly reduce emissions from traditional oil and gas fuel supplies, whilst scaling-up the production of low carbon alternatives such as hydrogen and biofuels. Current gas prices spikes underline the need to get off hydrocarbons as quickly as possible, but we will manage the transition in a way that protects jobs and investment, uses existing infrastructure, maintains security of supply, and minimises environmental impacts.

Key policies:

- We have set up the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme to fund our new hydrogen and industrial carbon capture business models. We will be providing up to £140 million to establish the scheme, including up to £100 million to award contracts of up to 250MW of electrolytic hydrogen production capacity in 2023 with further allocation in 2024.
- Introducing a new climate compatibility checkpoint for future licensing on the UK Continental Shelf and regulating the oil and gas sector in a way that minimises greenhouse gases through the revised Oil and Gas Authority strategy.

Industry

The policies and proposals for industry in the Net Zero Strategy will…

Support up to 54,000 jobs in 2030 in industry	Start to mobilise additional public and private investment of at least £14 billion in industry, in line with our 2037 delivery pathway	Deliver four carbon capture usage and storage (CCUS) clusters, capturing 20-30 MtCO2 across the economy, including 6 $MtCO_2$ of industrial emissions, per year by 2030

We will decarbonise industry in line with our net zero goals whilst simultaneously transforming our industrial heartlands by attracting inward investment, future-proofing businesses, and securing high wage, high skill jobs. We will do this by supporting industry to switch to cleaner fuels; helping them improve their resource and energy efficiency, and through fair carbon pricing to drive deep decarbonisation of industry. Growing new industries in low carbon hydrogen alongside CCUS and renewable energy will put our industrial 'SuperPlaces' at the forefront of technological development – accelerating decarbonisation in 'clusters', which account for approximately half of the UK's industrial emissions. These clusters could have the opportunity to access support under government's CCUS programme, which includes the £1 billion CCS Infrastructure Fund and revenue support mechanisms.

Key policies:

- Following the Phase 1 of the Cluster Sequencing process, the Hynet and East Coast Clusters, will act as economic hubs for green jobs in line with our ambition to capture 20-30 MtCO2 per year by 2030. This puts Teesside and the Humber, Merseyside and North Wales, along with the North East of Scotland as a reserve cluster, among the potential early SuperPlaces which will be transformed over the next decade.
- Future-proofing industrial sectors, and the communities they employ through the £315 million Industrial Energy Transformation Fund (IETF), (£289 million for England, Wales and Northern Ireland, £26 million for Scotland).
- Incentivise cost-effective abatement in industry at the pace and scale required to deliver net zero, through the UK ETS by consulting on a net zero consistent UK ETS cap (in partnership with the Devolved Administrations).

Heat and Buildings

The policies and proposals for heat and buildings in the Net Zero Strategy will…

Support up to 100,000 jobs n the middle of the 2020s and up to 175,000 in 2030	Start to mobilise additional public and private investment of approximately £200 billion, in line with our 2037 delivery pathway	Set a path to all new heating appliances in homes and workplaces from 2035 being low carbon

Reaching net zero means tackling all sources of emissions – and heating for homes and workspaces makes up almost a third of all UK carbon emissions. So we will improve the energy efficiency of housing and non-domestic properties across the UK, ensuring they require less energy to heat, making them cheaper to run and more comfortable to live and work in while reducing our dependence on imported energy. We are setting the ambition that, by 2035, once costs have come down, all new heating appliances installed in homes and workplaces will be low-carbon technologies, like electric heat pumps or hydrogen boilers. We will take a decision in 2026 on the role of hydrogen heating. Crucially, this will be a gradual transition that works with the grain of consumer choice. But the costs of low carbon technology can fall quickly – working with industry, we expect a heat pump to be as cheap to buy and run as a gas boiler this decade. We want to reduce electricity costs so when the current gas spike subsides we will look at options to shift or rebalance energy levies (such as RO and FiTs) and obligations (such ECO) away from electricity to gas over this decade. This will include looking at options to expand carbon pricing and remove costs from electricity bills while ensuring that we continue to limit any impact on bills overall. We know that in the long run, green products are more efficient and cheaper, and we are putting fairness and affordability at the heart of our approach.

Key policies:

- An ambition that by 2035, no new gas boilers will be sold.
- A new £450 million three-year Boiler Upgrade Scheme will see households offered grants of up to £5,000 for low-carbon heating systems so they cost the same as a gas boiler now.
- A new £60 million Heat Pump Ready programme that will provide funding for pioneering heat pump technologies and will support the government's target of 600,000 installations a year by 2028.
- Delivering cheaper electricity by rebalancing of policy costs from electricity bills to gas bills this decade.

- Further funding for the Social Housing Decarbonisation Scheme and Home Upgrade Grants, investing £1.75 billion. Additional funding of £1.425 billion for Public Sector Decarbonisation, with the aim of reducing emissions from public sector buildings by 75% by 2037.
- Launching a Hydrogen Village trial to inform a decision on the role of hydrogen in the heating system by 2026.

Transport

The policies and proposals for transport in the Net Zero Strategy will …

Support for up to 22,000 jobs in 2024 and up to 74,000 jobs in 2030

Start to mobilise additional public and private investment of around £220 billion, in line with our 2037 delivery pathway

Remove all road emissions at the tailpipe and kickstart zero emissions international travel

We will transform our cities and towns with greener, faster and more efficient transport. Our streets will be cleaner and people healthier from breathing cleaner air, walking and cycling more. Our zero emissions vehicle (ZEV) mandate will guarantee greater number of zero emission vehicles on our roads, unlocking the transformation of our road transport. Additional funding will support our automotive sector to stay at the cutting edge and capture jobs of the future. Significant new investment in vehicle grants and electric vehicle infrastructure will ensure that we see even more green vans delivering our goods and big improvements in local public chargepoint provision. We will increase the share of journeys taken by public transport, cycling and walking, electrifying more railway lines, investing £3 billion to transform bus services and £2 billion for cycling. We will build on our strong maritime heritage and the success of the Clean Maritime Demonstration Competition to deliver a more ambitious multi-year programme for the sector. Setting out an ambitious position on SAF will set us on a path to decarbonise this challenging sector. Accelerating the decarbonisation of transport will save lives and significantly reduce noise, making our urban centres more enjoyable places to live.

Key policies:

- A zero emission vehicle mandate to improve consumer choice and ensure we maximise the economic benefit from this transition by giving a clear signal to investors. This will deliver on our 2030 commitment to end the sale of new petrol and diesel cars, and 2035 commitment that all cars must be fully zero emissions capable.
- Further funding of £620 million for zero emission vehicle grants and EV Infrastructure, including further funding for local EV Infrastructure, with a focus on local on street residential charging.
- Allocating a further £350 million of our up to £1 billion Automotive Transformation Fund (ATF) to support the electrification of UK vehicles and their supply chains.
- Building on the success of our £20 million zero emission road freight trials, we will expand these to trial three zero emission HGV technologies at scale on UK roads to determine their operational benefits, as well as their infrastructure needs.

- £2 billion investment which will help enable half of journeys in towns and cities to be cycled or walked by 2030.
- £3 billion to create integrated bus networks, more frequent services and bus lanes to speed journeys.
- Transformation of local transport systems, with 4,000 new zero emission buses and the infrastructure to support them, and a net zero rail network by 2050, with the ambition to remove all diesel-only trains by 2040.
- Building on the success of the Clean Maritime Demonstration Competition, we will be extending this to a multi-year programme, delivering real-world demonstrations and technology trials of clean maritime vessels and infrastructure to decarbonise the maritime sector. This is part of our commitment to a UK Shipping Office for Reducing Emissions.
- Significant investment in rail electrification and city rapid transit systems.
- Aim to become a world-leader in zero emission flight and kick-starting the commercialisation of the UK sustainable aviation fuel so people can fly, and connect without guilt. Our ambition is to enable delivery of 10% SAF by 2030 and will be supporting UK industry with £180 million funding for the development of SAF plants.

Natural Resources, waste and fluorinated gases

The policies and proposals for natural resources, waste, and fluorinated gases in the Net Zero Strategy will…

New employment opportunities across the UK. Afforestation in England could support up to 1,900 jobs in 2024 and 2,000 jobs in 2030

Start to mobilise additional public and private investment of approximately £30 billion, in line with our 2037 delivery pathway

Treble woodland creation rates in England, contributing to the UK's overall target of increasing planting rates to 30,000 hectares per year by the end of this Parliament

Halting climate change and protecting the natural world are two sides of the same coin, so we will restore our countryside to reduce emissions, sequester carbon and build our resilience to climate change at the same time. We will support farmers to implement a range of low carbon farming practices that can help increase productivity and enable more efficient use of land, such as through agroforestry. We will increase tree planting to sequester carbon, and protect and restore our peatlands. As part of reforms to the resources and waste system, we also will move towards a circular economy, improve resource efficiency, and achieve near elimination of biodegradable waste to landfill. We will continue to phase down the use of F-gases in line with domestic regulations and international commitments.

Key policies:

- Supporting low-carbon farming and agricultural innovation through the Farming Investment Fund and the Farming Innovation Programme to invest in equipment, technology, and infrastructure to improve profitability, benefit the environment and support emissions reductions.
- We will boost the existing £640 million Nature for Climate Fund with a further £124 million of new money, ensuring total spend of more than £750 million by 2025 on peat restoration, woodland creation and management – above and beyond what was promised in the manifesto. This will enable more opportunities for farmers and landowners to support Net Zero through land use change.
- Restoring approximately 280,000 hectares of peat in England by 2050 and trebling woodland creation rates in England, contributing to the UK's overall target of increasing planting rates to 30,000 hectares per year by the end of the Parliament.
- £75 million on net zero related R&D across Natural Resources, Waste & F-gases, to inform our pathway to 2037.

- To support our commitment to explore options for the near elimination of biodegradable municipal waste to landfill from 2028, we are bringing forward £295 million of capital funding which will allow local authorities in England to prepare to implement free separate food waste collections for all households from 2025.

Greenhouse Gas Removals

The policies and proposals for GGRs in the Net Zero Strategy will provide…

New, highly skilled, jobs in our industrial heartlands

Start to mobilise additional public and private investment of around £20 billion, in line with our 2037 delivery pathway

An ambition to deploy at least 5 $MtCO_2$/year of engineered GGRs by 2030.

Our most important step to achieving net zero is to take ambitious decarbonisation measures across society. However, greenhouse gas removals (GGRs) will also play a critical role in balancing residual emissions from the hardest to decarbonise sectors such as aviation, agriculture, and heavy industry. Our innovation-led approach position the UK as a global leader in this rapidly developing sector.

Government intervention in the short term will support early commercial deployment of GGRs, with an ambition to move towards a market-based framework for GGRs. This will support our delivery of net zero emissions and position us to export our skills and expertise, capitalising on economic opportunities for the UK and supporting the global shift to net zero.

Key policies:

- Delivering £100 million of investment in GGR innovation could enable further deployment of GGRs, which in turn will leverage private investment and demand for transferrable engineering expertise from the UK's oil and gas sector.
- Explore options for regulatory oversight to provide robust monitoring, reporting and verification (MRV) of GGRs, following the recommendations of the BEIS-led MRV Task & Finish Group involving experts from industry and academia.

Supporting the transition with cross-cutting action

We will maximise the opportunities of this transition, and make sure we are geared up to deliver these changes by also taking cross-cutting action. As the host nation for COP26 in Glasgow this year, we will use our global platform to continue to urge countries to set targets to get to net zero by 2050, and more ambitious 2030 emissions reduction targets to get us there. We will back innovation and our world-leading green finance sector. We will support each stage of the innovation chain to drive down costs and bring through key technologies and ideas to meet net zero. We will work with the private sector to leverage private investment to provide the finance needed, while providing the conditions for green finance to flourish.

We will put consumers at the heart of the transition and our goal is to make choosing green options significantly easier, cheaper, and more rewarding. We will back training and skills, supporting workers to retrain and upskill and build low carbon industries with strong UK supply chains that are resilient to changes. We will also take a place-based approach to net zero, working with local government to ensure that all local areas have the capability and capacity for net zero delivery as we level up the country. And Government is leading the way – embedding climate into our policy and spending decisions, increasing the transparency of our progress on climate goals, and providing funding to drive ambitious emissions reductions in schools and hospitals.

Key policies:

- Deliver at least £1.5 billion of funding to support net zero innovation projects.
- Use the UK Infrastructure Bank (UKIB) to crowd in private finance, support more than £40 billion of investment, and pull through low carbon technologies and sectors to maturity and scale.
- Introduce a new Sustainability Disclosures Regime, including mandatory climate related financial disclosures and a UK green taxonomy.
- Reform the skills system so that training providers, employers and learners are incentivised and equipped to play their part in delivering the transition to net zero.
- Publish an annual progress update against a set of key indicators for achieving our climate goals.

Delivering the Prime Minister's Ten Point Plan

In the past year, we have already taken important action on climate change, delivering on the commitments in the Prime Minister's Ten Point Plan.

***56,000 jobs** have been protected and created over the last ten months, since the publication of the Prime Minister's Ten Point Plan and wider green agenda - with some already on line and others set to come on line over the coming decade*

We committed to…	Since then we have…
Point 1: Advancing Offshore Wind, *including:* – 40GW of offshore wind by 2030 including 1GW of floating wind (wind turbines generating electricity in water depths) – £160 million into modern ports and manufacturing infrastructure – The Offshore Transmission Network Review	– Supported manufacturers via government investment schemes. Six manufacturers have already announced major investments in the UK offshore wind sectors and delivering up to 3,600 jobs by 2030. – Built our Offshore Wind capacity to 10.5GW, enough in 2020 to power 4.5 trillion LED light bulbs. This increased our share of electricity generated by Offshore Wind from 1% to 13% over the last decade. – Kicked off the biggest-ever round of our flagship renewable energy scheme for low carbon electricity (Contract for Difference) with £200 million for offshore wind projects and £24m for floating offshore wind. – Launched a £17.5 million competition to support innovative floating wind ideas from industry and joined the ORE Catapult's FOW Centre of Excellence, contributing £2 million. – Leveraged over £1.5 billion investment into our offshore wind industry, following the £160 million to upgrade ports and infrastructure. – Published the *Offshore Transmission Network Review*, setting out two initial policy consultations to move to a coordinated approach for both in-flight and future offshore wind projects.
Point 2: Driving the Growth of Low Carbon Hydrogen, *including:* – An ambition for 5GW of low carbon hydrogen production capacity by 2030 – £240 million Net Zero Hydrogen Fund – Hydrogen trials to test use of hydrogen in heating	– Published the *Hydrogen Strategy*, setting out our comprehensive approach to growing the UK hydrogen economy. – Commenced an allocation process for electrolytic hydrogen in 2022 to award up to 100MW of contracts in 2023 and up to 400MW of contracts in 2024 and announcing a funding envelope in 2022 that will enable us to award the first contracts to CCUS-enabled hydrogen from 2023 through the Cluster Sequencing process, to deliver up to 1GW of CCUS-enabled hydrogen. – Following our consultation on a proposed hydrogen business model, design of the £240 million Net Zero Hydrogen Fund and on a UK low carbon hydrogen standard. – Invested £3 million to kick start the Tees Valley hydrogen transport hub, which is building early collaborations and operational learning. – Announced a £60 million competition to fund projects to develop innovative low carbon hydrogen supply solutions. – Started preparations for a hydrogen heating neighbourhood trial in Levenmouth, Fife led by SGN following funding awards by Ofgem and Scottish Government.

We committed to…	Since then we have…
Point 3: Delivering New and Advanced Nuclear Power, *including:* – Pursuing large-scale nuclear projects, subject to value for money – Legislating for a new financing model for nuclear projects – £385 million Advanced Nuclear Fund to enable up to £215 million into Small Modular Reactors – £170 million for a R&D programme on Advanced Modular Reactors	– Announced our aim to bring at least one large-scale nuclear project to the point of Final Investment Decision by the end of this Parliament, subject to value for money and all relevant approvals. Entered into negotiations with the developer of Sizewell C power station in December 2020. – Launched a Call for Evidence on Government's preference to explore the potential of High Temperature Gas Reactors (HTGRs) to enable an AMR demonstration by the early 2030s.
Point 4: Accelerating the Shift to Zero Emission Vehicles, *including:* – End the sale of new pure petrol and diesel cars and vans by 2030 and consult on phase out for diesel HGVs – £1 billion to support electrification of UK vehicles and their supply chains – £1.3 billion to accelerate the roll-out of charging infrastructure – Publish a Green Paper in 2021 on the UK's post-EU emissions regulation	– Announced we will introduce a ZEV mandate to deliver our end of sales dates for new petrol and diesel cars and vans. – Announced funding for the UK's first large-scale gigafactory as part of the Automotive Transformation Fund. The investor has committed to creating 1,000 jobs which will be realised during the period to 2025/26 as the facility is built and becomes operational. – Secured an additional 950 jobs through other automotive projects, for a total of 1,950 jobs to be realised through to 2025/26. – Built on existing successful projects, such as the Advanced Propulsion Centre - according to participating companies, APC projects agreed this year will support up to 5,200 direct jobs. – Seen increased demand for ZEVs – industry figures state that nearly one in ten of all new cars sold so far this year in the UK is fully electric and over 650,000 plug-in cars have been registered in the UK since 2010. – For this financial year, committed £70 million to roll out home, on-street and workplace chargepoints. – 70% of motorway service areas now have plans to install at least 6 high-powered chargers by 2023. – Announced the winners of the £20 million Zero Emission Road Freight Trials – projects that will help to design and develop cost-effective, zero emission HGVs and refuelling infrastructure. – Consulted on the phase out of non-zero emission HGVs.

We committed to…	Since then we have…
Point 5: Green Public Transport, Cycling and Walking, *including:* – £120 million to begin introducing at least 4,000 zero emission buses – Billions of pounds in enhancements and renewals of the rail network – £5 billion to support buses, cycling and walking	– Launched the National Bus Strategy and a consultation on phase out of new non-zero emission buses and the £120 million Zero Emission Bus Regional Area (ZEBRA) scheme to support local transport authorities outside London. – Supported Coventry to become UK's first all-electric bus city, with £50 million to fund up to 300 electric buses and charging infrastructure. – Committed £17.5 billion in the November 2020 Spending Review in capital funding for renewals, upgrades, and enhancements of the existing rail network up to 2024. – Delivered more than 300 walking and cycling schemes.
Point 6: Jet Zero and Green Ships, *including:* – A Jet Zero Council – £15 million to support production of Sustainable Aviation Fuels – £20 million for the Clean Maritime Demonstration Programme	– Consulted on our proposals for reaching net zero aviation by 2050 and following a consultation on a UK Sustainable Aviation Fuels (SAF) mandate, confirmed our ambition for it to enable delivery of 10% SAF by 2030 , and we will make £180 million available to support the development of the UK SAF industry. – Announced the shortlist for the £15 million Green Fuels, Green Skies competition, to support UK pioneers in Sustainable Aviation Fuels. – Co-invested £150 million per year through the Aerospace Technology Institute to support greener aircraft technology like Rolls-Royce's next gen UltraFan jet engine which aims to cut emissions by 25% and ZeroAvia's zero-emission hydrogen-propulsion system. – Allocated up to £23 million of match-funding to 55 projects through the Clean Maritime Demonstration Competition to support the development of zero emission technologies and greener ports.
Point 7: Greener Buildings, *including*: – Ambition to install 600,000 heat pumps per year by 2028 – Energy efficiency funding, including the Public Sector Decarbonisation Scheme and Social Housing Decarbonisation Fund – Strengthened energy efficiency requirements for private sector landlords	– Supported approximately 45,000 jobs in greener buildings in the first year since the Ten Point Plan was launched.[1] – Announced that we will tighten Minimum Energy Efficiency Standards to ensure that landlords can no longer let properties covered by the Domestic Minimum Energy Efficiency Standards Regulations if they have an EPC rating below E, unless they have a valid exemption in place. – Allocated £1 billion funds from the Public Sector Decarbonisation Scheme, supporting up to 30,000 jobs.[2] – Awarded £62 million to 19 projects in the Social Housing Decarbonisation Fund Demonstrator, with over 2,300 homes in the process of being improved.

We committed to…	Since then we have…
Point 8: Investing in Carbon Capture, Usage and Storage, *including* – Commitment for two industrial clusters by mid 2020s, and an aim for four sites by 2030, capturing up to 10Mt CO2 emissions per year – £1 billion CCUS Infrastructure Fund	– We have set up the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme, providing up to up to £140 million to fund our new hydrogen and industrial carbon capture business models. – Announced £19.5 million of grant funding for projects developing novel CCUS technology and processes that reduce the cost of deployment. – Kicked off the process to decide the first carbon capture cluster locations in our industrial heartlands. – Published details of the design of funding mechanisms, including the business model for CO_2 transport and storage, industrial CCUS, power CCUS, as well as the CCS Infrastructure Fund.
Point 9: Protecting Our Natural Environment, *including* – £5.2 billion for flood and coastal defences – New National Parks and Areas of Outstanding Natural Beauty – £40 million second round for the Green Recovery Challenge Fund – Establish 10 long-term Landscape Recovery projects over the next four years	– Supported an estimated 850 jobs in environmental protection and enhancement. – Launched the floods investment programme that is on track to better protect 336,000 properties from flooding. – Natural England has set out plans to start the process to designate four new areas of outstanding natural beauty - Yorkshire Wolds AONB, Cheshire Sandstone Ridge AONB, an extension to the Surrey Hills AONB, and an extension to the Chilterns AONB. – Announced 90 projects awarded grants under round 2 of the £80 million Green Recovery Challenge Fund (GRCF). Across all 159 projects, the GRCF is set to plant almost 1 million trees and create and retain up to 2,500 jobs. – Held three Landscape Recovery market engagement events and, subject to feedback, we aim to open applications for the first wave of pilot projects later this year. – Launched several schemes under the Nature for Climate Fund to expand our pipeline of tree planting and peatland restoration projects in England, including the new England Woodland Creation Offer and Tree Production Innovation Fund.

Point 10: Green Finance and Innovation, *including*
– £1 billion Net Zero Innovation Portfolio (NZIP), including £100 million for Direct Air Capture and other Greenhouse Gas Removal (GGR) technologies
– UK's first Sovereign Green Bond
– Green Jobs Taskforce
	– Launched the Net Zero Innovation Portfoliow, providing funding for low-carbon technologies and systems across the areas of the *10 Point Plan*, including:
	  – Up to £68 million across two competition streams for Longer Duration Energy Storage Demonstration.
	  – Funding for the first phase of GGR studies, which could remove between 100 and 1,000 tonnes of CO_2e per year in 2025.
	– Issued £10 billion Sovereign Green Bond, to raise money for green government projects like zero-emission buses, offshore wind, and decarbonising homes.
	– Launched the Green Jobs Taskforce in November 2020, which reported 15 recommendations in July 2021.

Endnotes

[1] Estimate based on internal HMG analysis.

[2] This figure is already included in the headline 45,000 figure for greener buildings.

Why Net Zero

Chapter 1

Levelling up the country, ending our domestic contribution to climate change, and leading the world to a greener, more sustainable future

The case for action

1. We are at a crossroads in our history. As we recover from the impact of the pandemic on our lives and livelihoods, we know that it will not be enough to go back to the way things were before. The science is clear, we know that human activity is changing our climate and that this will have a devasting impact on human lives, the economy, and the natural world – ranging from the extinction of some species and the melting of ice caps to extreme weather patterns threatening our homes, businesses, and communities.[1] As the latest report by the Intergovernmental Panel on Climate Change (IPCC) shows,[2] this is no longer a challenge for tomorrow: we are already seeing the impacts today with increased incidence of events such as extreme heat, floods, and wildfires across the globe. We need to act urgently and reduce emissions globally to limit further global warming. The landmark 2015 Paris Agreement agreed to hold the increase in the global average temperature to well below 2°C above pre-industrial levels, and to pursue efforts to limit it to 1.5°C.

The UK's net zero target

The UK was the first major economy to create a legally binding target to bring greenhouse gas emissions to net zero by 2050. This target was set considering the latest scientific evidence and was recommended by the Climate Change Committee (CCC), the UK's independent climate advisory body. The net zero target also responds to the overwhelming public support for acting on climate change. In recent surveys of the UK public, 80% of participants expressed concern about climate change.[3]

Government is committed to ambitious decarbonisation measures across society. However, we know that this does not mean emissions will drop to *absolute* zero by 2050 – we acknowledge that sectors such as industry, agriculture, and aviation are difficult to decarbonise completely. Greenhouse gas removals (GGR), like trees and carbon capture and storage technology, are therefore essential to compensate for the residual emissions arising from these hard to decarbonise sectors, so we can reach *net* zero by 2050.

2. The sooner we act on climate change the lower the costs will be. Globally, the costs of failing to get climate change under control would far exceed the costs of bringing greenhouse gas emissions down to net zero. The Office for Budget Responsibility concluded that there could be significant fiscal benefits from early action to transition to net zero, meaning the costs will be lower than if we delay.[4] Delaying action would only serve to put future generations at risk of crossing critical thresholds resulting in severe and irreversible changes to the planet, the environment, and human society. On the other hand, early and ambitious action would help protect lives and livelihoods, while maximising the co-benefits for people, society, the environment, and the economy.[5] As part of the transition to net zero emissions, we will transform our energy system away from fossil fuels to low carbon sources of energy, such as renewable electricity generated in the UK. This will ensure sustainable and affordable energy supplies and protect consumers by reducing our exposure to volatile international fossil fuel markets which have caused the recent spike in gas prices.

3. The UK has long led the way in tackling climate change, and immediate action to reduce emissions brings enormous economic opportunities to revitalise our economy and deliver on our priority to level up the country. Across the globe, as governments, people and businesses rise to this challenge, a growing global green economy has the potential to create millions of new jobs. We are uniquely placed to seize this once-in-a generation opportunity and deliver a transition to net zero that has the potential to create thousands of jobs in every part of the UK.

4. We must, therefore, build back better. Our vision, building on the Prime Minister's *Ten Point Plan for a Green Industrial Revolution*, is to level up our country with new green jobs, end our contribution to climate change, and reverse the decline of our natural environment, leading the world to a greener, more sustainable future.

Plan for Growth and green sector vision

This strategy sets out how we will build on the Prime Minister's *Ten Point Plan* with our vision to create new jobs and net zero industries as we meet our climate targets. In turn, this will support levelling up the country, and put the UK at the forefront of the global green markets.

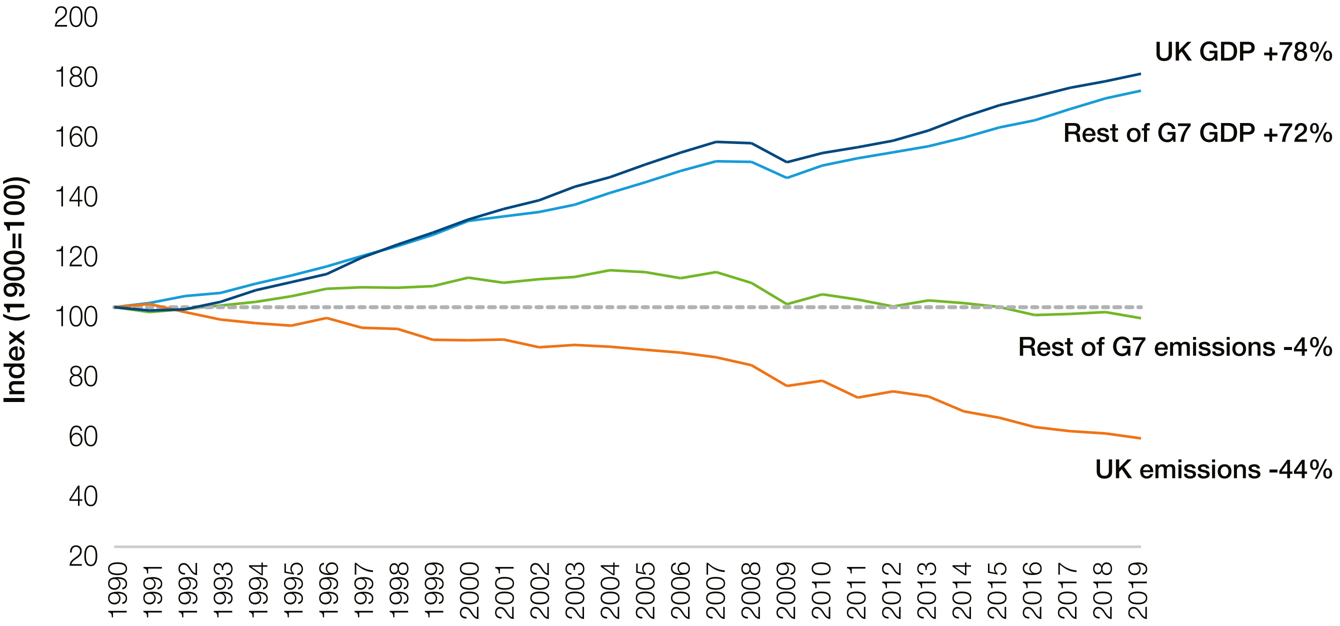
We are laying the foundations for businesses to invest in the UK's green economy, taking action to ensure we have the right skills to deliver a green industrial revolution and committing to work with industry to develop sector and supply chain action plans in areas where the UK has an economic advantage.

Build Back Better: Our Plan for Growth sets out the Government's commitment to supporting future growth sectors based on the UK's comparative advantage and growth potential, and commits to publishing sector visions across these sectors. This strategy articulates our vision for the green economy. We will build on this with more detail in further Sector and Supply Chain Development Plans – such as the CCUS supply chains roadmap published earlier this year, and the Hydrogen Sector Development Action Plan which we will publish in 2022.

Driving a green industrial revolution and levelling up the UK

5. The UK has long proved that tackling climate change and delivering economic growth can go hand in hand. Between 1990 and 2019, we cut emissions faster than any other G7 country, a 44% reduction.[6] We achieved this whilst growing our economy by 78%.[7] Our latest official estimates show that 410,000 people work in the UK's low carbon economy and its supply chains across the country, with an estimated turnover of £42.6 billion in 2019.[8] These numbers are even higher once we account for the jobs and economic activity supporting broader environmental policies such as climate adaptation and biodiversity.

Figure 2: UK vs Rest of G7 GDP and GHG Emissions[9]



Source: The World Bank, UNFCCC National Inventory Submissions, ONS, BEIS Greenhouse Gas Inventory.

6. As the world moves to tackle climate change, new opportunities will arise for UK companies in domestic and international markets. Updated analysis, based on the BEIS Energy Innovation Needs Assessment (EINA) suggests key net zero aligned sectors in the UK could contribute up to £60 billion of gross value added (GVA) a year by 2050.[10]

7. We have immediate opportunities to capitalise on our core strengths: the largest market for offshore wind in the world, a world-class oil and gas sector, and the City of London is long established as a leader in green finance.[11] In the long term, evidence from the Energy Innovation Needs Assessment (2019) and subsequent analysis, point to domestic and export opportunities for the UK in electric vehicle technologies and manufacturing, the next generation of offshore wind (including new approaches such as floating offshore wind), carbon capture, usage and storage (CCUS), low carbon hydrogen, smart energy systems and storage, and direct air carbon capture and storage (DACCS).

8. The opportunities for British innovation, expertise, and products will not just be confined to these shores. The value of goods and services exported by UK low carbon and renewable energy businesses exceeds £7 billion.[12] The net zero transition will create new growth opportunities for UK based companies, such as Livingstone based FoundOcean and Trelleborg's North West England based operation, who won contracts with the support of UK Export Finance (UKEF) to supply Taiwan's growing offshore wind market.

9. These opportunities show that net zero and levelling up go hand in hand. Delivering net zero allows us to boost living standards by supporting jobs and attracting investment in the green industries of the future, which can be in areas that need this the most. Crucially, delivering net zero also involves supporting workers employed in high carbon industries that will be affected by the transition, by giving them the skills they need to make the most of new opportunities in the green economy. But the link between net zero and levelling up is wider than just the economy, net zero can deliver wider benefits for people and communities across the UK by helping spread opportunity and restore pride in place.

10. We are already taking action to make the most of these opportunities. We have embedded a net zero principle in our levelling up funding initiatives, such as the Levelling Up Fund and the Towns Fund, so that these schemes can contribute to meeting our net zero targets and help places to reduce their carbon impacts. Later this year, we will publish a Levelling Up White Paper. This will build on the actions the government is already taking to both deliver net zero and level up across the country, including the ones set out in this strategy, and set out new interventions to improve livelihoods and drive economic growth in all parts of the UK.

Maximising opportunities after leaving the EU

Following the UK's departure from the European Union in January 2020 the UK now has the flexibility to determine our own decarbonisation pathways to 2050, in a way that fully utilises the unique strengths and opportunities of UK diplomacy, industry and innovation.

Since leaving the EU, the UK has built on our climate leadership, demonstrating an independent and ambitious approach to meeting our 2050 target:

- Setting an ambitious Nationally Determined Contribution (NDC) under the Paris Agreement, committing to the fastest rate of reducing emissions on 1990 levels of any major economy.
- Setting out ambitious plans with bold policy action across key sectors of the economy, such as the Prime Minister's *Ten Point Plan for a Green Industrial Revolution*, the *Energy White Paper*, *North Sea Transition Deal*, *Industrial Decarbonisation Strategy*, *Transport Decarbonisation Plan*, *Hydrogen Strategy*, and the *Heat and Buildings Strategy.*
- Establishing a UK Emissions Trading Scheme (UK ETS), to replace the UK's participation in the EU ETS, that demonstrates the UK's commitment to carbon pricing as an effective tool that will help fulfil our climate change objectives. The UK ETS will be aligned to our net zero target, giving industry the certainty they need to invest in low carbon technologies.

Supporting green jobs across the UK

11. Last year, the Prime Minister set out his *Ten Point Plan for a Green Industrial Revolution*, laying the foundations for a green economic recovery from the impact of COVID-19, outlining how we will level up the country and put the UK at the forefront of the growing global green economy.

12. This strategy builds upon that approach: the package of policies will support up to 190,000 jobs by the middle of the 2020s and up to 440,000 jobs in 2030. These jobs will contribute to our wider ambition of 2 million green jobs by 2030, which also factor in employment that contributes to other environmental goals. Updated analysis suggests that around 56,000 green jobs have been secured or created across the UK economy, with some being already online and others in the pipeline over the next decade.

13. There will be opportunities for each region of the UK. For example, we are supporting new investment in hydrogen and CCUS into industrial clusters across the UK. We are also driving the electrification of vehicles impacting manufacturing and supply chains in Wales, the Midlands and North East England, developing Gigafactories in the UK, accelerating the roll out of charging infrastructure across the UK, and supporting roll-out of zero emission buses which would boost manufacturers in Scotland and Northern Ireland. We are also supporting the development of new offshore wind power off the coast of England, Scotland, and Wales; and already investing in nuclear power in the South East and West of England.

14. The impact of the transition to net zero on the UK's labour market could be significant: with one estimate suggesting up to 20% of the workforce could see demand for their skills affected, either positively or negatively.[13] Furthermore, as set out by HM Treasury's *Net Zero Review*, although the net macroeconomic impact is likely to be small in 2050 relative to total growth over the period, impacts between and within regions over the next three decades can vary. Our approach will need to reflect that benefits and impacts of the transition will be dependent on individual household characteristics, such as their housing type and current vehicle usage, to support those low-income households most affected by individual technology transitions.

15. Our approach to supporting green jobs, attracting private investment, and tackling climate change will benefit the whole of the UK, including areas where a large proportion of people are currently employed in high-carbon sectors. However, while employment opportunities in green industries will emerge, high-carbon sectors will have to adapt or decline, resulting in a need to transition local labour markets to ensure people have the right skills to make the most of these opportunities.

16. Our sector deals, including on nuclear, offshore wind, automotive and the North Sea Transition Deal considered the skills needs and support for the labour market transition to net zero on a sectoral basis. The North Sea Transition Deal, for example, will support workers, businesses, and the supply chain throughout the transition by harnessing the sector's existing capabilities, infrastructure, and private investment potential to exploit new and emerging technologies such as hydrogen production, CCUS, offshore wind and decommissioning. Through the Deal, the sector, government, and unions will work together over the next decade and beyond to deliver the skills, innovation, and new infrastructure required to decarbonise North Sea production.

17. Our Automotive Transformation Fund and industrial clusters framework will help these industries, transition to a sustainable future. We are also taking action to enable local employers to set out their green skills needs, and support workers to gain the skills they need to access green jobs - such as through our Skills Bootcamps.

18. Supporting innovation will also help unlock jobs across low carbon sectors. For example, our portfolio of net zero innovation will provide at least £1.5 billion of government funding to help commercialise clean technologies and boost private investment across the UK.

Examples of clean growth investment across the UK

Scotland, Aberdeen

Scotland has a technology hub for offshore wind, including the first successful floating turbines in Aberdeen. The city is benefiting from funding for the Aberdeen Energy Transition Zone and the Global Underwater Hub, as well as the Net Zero Technology Transition Programme.

Scotland, Orkney

Hydrogen in an Integrated Maritime Energy Transition' project £1.6 million from the UK Government match-funding a £2.3 million project to develop hydrogen-based clean maritime solutions.

Wales

South Wales Industrial Cluster

Nearly £20 million to support the deployment of decarbonisaton infrastructure will go to the South Wales Industrial Cluster which aims to create a net zero industrial zone from Pembrokeshire to the Welsh/English border by 2040.

Wales, Cwmbran

EPIC - Electric Powertrain Integration for heavy Commercial vehicles £31.8 million project (£15.8 million from the UK government) to develop lightweight electric powertrains for heavy goods to manage extreme levels of electrical power.

Northern Ireland, Belfast

Wrightbus zero-emission buses £11.2 million from the UK Government to develop hydrogen-fuel technology.

North West

Ellesmere Port plant transforming to build electric vans £100 million from Stellantis to build electric vans, safeguarding 1,000 jobs.

North West, Greater Manchester

People Powered Retrofit

£1 million from the UK Government to support initial business development, leading to 1,150 homes retrofitted and 3,500 local contractors retrained over the next five years.

West Midlands

Public Sector Decarbonisation Scheme £2 million from the UK Government to Windsor Academy Trust for heat decarbonisation and energy efficiency measures across seven schools.

South West & East of England

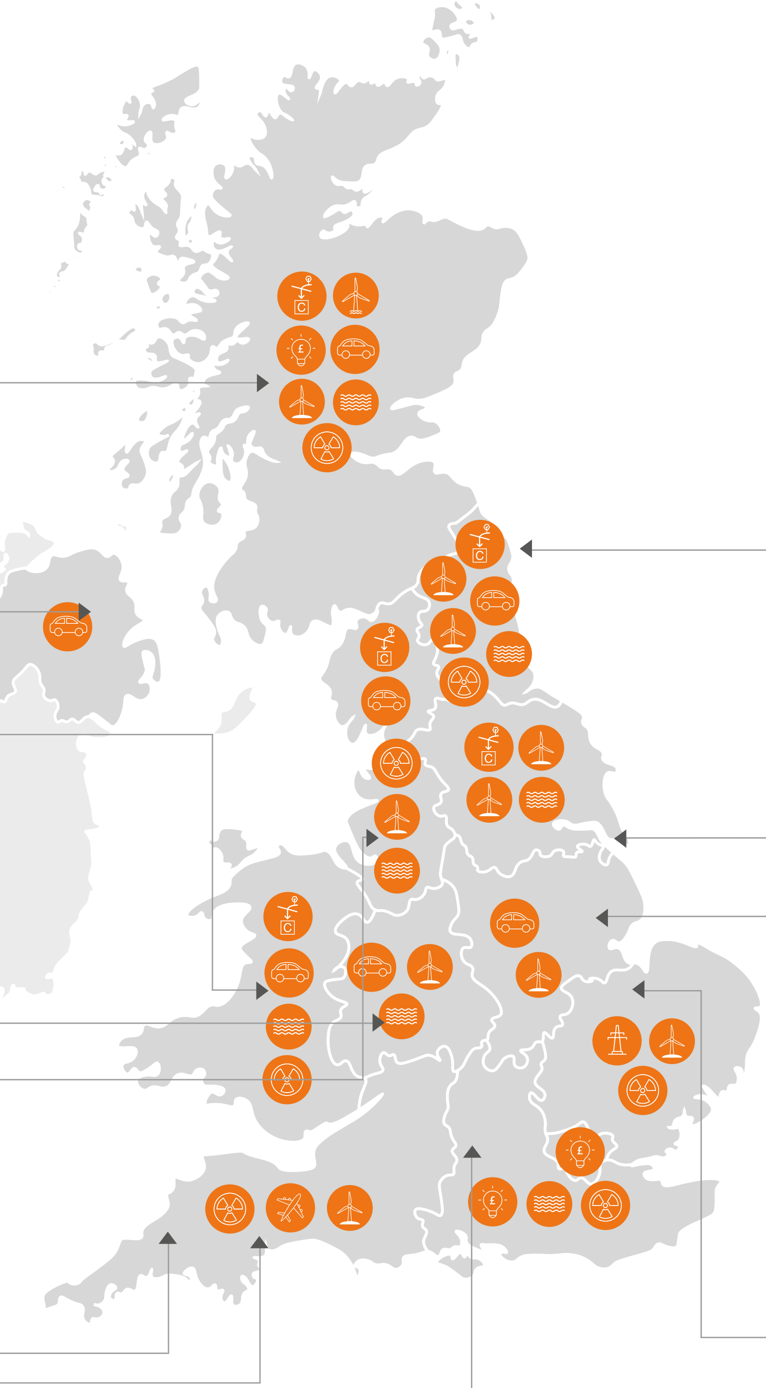
£84.6 million invested by government and industry in 3 ambitious aerospace R&D projects based in Bedford, Bristol and Cranfield to help the industry build back greener.

South West, Somerset

Hinkley Point C Nuclear Power Station) £3.5 billion already spent with companies in the South West and 12,786 jobs created so far, including 787 apprentices.

- Heat Pumps
- CCUS
- Offshore Wind
- Automotive
- Rail
- Waste and Circular Economy
- Climate Change Adaptation
- Heat Networks
- Retrofit
- Nuclear
- Aerospace
- Forestry
- Oil and Gas
- Science and Innovation
- Low Carbon Hydrogen
- Electricity Networks
- Green Finance
- Maritime
- Agriculture
- Steel
- Public Transport and Cycling
- Onshore Wind
- Solar
- Tidal
- Smart Systems
- Nature Conservation & Restoration

UK-wide



North East, Teesside

Whitetail Clean Energy 8 Rivers Capital and Sembcorp Energy UK's 300MW NET power plant, creating over 2000 construction and 200 operational jobs.

North East

Transforming automotive manufacturing £1 billion announced by Nissan and Envision AESC to create an electric vehicle manufacturing hub supporting 6,200 jobs.

North East

Gateshead District Energy Scheme £5.9 million of UK government funding for heat network project with mine water source heat pump connecting 5 buildings and up to 1,250 new homes to the Gateshead District Energy Scheme.

Yorkshire and the Humber

Able Marine Energy Park Up to £75 million from the UK Government to facilitate a c.£500 million offshore wind manufacturing port hub, supporting up to 3,000 local jobs.

Yorkshire and the Humber

Siemens Gamesa offshore wind factory expansion £186 million from Siemens Gamesa to expand their offshore wind turbine blade factory, creating and safeguarding up to 1,080 local jobs.

East Midlands

Tackling Climate Change on the River Rase £200,000 from the UK Government for nature-based solutions in the River Rase catchment helping climate adaptation.

East of England

Advanced Greenhouses £120million from Greencoat Capital backed by UK pension funds to build 2 greenhouses (covering 72 acres) warmed by heat pumps utilising warm waste water, creating 360 new green jobs and 120 seasonal jobs.

Midlands, Coventry

Coventry will be the first zero emission bus town awarded ten of millions to replace the entire local operator bus fleet with electric buses.

Case Study: North East of England

This region is leading the way in championing new technologies, whether it is electric vehicles (EVs), carbon capture, hydrogen, or renewables. Research undertaken for government indicates that the North East could gain an extra 27,000 jobs by 2050 arising from UK climate action.[14] The research indicates that the gains to the region over time come to a large extent from specific investments needed for the UK to meet net zero, rather than baseline economic growth. In depth interviews with regional and industry stakeholders has also revealed a real and justified optimism about the region's potential to level up due to the Green Industrial Revolution and remain an attractive location for people to live and work.

The optimism is backed by significant investments in offshore wind and EV manufacturing. Spurred on by our 40 GW offshore wind deployment plans and £160 million investment in ports and manufacturing, we have seen almost £1.5 billion in investment in our offshore wind manufacturing capabilities. Recently announced projects include GE Renewable Energy's plans for a new blade factory in Teesside, South Korea's SeAH Wind, and GRI Renewable Industries' construction of factories in the Humber and Smulders (Newcastle), and the expansion of Siemens Gamesa's existing site in Hull.[15] Combined these projects will support up to 3,600, direct green jobs.

Nissan and Envision AESC have reaffirmed their belief in the region and in Britain's plans to shift to EVs, through their £1 billion flagship investment to establish an Electric Vehicle Hub in Sunderland. The hub will bring together electric vehicles, renewable energy, and battery production. Nissan will invest up to £423 million to produce a new-generation all-electric vehicle in the UK. Envision AESC will invest £450 million to build the UK's first large-scale Gigafactory.

Leveraging private investment

19. We estimate that additional capital investment must grow from present levels to an average of £50-60 billion per year through the late 2020s and 2030s. Most of this investment will come from the private sector, providing new opportunities for businesses and investors. Over the same period, we could see additional resource savings of around £180 billion as a result of our reduced use of oil and natural gas.

20. The policies and spending brought forward in the Net Zero Strategy mean that since the *Ten Point Plan*, HMG has mobilised £26 billion of government capital investment for the green industrial revolution. Along with regulations, this will support up to 190,000 jobs in 2025, and up to 440,000 jobs in 2030, and leverage up to £90 billion of private investment by 2030.

21. Development of existing clean energy industries can give a sense of the scale of investment we will likely need to develop and grow new low carbon sectors. According to Wind Europe[16,] from 2010-20 the UK leveraged around £47 billion in our world leading offshore wind industry, almost half of all European investment in the sector. As existing strengths expand and newer strengths emerge, we will work with industry, investors, and innovators to mobilise the private investment required to deliver net zero.

22. Government has an important role to play in ensuring a comprehensive financing offer, long-term investment signalling and fit-for-purpose business models coupled with investment from numerous private sources. We will work to create an attractive environment to secure the right investment in UK projects, with benefits to UK business and communities. By building on our strengths, including potential for rapid scale up across the domestic value chain, and coupling this with a strategic approach from government on policy and investment, we can create the right conditions to unlock the significant scale of private investment that will be needed.

23. Recent steps include establishing a new Office for Investment (OFI), which will support high value investment opportunities into the UK which align with key government priorities. The new UK Infrastructure Bank will provide leadership to the market in the development of new technologies, particularly in the scaling early-stage technologies that have moved through the R&D phase. With an initial £12 billion of investment the Bank will crowd in private investment to accelerate our progress to net zero whilst helping to level up across the UK. (See *Green Investment* chapter for more detail).

Creating wider benefits for society, the economy and the environment

24. Acting on climate change also brings the opportunity for wider benefits for our society individual wellbeing,[17] economy, and environment from improving public health to protecting biodiversity. These include:

- ✓ Cleaner air and less noise pollution, by replacing fossil fuels with renewables for generating electricity and moving to electric vehicles.
- ✓ Better insulated homes will reduce energy consumption and lower bills, alongside health benefits.
- ✓ Opportunities to tackle mitigation and adaptation together, and bring wider benefits. For example, sustainable land management can reduce emissions from land, assist adaptation, improve food security, and protect wildlife.[18]
- ✓ Supporting biodiversity by planting woodlands and restoring peatlands.
- ✓ Physical and mental health benefits, and better connectivity to jobs, public services, and each other, by promoting more walking and cycling, and improving access to green spaces.

25. We know central government cannot and should not deliver these benefits by acting alone. We want to work in partnership with people and communities across the country. To do so, we will empower local leaders to kickstart their own net zero initiatives, taking responsibility for improving their areas and shaping their own futures.

UK framework for ending our domestic contribution to climate change

26. The UK has long been a global leader in tackling climate change. The 2008 Climate Change Act sets the legal framework for reducing emissions across the UK economy. In 2019, we became the first major economy to legislate to reach net zero by 2050.

27. On our pathway to net zero, the UK has interim targets called carbon budgets and Nationally Determined Contributions (NDCs). Carbon budgets restrict the total amount of greenhouse gases that the UK can emit over five-year periods, ensuring continued progress towards our long-term climate target. NDCs are commitments made by Parties to the Paris Agreement. They show how Parties intend to reduce their greenhouse gas emissions to meet the temperature goal of the Paris Agreement.

28. In 2020, we communicated to the UN Framework Convention on Climate Change (UNFCCC) our NDC pledge to reduce UK emissions by at least 68% by 2030 on 1990 levels.[19,20]

29. In June 2021, the Government set in law the sixth carbon budget (CB6) limiting the volume of greenhouse gases emitted from 2033 to 2037. CB6 reduces emissions by approximately 78% by 2035 compared to 1990 levels. For the first time, this carbon budget formally incorporates the UK's share of international aviation and shipping emissions, enabling these emissions to be accounted for consistently with other emissions and demonstrating leadership in how we account for our emissions.[21]

30. This strategy sets out the action we will take to keep us on track for the UK's carbon budgets and 2030 NDC, and establishes our longer-term pathway towards net zero by 2050. The Net Zero Strategy will be submitted to the UNFCCC as our second Long-Term Low Greenhouse Gas Emission Development Strategy under the Paris Agreement.

Emission reduction targets in Scotland, Wales, and Northern Ireland

The UK Government's net zero target covers the whole of the UK. All parts of the UK have an integral role to play in delivering the UK-wide carbon budgets on the path to net zero by 2050. Each nation faces different challenges based on the share of its emissions from hard-to-treat sectors. For example, Northern Ireland has a higher proportion of its total emissions from agriculture (29%), compared to the UK overall (11%).[22]

Scotland

The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019, which amends the Climate Change (Scotland) Act 2009, sets targets to reduce Scotland's emissions of all greenhouse gases to net zero by 2045 at the latest, with interim targets for reductions of 75% by 2030 and 90% by 2040 and annual targets for other years. Scotland's net zero target is in line with the independent, expert advice of the Climate Change Committee.

The update to the Scottish Government's 2018-2032 Climate Change Plan sets out the pathway to its new and ambitious targets set by the Climate Change Act 2019. It is also a key strategic document for its green recovery from COVID-19.

Wales

In March 2021, the Senedd passed a suite of regulations to set a Net Zero Wales 2050 target, increase Wales decadal emissions targets, and set Wales Carbon Budgets 2 and 3 in line with them. Relative to the baseline established in legislation, the targets and budgets set in law are:

- Carbon Budget 2 (2021-25): 37% average reduction with a 0% offset limit
- Carbon Budget 3 (2026-30): 58% average reduction
- 2030: 63% reduction
- 2040: 89% reduction
- 2050: at least 100% reduction (net zero)

Welsh legislation requires Welsh Government Ministers to publish a plan for meeting each of its carbon budgets. *Net Zero Wales* will be published before COP26 and will set out the policies and proposals to meet Wales Carbon Budget 2 (2021-25) and set Wales on a longer-term pathway to net zero.

Northern Ireland

The current legislative framework for tackling climate change in Northern Ireland is the UK Climate Change Act 2008. Although this extends to Northern Ireland, it does not set a specific greenhouse gas emissions reduction target for Northern Ireland. It is implicit, and based on independent advice of the Climate Change Committee, that Northern Ireland contributes its fair share of required greenhouse gas emission reductions to meet the UK-wide net zero by 2050 target and the UK Government's 5-yearly carbon budgets set under the UK Climate Change Act. A Climate Change Act for Northern Ireland, whilst not yet introduced, is currently being progressed and remains a priority for delivery during the current Assembly mandate, by March 2022.

The Northern Ireland Executive is also currently developing a multi-decade Green Growth Strategy. This longer-term Strategy will be delivered through a series of Climate Action Plans, which will set out the actions to meet sector-specific greenhouse gas emission targets.

Leading the world to a greener, more sustainable future

31. The UK accounts for less than 1% of global emissions.[23] It is essential to enhance international collaboration with other countries and take urgent, concrete action globally to reduce emissions in the near-term. The 2020s is a critical decade in determining whether the Paris temperature goals can be kept within reach. The UK's role in international climate action is set out in the *International Climate Leadership and Collaboration* chapter.

32. The UK is leading the way in global climate action. Countries that are covered by a commitment to net zero or carbon neutrality now account for around 75% of global GHG emissions, and around 80% of global GDP. When the UK took the role of incoming COP Presidency in December 2019, coverage was less than 30% of world GDP. We have a unique opportunity to further this leadership through our G7 Presidency in 2021, and as the host and president of the COP26 summit, in partnership with Italy. The COP26 summit will bring together nearly 200 Parties to accelerate action towards the goals of the Paris Agreement and the UNFCCC, and our drive towards global net zero.

33. COP26 will be the forum to define the decisive decade of climate action and setting the path to global net zero emissions. The UK is urging all parties to demonstrate how they will reach net zero greenhouse gas emissions through near term 2030 NDC targets and Long-Term Strategies to 2050, protect people and nature from climate change impacts, fund climate action, and work together to deliver immediate steps to keep warming within 1.5°C. There will also be a renewed focus on accelerating near-term action in the top priority areas of coal phase out, zero-emission vehicles, climate finance, and halting deforestation.

34. The four goals for the UK's COP26 Presidency are:

a. **Mitigation: bring parties together to deliver commitments on mitigation.** All countries should come forward with ambitious 2030 climate plans (Nationally Determined Contributions, or NDCs) and long-term strategies to reach net zero greenhouse gas emissions, with the aim of keeping the goal of limiting global warming to 1.5°C in reach.

b. **Adaptation: establish a new consensus on protecting people and nature from climate change impacts.** All countries should come forward with ambitious adaptation plans and communications to help their societies and economies adapt to climate change.

c. **Finance:** To deliver on our first two goals, developed countries must deliver on their promise to mobilise at least $100 billion in climate finance per year by 2020, and through to 2025, to help developing countries tackle and adapt to climate change. International financial institutions must play their part and we need work towards unleashing the trillions in private and public sector finance required to secure global net zero.

d. **Collaboration: bring countries together to reach an outcome accelerating climate action and finalising the Paris Rulebook.** Use the power of a fair and inclusive Presidency to enhance international collaboration among policy makers, investors, business, young people, indigenous peoples, and civil society. This can help to solve key challenges and accelerate the delivery of the Paris Agreement goals, particularly: adaptation and resilience, nature, clean energy and transport, and finance.

35. In delivering net zero, the UK also has the opportunity to be at the forefront of large, expanding global markets and capitalise on export opportunities in low carbon technologies and services. This includes renewables, CCUS, hydrogen, smart energy systems and storage, Greenhouse Gas Removals (GGRs), Advanced Modular Reactors (AMRs), and transport. By leading the world in the transition to a net zero future, the UK will be well placed to benefit economically by leading in the export of sustainable technologies and solutions.

36. As the world economy moves to meet the Paris commitments, with over 80% of world GDP now committed to net zero, the UK will set a clear direction and give businesses the certainty they need to invest, grow, and develop the technologies of the future. Some commentators estimate global investment in energy supply and infrastructure to reach \$92 trillion and \$173 trillion over the next thirty years. To achieve this level, the global economy will need to more than double annual investments from around \$1.7 trillion per year to between \$3.1 and \$5.8 trillion per year on average.[24]

37. This strategy sets out our approach to reaching net zero emissions and securing the vast wider benefits as we transition to a greener, more sustainable future. We urge other countries to follow this example with ambitious commitments at COP26 and detailed plans to deliver on them.

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[10] BEIS (2019), 'Energy Innovation Needs Assessment', https://www.gov.uk/government/publications/energy-innovation-needs-assessments, 38

[11] The UK has a comparative advantage in a product or activity if it can produce it at a lower opportunity cost than its competitors. The principle implies that the UK should focus on production of those high-value goods, services and innovative activities where it is most competitive. It can then trade these for other goods and services where other countries have a comparative advantage over the UK. Consumers and producers in the UK and trading partners enjoy the efficiency gains from each country specialising and trading.

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[20] The UK NDC is based on territorial emissions – greenhouse gases emitted from sources within the UK – so does not include emissions from international aviation and shipping. This is in line with international reporting requirements, international expectations, and advice from the Climate Change Committee.

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The Journey to Net Zero

Chapter 2

1. Transforming the UK's economy over the next three decades to reach net zero will be a journey of unprecedented opportunity and change. Our greenhouse gas emissions have fallen by more than two-fifths in the last thirty years, with particular progress in the decarbonisation of our electricity system, but we need to go further and faster in the next thirty years, right across the economy.[1] It will mean developing and rolling out new, innovative, and climate resilient technologies; embracing new ways of doing things – from new ways of travelling, heating our homes, and using our land; and creating new industries and jobs through our green industrial revolution.

2. The policies to drive these changes, and the opportunities arising for individuals and the UK economy, are set out across the remaining chapters of this Strategy. This chapter first explores what reaching net zero by 2050 could mean for the UK; potential scenarios of how we will get there; and an indicative pathway to deliver on our ambitious carbon budgets along the way, while navigating the inherent uncertainty. We look at this journey from a whole-economy perspective, considering the key interactions between sectors, technologies and the energy system that need to be planned for as we decarbonise.

The UK’s Net Zero Future

Our **industrial heartlands** are reinvigorated, with **innovation** and **private investment** in clean technologies – such as wind, carbon capture and hydrogen in multiple locations across the UK including the North East; or the manufacture of batteries and electric vehicles in the Midlands.

Our **green economy** and its **supply chains** provide sustainable jobs for highly-skilled workers – in construction, manufacturing, engineering, science, nature conservation, finance and more, across the economy and the UK, including in rural areas.

Our **businesses** are delivering the latest low carbon technologies, services and innovations for the UK and export markets; and are more resilient to the global net zero transition.

Our **homes** are warm and comfortable, powered and heated by clean, affordable energy.

Our **journeys** are made in zero emission vehicles, with trains, ships and planes running on new low carbon energy sources.

Our **towns and cities** have cleaner air for everyone, and support walking and cycling with benefits for health.

Our **goods** are designed to last longer and be more efficient, while being used, repaired and remanufactured within a circular economy.

Our **natural environment** is protected, enhanced, and more diverse, with healthy ecosystems and increased biodiversity, supporting a sustainable rural economy and providing wider benefits, including improved mental health and protection from risks like flooding and overheating.

A systems approach to the net zero journey

3. The characteristics of the net zero challenge – requiring action by multiple parties across the public and private sectors, delivery at pace, and management of large uncertainties – underline the need for strong coordination in policy development and clear signalling to markets. Government taking a systems approach to policy will help to navigate this complexity. We must consider the environment, society, and economy as parts of an interconnected system, where changes to one area can directly or indirectly impact others. This will help to ensure we design policy to maximise benefits, account for dependencies, mitigate conflicting interests and take account of learning as we go. It reduces the risk of unintended consequences, ensuring individual decisions designed to help achieve net zero do not end up hindering it or other important objectives.

4. A systems approach does not attempt to design a 'perfect' net zero end-state thirty years into the future. It aims to enable innovative and desirable solutions to be developed, and to ensure that decisions are made when needed, based on the best evidence available at that time and with the fullest possible range of considerations brought to bear. This includes taking a dynamic approach to policymaking and updating our assumptions on an ongoing basis; considering public reactions to a policy; accounting for where a particular investment or technology deployment may affect another sector's decarbonisation; and considering the net costs and benefits across different parts of the economy and environment.

5. We have implemented several key elements of a systems approach, including:

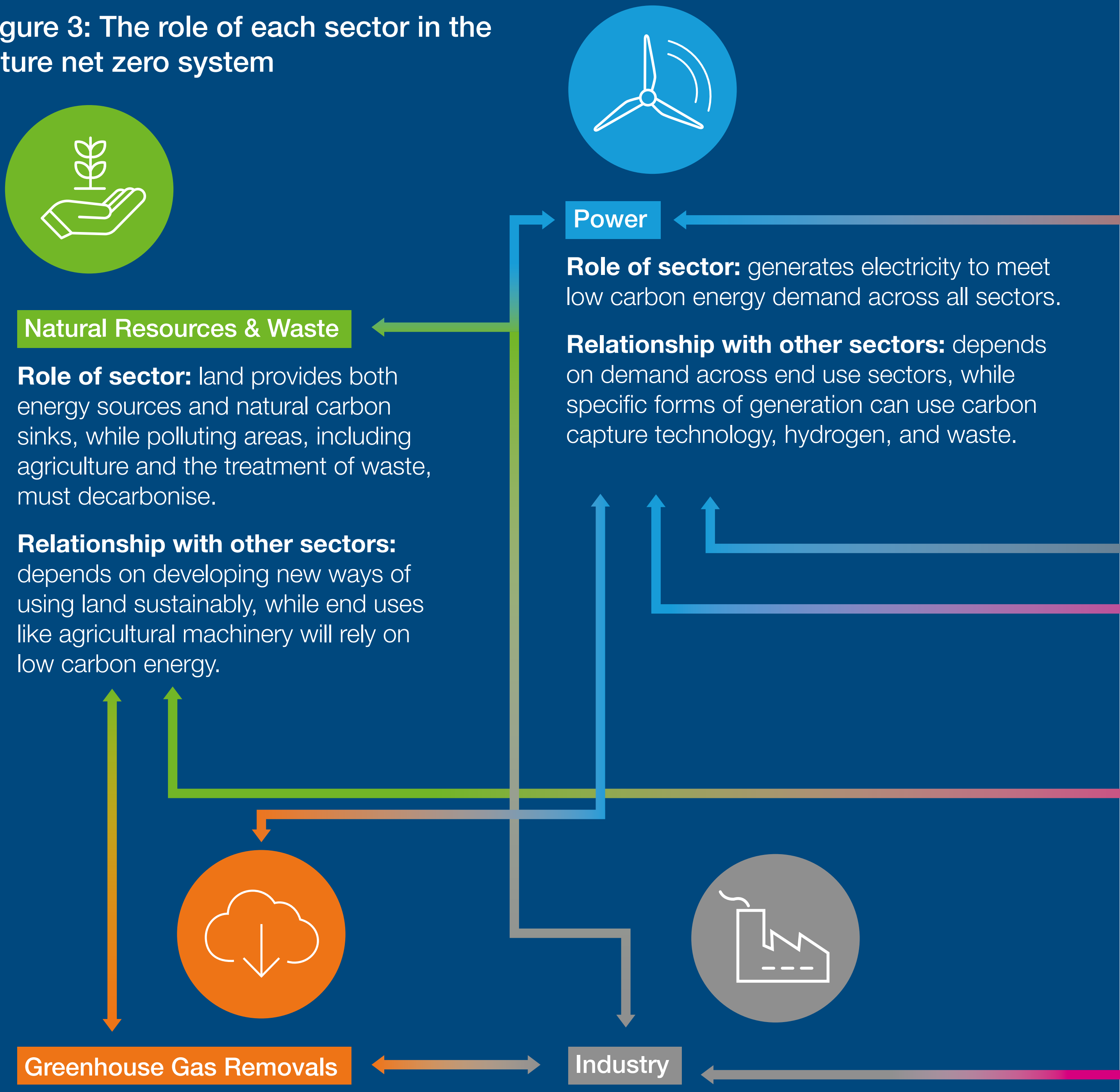
- Establishing forums for delivering shared net zero goals and identifying key issues through cross-system governance structures, including two new Cabinet committees;
- Working towards a shared understanding of interdependencies and risks across different parts of the net zero challenge, for example through £2 million funding from the Shared Outcomes Fund to develop systems tools;
- Testing and determining feasible net zero scenarios with our whole energy systems modelling suite, and supporting our work to identify high leverage, systemic actions such as CCUS that will be necessary in a wide range of scenarios.

6. Work will continue to develop this approach further. This Strategy encompasses changes from across the system that will need to be delivered to achieve net zero.

7. As summarised in Figure 3 below, each sector of the economy will play a vital role in the future net zero system, and these are highly connected – changes in one area can directly or indirectly impact others.

8. Applying a systems approach to policymaking can help to address complex policy challenges, including to identify interdependencies. The case study below for electric vehicles demonstrates the need to understand the complex interactions which drive change. Government will continue to test and update its understanding of systems and how they relate to one another, which forms an important part of how we will monitor delivery, explored further in the *Embedding net zero in government* chapter.

Figure 3: The role of each sector in the future net zero system



Natural Resources & Waste

Role of sector: land provides both energy sources and natural carbon sinks, while polluting areas, including agriculture and the treatment of waste, must decarbonise.

Relationship with other sectors: depends on developing new ways of using land sustainably, while end uses like agricultural machinery will rely on low carbon energy.

Power

Role of sector: generates electricity to meet low carbon energy demand across all sectors.

Relationship with other sectors: depends on demand across end use sectors, while specific forms of generation can use carbon capture technology, hydrogen, and waste.

Greenhouse Gas Removals

Role of sector: alongside natural carbon sinks, engineered removals deliver negative emissions, either directly from the air or as a co-benefit of methods to generate power, fuels and products.

Relationship with other sectors: compensates any residual emissions to ensure a net zero system. Engineered removals also use electricity.

Industry

Role of sector: develops cleaner ways to produce the wide range of products we all rely on, from food and drink to iron and steel.

Relationship with other sectors: depends on low carbon energy supply from power and hydrogen, as well as the use of carbon capture technology alongside power, hydrogen and greenhouse gas removals.

Heat & Buildings

Role of sector: our public, business, industrial and residential buildings, as well as products we use for cooking and everyday living, move to green forms of energy.

Relationship with other sectors: depends on low carbon energy, while different heat options will in turn affect the development of supply sectors.

Transport

Role of sector: all forms of travel that keep modern society moving – road, rail, aviation, and shipping – run on green forms of energy.

Relationship with other sectors: depends on low carbon energy, while different transport options will in turn impact the development of supply sectors.

Fuel Supply & Hydrogen

Role of sector: supports energy supply, especially in areas that are harder to electrify such as heavier transport. Oil and gas play a far reduced role where needed and abated by carbon capture technology where possible.

Relationship with other sectors: depends on demand across end use sectors, while different types of hydrogen production use electricity, carbon capture, and biomass.

Case study of a 'systems approach': Electric Vehicle (EV) roll out

The transition to EVs is central to decarbonising road transport. Higher sales of EVs means overall electricity demand will increase, requiring greater electricity generation and grid capacity. Over the lifetime of an EV, overall carbon emissions are already significantly lower than a traditional internal combustion engine car and, as the electricity grid continues to decarbonise, the lifetime of emissions from driving an EV reduce. The transition to EVs therefore has a potential knock-on impact on the industrial sector and its wider supply chains, particularly in certain regions of the UK, for example creating additional demand for new wind turbine manufacture and installation.

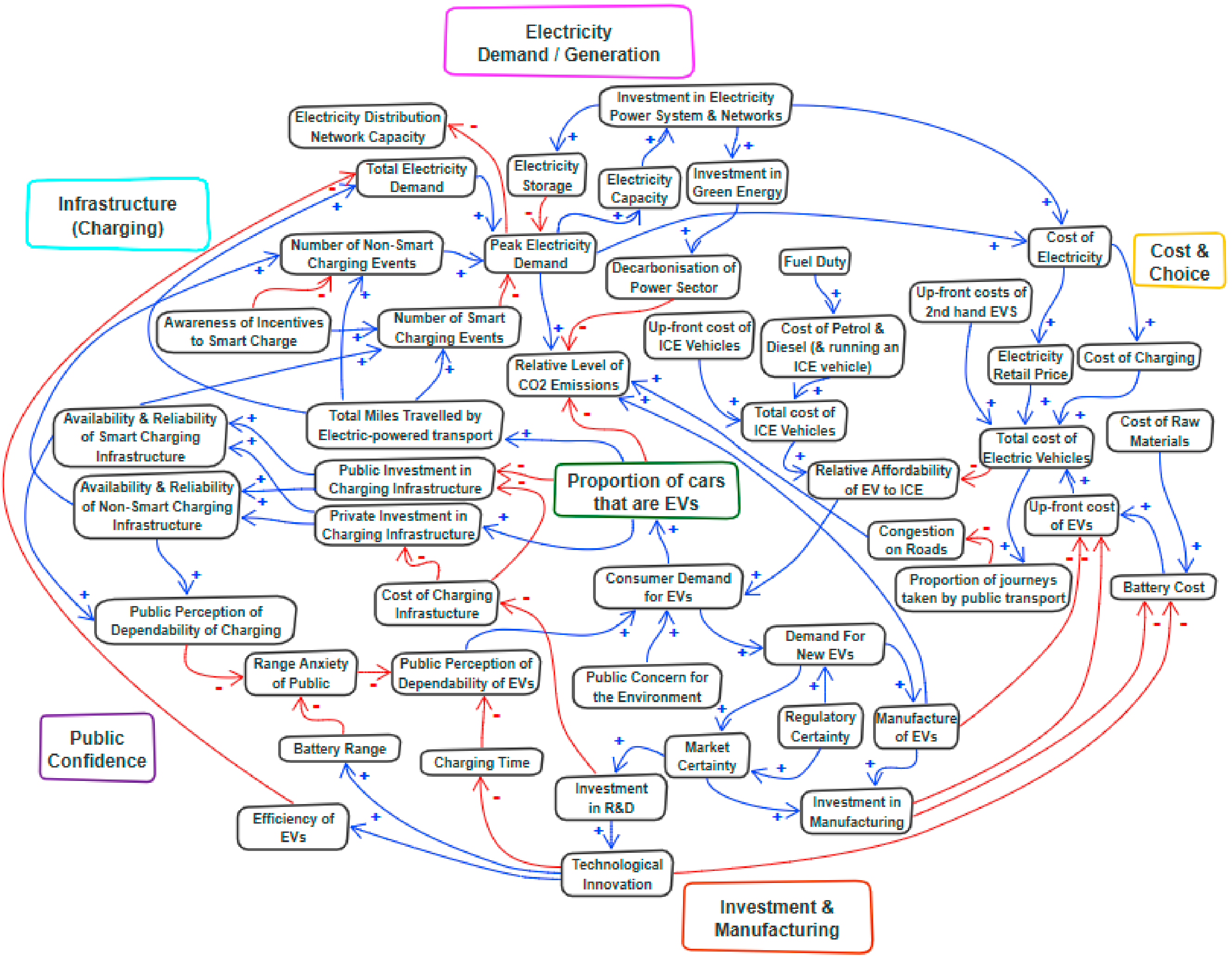
More EVs will affect both the scale and nature of electricity demand, including the timing and scale of peaks, as patterns of charging behaviour develop (e.g. many people choosing to charge at the end of the working day). The changes this could bring need to be carefully thought through, and opportunities seized. For example, innovative technology could support smoothing of electricity demand, by allowing electricity stored in batteries to be fed back into the grid at times of low renewable generation or high demand (vehicle-to-grid technology). Smart charging (enabled by regulations that Government plans to lay later this year) will also help to move demand away from peak times as well as helping consumers to benefit from lower cost off-peak electricity.

The roll out of EVs will have an impact on demand for petrol and diesel, with potential to impact through the supply chain, from production to processing, distribution and retail. Uptake will also have an impact on R&D, investment, and manufacturing of both EVs, and the infrastructure required to use them. The effect of investment in these areas would be wider availability of the infrastructure required for charging, reduction in the cost of manufacturing, and further advances in EV technology.

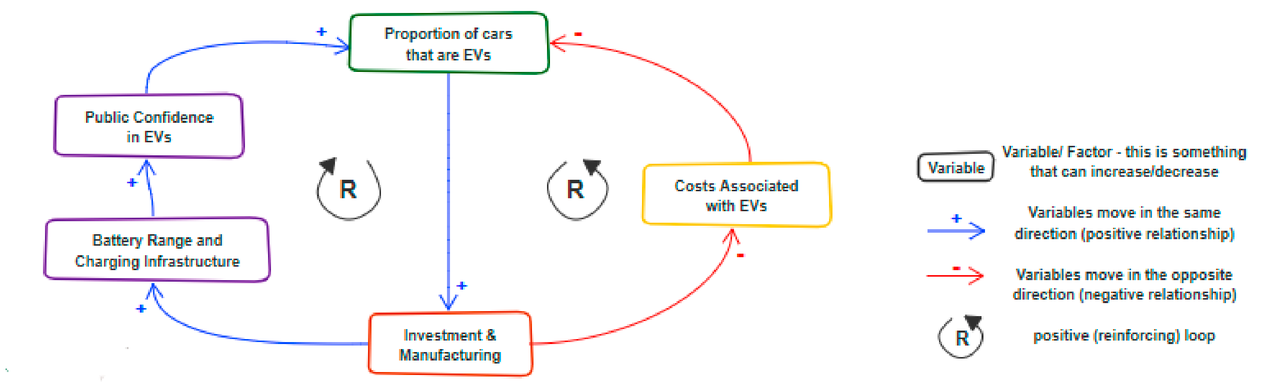
Manufacturing costs will likely fall as production increases at scale and investment in R&D will bring down the costs of components. Wider availability of reliable charging infrastructure should remove range anxiety for EV drivers and streamlining payment methods should improve the consumer experience. These two factors will then encourage further take up of EVs with these sets of relationships representing positive feedback loops.

The examples above are a significant simplification of some of the interactions between sectors as EV roll out progresses. The below systems map shows a more granular picture, though this is also a simplification and some variables will have other influences that are not displayed here.

Figure 4: Example of a 'systems map' showing some interactions to consider in the roll out of electric vehicles



Summary of Feedback Loops



Pathways to net zero by 2050

Key features of the net zero transition

9. There are a range of ways in which net zero could be achieved in the UK. Our exact route will depend on the availability and deployment of key technologies, supported by long-term market growth, as well as the extent to which individuals and businesses adopt green choices. Our approach must consider physical factors, such as land availability and climate change risks like drought and flooding. As a principle, we will pursue options that leave the environment in a better state for the next generation by improving biodiversity, air quality, water quality, natural capital, and resilience to climate change where appropriate.

10. As we increase our efforts to decarbonise domestically, we must ensure production, and the associated greenhouse gas emissions, does not shift to other countries with lower climate obligations. In the *Net Zero Review* we consider the carbon leakage risk facing UK businesses on a sectoral basis and discuss the approaches to help address this risk.[2] In addition to encouraging our trading partners to increase their own efforts, we are engaging with industry to better understand the risks and consider the full range of options to address these, including through the UK Emissions Trading Scheme, discussed further in the *Industry* chapter.

11. While there are significant costs in reaching net zero, the cost of inaction is much higher. The Office for Budget Responsibility's recent report showed unmitigated climate change resulting in "debt spiralling up to around 290% of GDP thanks to the cost of adapting to an ever hotter climate and of more frequent and more costly economic shocks".[3] In addition to reducing the risks of catastrophic climate change, net zero will also bring significant benefits and opportunities, such as economic growth and jobs in new green sectors, reducing air pollution with benefits for health, and enhancing biodiversity. We also expect costs to continue to fall as green technology advances, industries decarbonise, and private sector investment grows. Recent cost benefit analysis for the sixth carbon budget[4] suggests that the significant benefits of net zero more than offset the costs, resulting in a net benefit.

12. Most costs are the additional capital costs (and associated financing) of low carbon technologies, although significant fuel savings help to offset these. We estimate that the net cost, excluding air quality and emissions savings benefits, will be equivalent to 1-2% of GDP in 2050. Our approach will need to reflect that benefits and impacts of the transition will be dependent on individual household characteristics, such as their housing type and current vehicle usage, to support those low-income households most affected by individual technology transitions. The government's approach will also support the principle that those who produce the pollution should bear the costs of managing it. Further information on the economic impacts is set out in HM Treasury's *Net Zero Review*, which informs our approach to achieving a transition that works for households, businesses and public finances, and maximises economic growth.

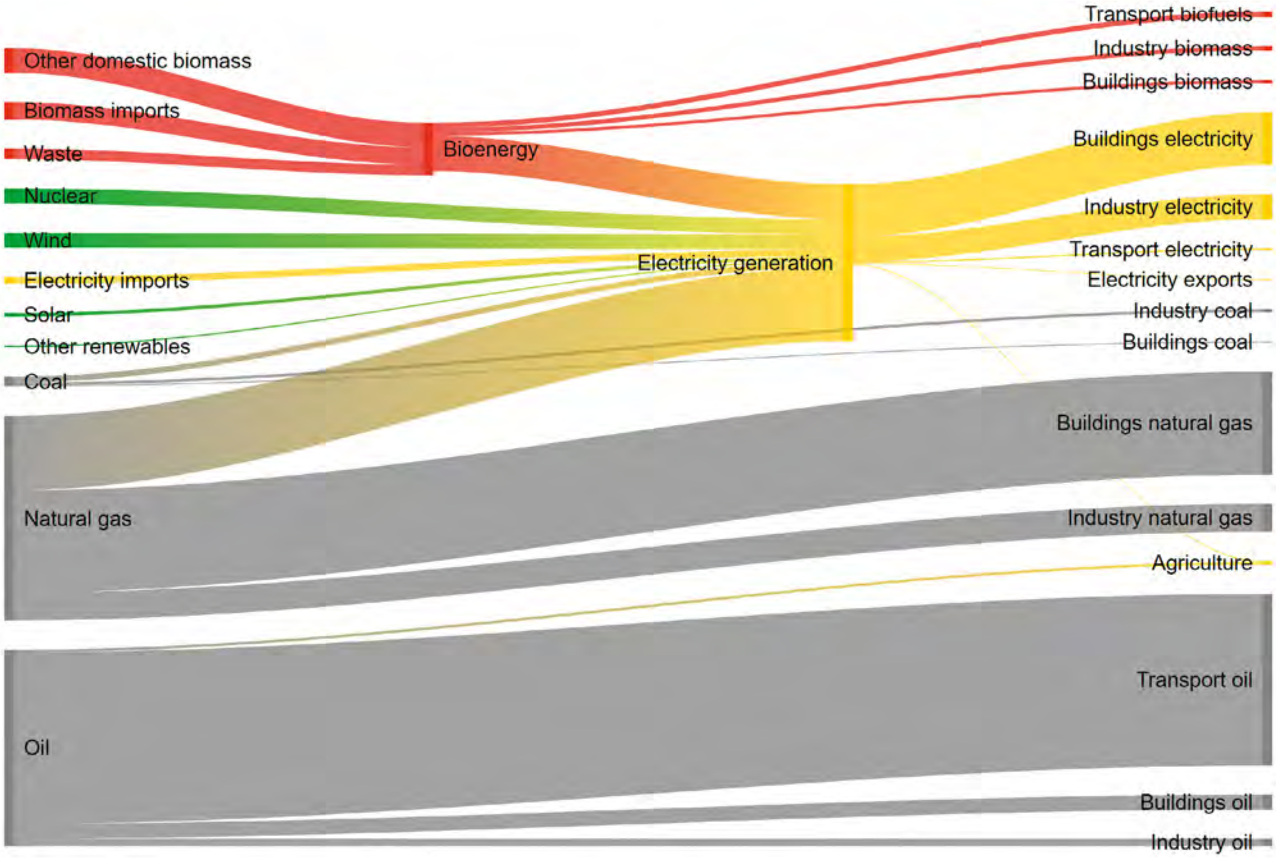
13. The exact technology and energy mix in 2050 cannot be known now, and our path to net zero will respond to the innovation and adoption of new technologies over time. We expect, however, to rely on the following key green technologies and energy carriers, which interact to meet demand across sectors and to remain low carbon.

- **Electricity** from low carbon generation and storage technologies meets higher demand for low carbon power in buildings, industry, transport, and agriculture;

- **Hydrogen** can complement the electricity system, especially in harder to electrify areas like parts of industry and heating, and in heavier transport such as aviation and shipping. A range of low carbon production methods could be used;[5]
- **Carbon capture usage and storage** (CCUS) can capture CO_2 from power generation, hydrogen production, and industrial processes – storing it underground or using it. This technology also supports negative emissions from engineered greenhouse gas removals – bioenergy with carbon capture and storage (BECCS) and Direct Air Carbon Capture and Storage (DACCS);
- **Biomass** combined with CCUS can remove carbon from the atmosphere and support low carbon electricity and hydrogen generation. Biomass and other wastes can also support low carbon fuels for industry, buildings, and transport.

14. These new technologies could transform our energy system by 2050. Electricity, low carbon hydrogen, and BECCS could all scale up, while reliance on fossil fuels will drop considerably and can be combined with carbon capture technology to abate emissions, with any residual emissions offset by greenhouse gas removals.

Figure 5: 2019 energy generation and end uses[6]



Illustrative 2050 scenarios

15. Modelling illustrative net zero scenarios allows us to explore possible energy and technology solutions in 2050, better understand important system-wide interactions, and identify features common to all options. Below we show three modelled scenarios all reaching net zero by 2050 through the same pace of decarbonisation, which demonstrate a range of practical ways in which net zero could feasibly be delivered with technology and resources known today.[7] They do not represent 'most likely' or 'preferred' solutions, and the actual position in 2050 may also vary outside of these scenarios. There is a great deal of uncertainty inherent in any modelling as far into the future as 2050, which is highly sensitive to economic, societal, and technological developments – see the *Technical Annex* for details of the modelling.

2050 Scenario 1: High electrification

Explores the impact of widespread electrification to support transport, heating, and industry decarbonisation, relative to other scenarios, with deep decarbonisation of electricity supply.

This pathway sees UK electricity generation increasing to around 690 TWh, more than doubling from today,[8] and low carbon hydrogen production scaling up to 240 TWh by 2050. Sectors such as road transport and buildings reach near zero emissions, through widespread electrification, with small residual emissions possible in personal and heavy goods transport; while the majority of buildings use electric heating, with the remainder using connected low carbon district heat networks. Industry emissions are near zero, through the full suite of green technologies (electricity, hydrogen, and CCUS), alongside energy efficiency measures. Electricity generation is overwhelmingly decarbonised, through widespread deployment of renewables alongside other low carbon generation including nuclear power and gas with CCUS. Residual emissions remain in aviation, agriculture, and waste, though these reduce from today's levels through, for example, sustainable aviation fuels, more efficient farm practices, and reduction in landfill waste. These emissions are balanced by significant afforestation, together with engineered removals (primarily BECCS but also DACCS).[9]

Figure 6: High electrification scenario: energy generation and end uses in 2050

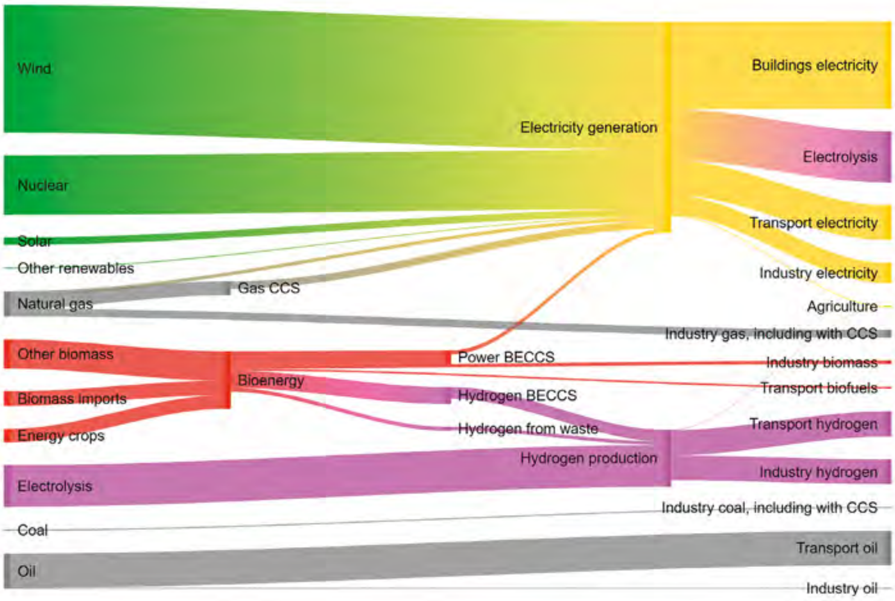
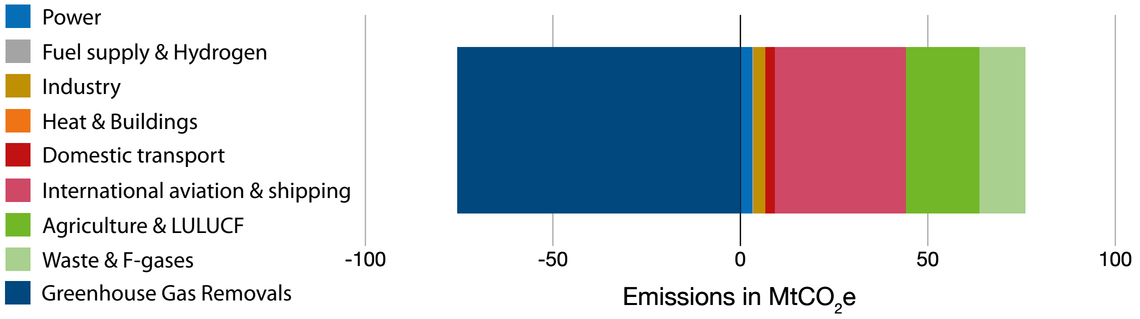


Figure 7: High electrification scenario: residual emissions in 2050



2050 Scenario 2: High resource

Explores the impact of using low carbon hydrogen more extensively, particularly for decarbonising buildings, power, and heavy vehicles. It also assumes higher levels of tree-planting are achievable, increasing the 'negative emissions' available from land-use sinks.

This pathway sees low carbon hydrogen generation increasing to around 500 TWh. As hydrogen is the main energy source for heating, electricity demand and therefore generation is lower than in scenario 1 at 610 TWh. Electricity and district heat still play a role in both residential and non-domestic buildings but the majority of building heat demand is assumed to be met by hydrogen. End users of energy (e.g. transport and buildings) reach similar levels of decarbonisation as in scenario 1. In heavy transport, there is a shift to increased use of hydrogen. Compared to scenario 1, greater levels of tree planting allow for slightly higher residual emissions to remain, primarily in hydrogen production. Engineered removals are at a similar scale to scenario 1 to offset remaining residual emissions in the hardest-to-decarbonise sectors of aviation and agriculture.

Figure 8: High resource scenario: energy generation and end uses in 2050

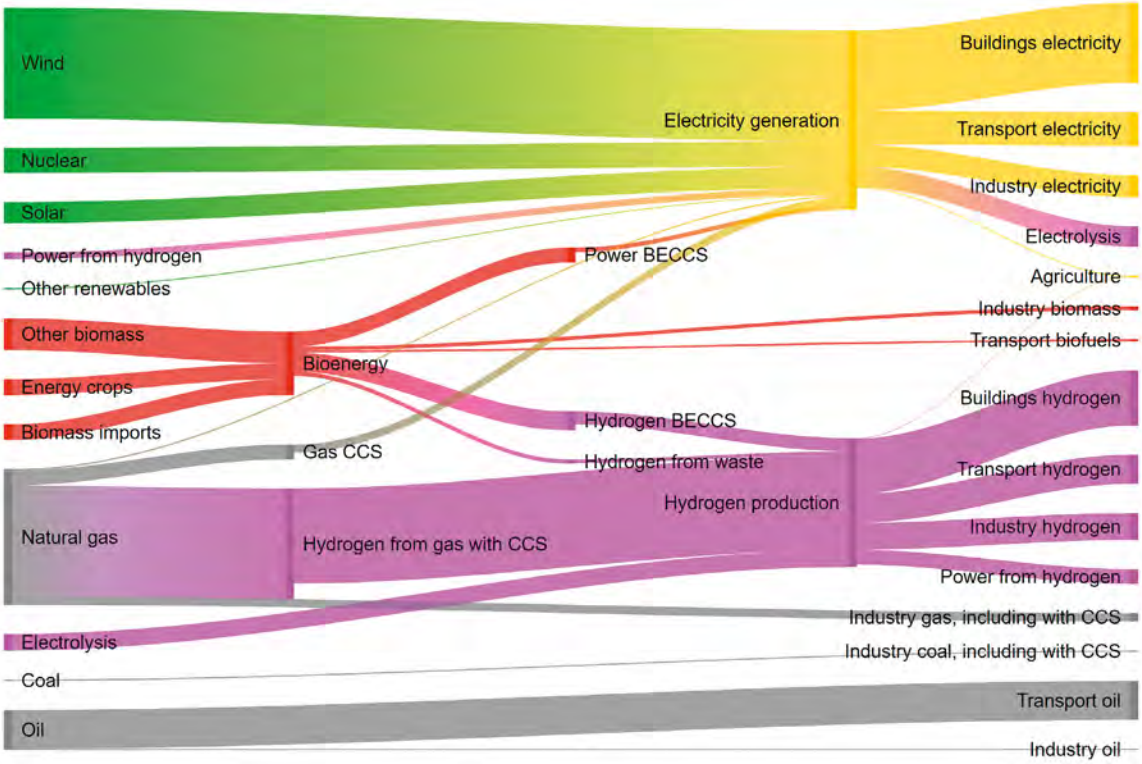
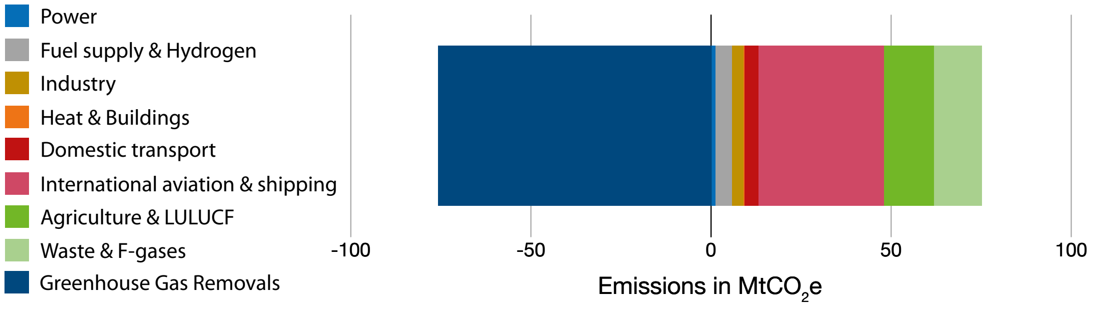


Figure 9: High resource scenario: residual emissions in 2050



2050 Scenario 3: High innovation

Explores a world in which successful innovations enable lower residual emissions to be reached in aviation, while higher capture rates increase the impact of carbon capture technologies, with higher levels of DACCS deployed over the 2040s.

In scenarios 1 and 2, end users of energy such as transport, industry, and buildings are decarbonised extensively, while accounting for residual emissions in aviation and baseline assumptions on the technological potential for carbon capture. In this scenario more optimistic assumptions around carbon capture and aviation, such as the availability of sustainable fuels at scale and zero emission aircraft, cause a divergence from scenarios 1 and 2 in the deployment of certain technologies. With lower residual emissions in aviation and improvement in capture or negative emission potential, end use sectors such as transport, buildings, agriculture and industrial dispersed sites can decarbonise to a lesser extent. This pathway sees electricity and low carbon hydrogen generation requirements in between the two scenarios explored previously, at 670 TWh and 330 TWh respectively.

Figure 10: High innovation scenario: energy generation and end uses in 2050

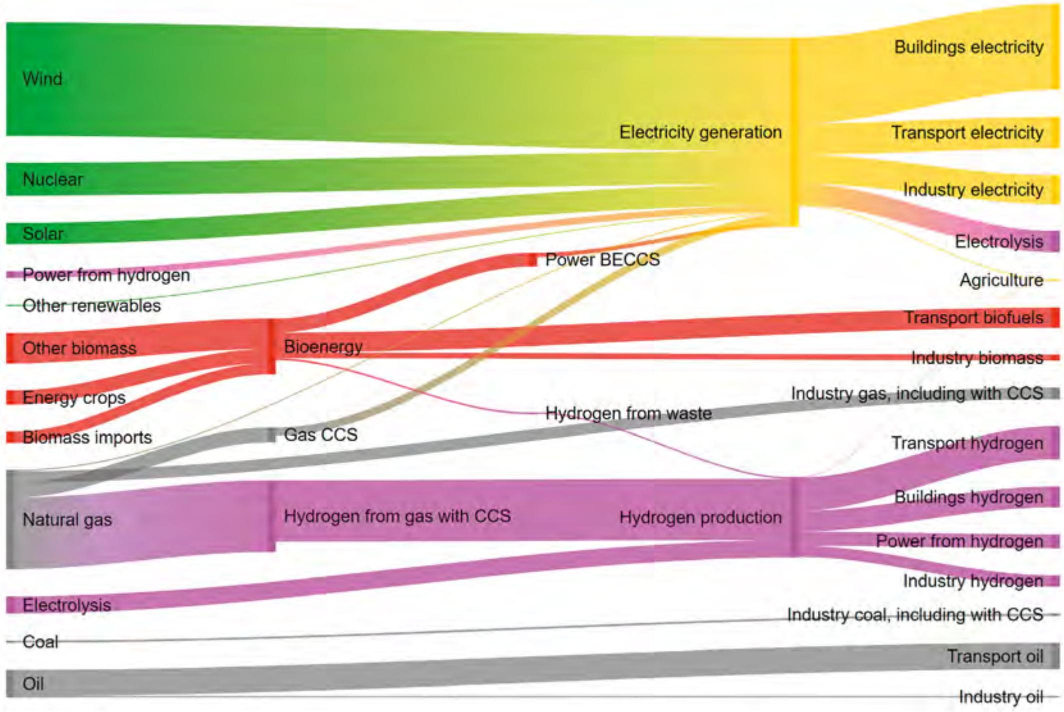
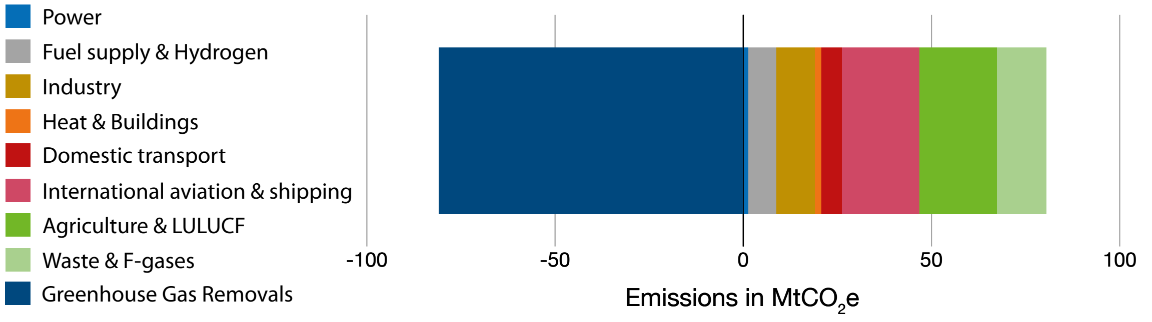


Figure 11: High innovation scenario: residual emissions in 2050



Insights from potential 2050 outcomes for net zero journey

16. Despite the uncertainties, we can draw some broad conclusions from the illustrative scenarios above to help shape our approach to net zero:

- Extensive decarbonisation is required across transport, buildings, and industry, given the need to account for possible residual emissions in agriculture, aviation, waste, and heavy industry and possible limitations on deployment of greenhouse gas removals;
- Given this, extensive energy efficiency measures across these sectors are likely to be beneficial to bring down energy demand and cost across the system. Every scenario sees overall energy demand from end use sectors reduce substantially;
- Different technologies for these sectors can be accommodated (for example, predominantly electric heat pumps or hydrogen for heating), meaning wide ranges of possible electricity and hydrogen demand remain plausible;
- Both electricity and hydrogen demand grow significantly from today, and need to be produced with very low levels of emissions by 2050. Biomass also becomes a key energy carrier to enable engineered removals and support low carbon fuel production;
- Given the need to plan for some residual emissions, it is appropriate to plan for use of greenhouse gas removals. The carbon capture processes needed for this are likely to play a significant role in wider decarbonisation, for example in power;
- Primary energy sources increase in number and diversify, including a range of renewables, and from biomass and waste. This diversified system for energy generation also becomes more interdependent to ensure security of supply.

Indicative delivery pathway to 2037

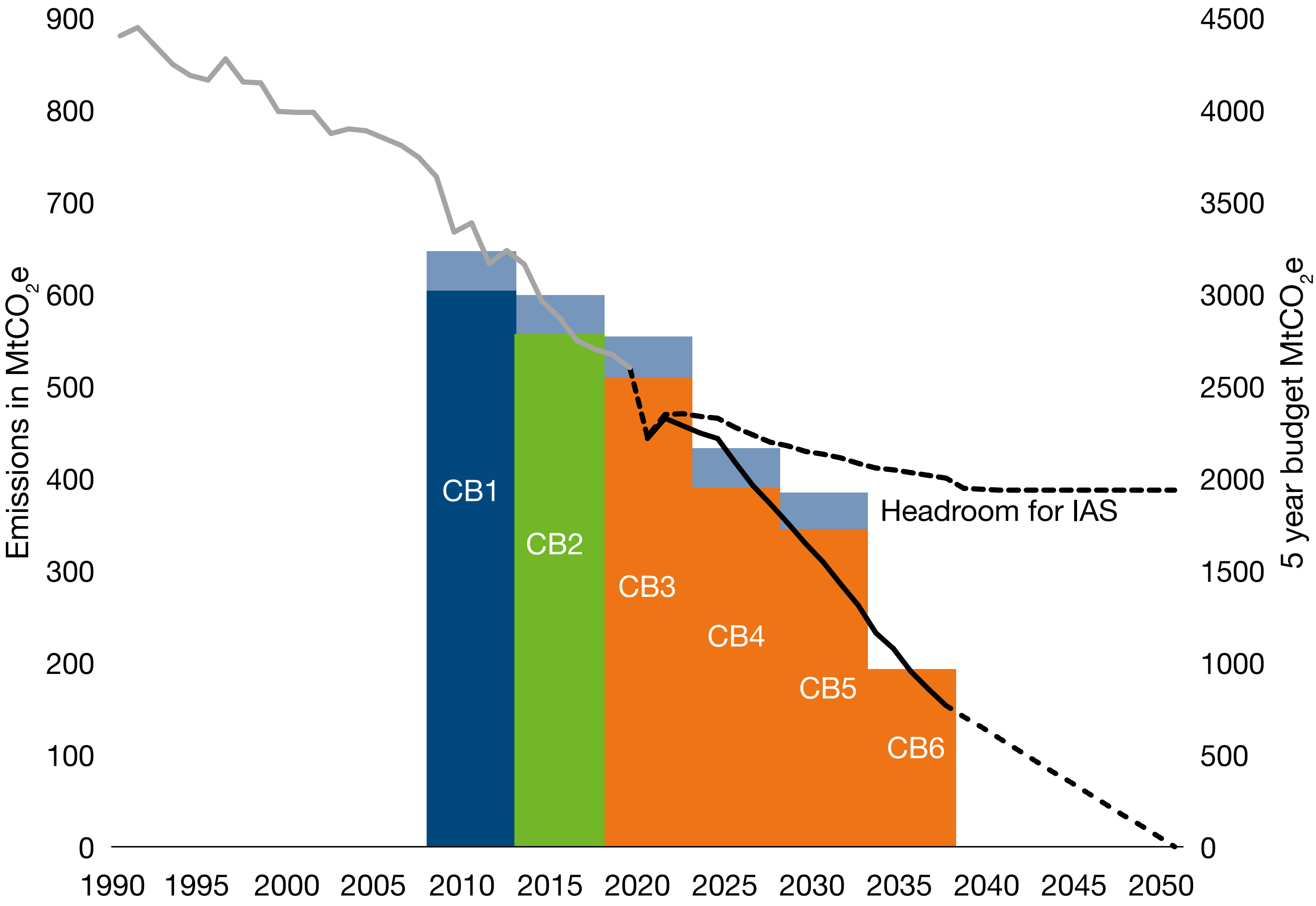
An indicative pathway meeting our emissions targets up to Carbon Budget 6

17. Drawing on the insights from our illustrative 2050 scenarios, we have developed a delivery pathway: an indicative trajectory of emissions reductions which meets our targets up to the sixth carbon budget ending in 2037. This is broadly consistent with all three 2050 scenarios and follows decarbonisation that we aim to achieve through this Strategy. The uncertainties inherent in our 2050 scenarios also apply to our 2037 delivery pathway. It is designed only to provide an indicative basis on which to make policy and plan to deliver on our whole-economy emissions targets. The exact path we take is likely to differ and must respond flexibly to changes that arise over time.

18. The pathway is based on our understanding now of the potential for each sector to reduce emissions up to 2037, considering the balance between sectors that is optimal for the entire economy in terms of delivery and cost. Emission reductions beyond our existing policies combine evidence on theoretical potential for abatement with judgements about barriers to delivery, the rate at which low carbon options could be adopted in practice and timescales for key decisions. We take an economy-wide view, including to balance end use sector demands with supply side considerations, such as infrastructure and the operation of the electricity and other fuel supply sectors.

19. As a general principle, our indicative pathway to 2037 prioritises emissions reductions where known technologies and solutions exist and thereby minimises reliance on the use of greenhouse gas removals to meet our targets. It is designed to drive progress in the short-term, while creating options in a way that seeks to keep the range of options presented in the illustrative 2050 scenarios open. The *Embedding Net Zero in Government* chapter sets out how Government will monitor progress to ensure we stay on track for our emissions targets and respond to developments affecting our long-term goals.

Figure 12: Indicative emissions reductions to meet UK carbon budgets and NDC[10]



2025 – 55% reduction (excluding international aviation and shipping emissions)

2030 – NDC target for at least 68% reduction (excluding international aviation and shipping)

2035 – 78% reduction (including international aviation and shipping)

2050 – 100% reduction

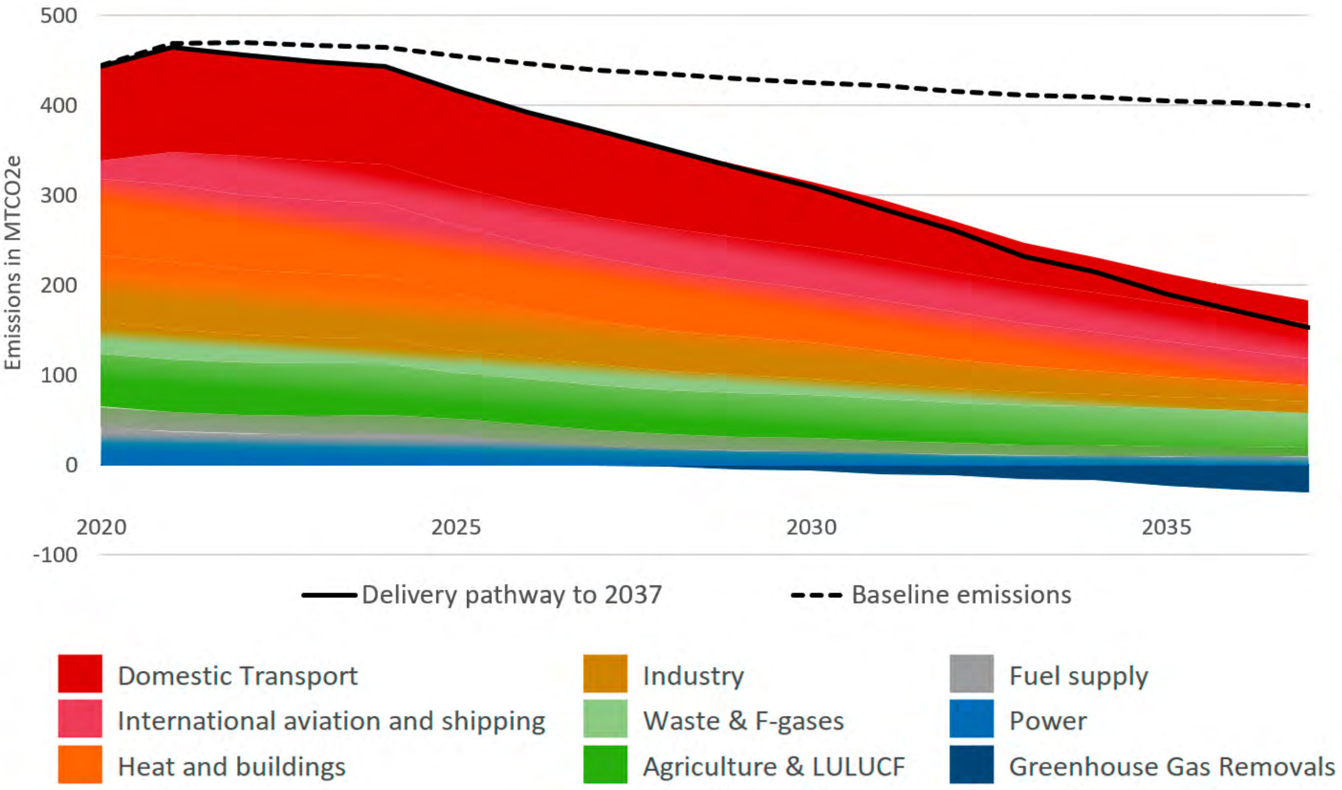
To meet whole-economy net zero target

Indicative sectoral decarbonisation pathways

20. Broken down by sector, our indicative delivery pathway implies the reduction in emissions up to 2037. These indicative sector pathways, presented as ranges for residual emissions to reflect the inherent uncertainty, help to drive change and to plan how we can remain on track to meet our targets.

Given the interdependencies and interactions within and between sectors, the exact areas for emissions savings may shift, as our understanding increases. These pathways are therefore not predictions or targets: the emissions savings ultimately contributed by each sector are likely to differ as we respond to real-world changes.

Figure 13: Indicative delivery pathway to 2037 by sector



Source: BEIS analysis

21. The pathway considers that sectors have the potential to make progress at different rates, for example, depending on the availability and deployment of technological solutions; development of supply chains, financing, and infrastructure; and the need to overcome wider delivery barriers. These constraints and action to overcome them are summarised below and explored in more detail in subsequent chapters.

Sector	% of UK emissions (2019)[11]	Expected reduction by 2035 from 1990	Key features of the delivery pathway to 2037
Power	11%	80-85%	By 2035, all our electricity will need to come from low carbon sources, subject to security of supply, moving to a fully decarbonised power system whilst meeting a 40-60% increase in demand. Expected residual emissions will be limited to CCUS plants, unabated gas, and energy from waste. This means increased investment in the grid network, electricity storage solutions and flexible grid management, to ensure decarbonisation without risking security of supply.
Fuel supply and Hydrogen	5%	53-60%	Large potential from electrification of oil and gas installations and addressing venting and flaring in the existing fuel supply sectors where demand is expected to fall over time. Emissions savings in the incumbent fuel supply sector will be marginally offset by emissions expected from low carbon hydrogen and fuel production, which will enable significant emissions savings through fuel switching across a range of end use sectors. Hydrogen production is expected to establish in the 2020s before a significant ramp up in the early 2030s, using a range of production methods to meet demand.
Industry	15%	63-76%	Deep decarbonisation through resource and energy efficiency, fuel switching, and CCUS deployment are all required, starting with industrial clusters and major emitters, such as the steel sector. Decarbonisation of smaller and more dispersed sites will also be needed, placing demands on associated infrastructure.

Heat and Buildings	17%	47-62%	Addressing heat emissions will require a substantial increase in the uptake of low carbon heating up to 2035, when all new installations will be net zero compatible. In any heat pathway, improved energy efficiency – through investment in buildings fabrics and better product standards – will reduce overall energy use and costs. Advanced smart meters will inform consumers and businesses about their energy use, encouraging energy-saving behaviour.
Transport[12]	32%	47-59%	Road transport is transformed through increasing use of zero emission vehicles, driven in part by ending the sale of new petrol and diesel cars and vans by 2030 and supported by increasing the share of trips taken by cycling, walking, and public transport. Progress is expected to decarbonise aviation and shipping through efficiency improvements and the uptake of low carbon fuels. These will require international coordination.
Natural Resources	20%	39-51%	Increased afforestation and peat restoration contribute significantly, though with long lead-in times. By 2035, perennial energy crop and short rotation forestry can contribute significantly to carbon sequestration, with potential to support power, fuel supply, industry, and transport through BECCS and generation of biofuels. Waste emissions reduce with increased diversion of municipal biodegradable waste streams away from landfill, and potential savings from other parts of the sector, such as wastewater. Use and therefore emissions of F-gases continues to reduce in response to future control measures. Agriculture emissions are largely from livestock and nutrient management. The pathway assumes emissions will be reduced through improved and innovative farming practices.
Greenhouse Gas Removals	Not applicable		Deployment of BECCS and DACCS. Deployment dependent on development of UK CCUS infrastructure and the availability of suitable, sustainable, and low-cost biomass feedstocks.

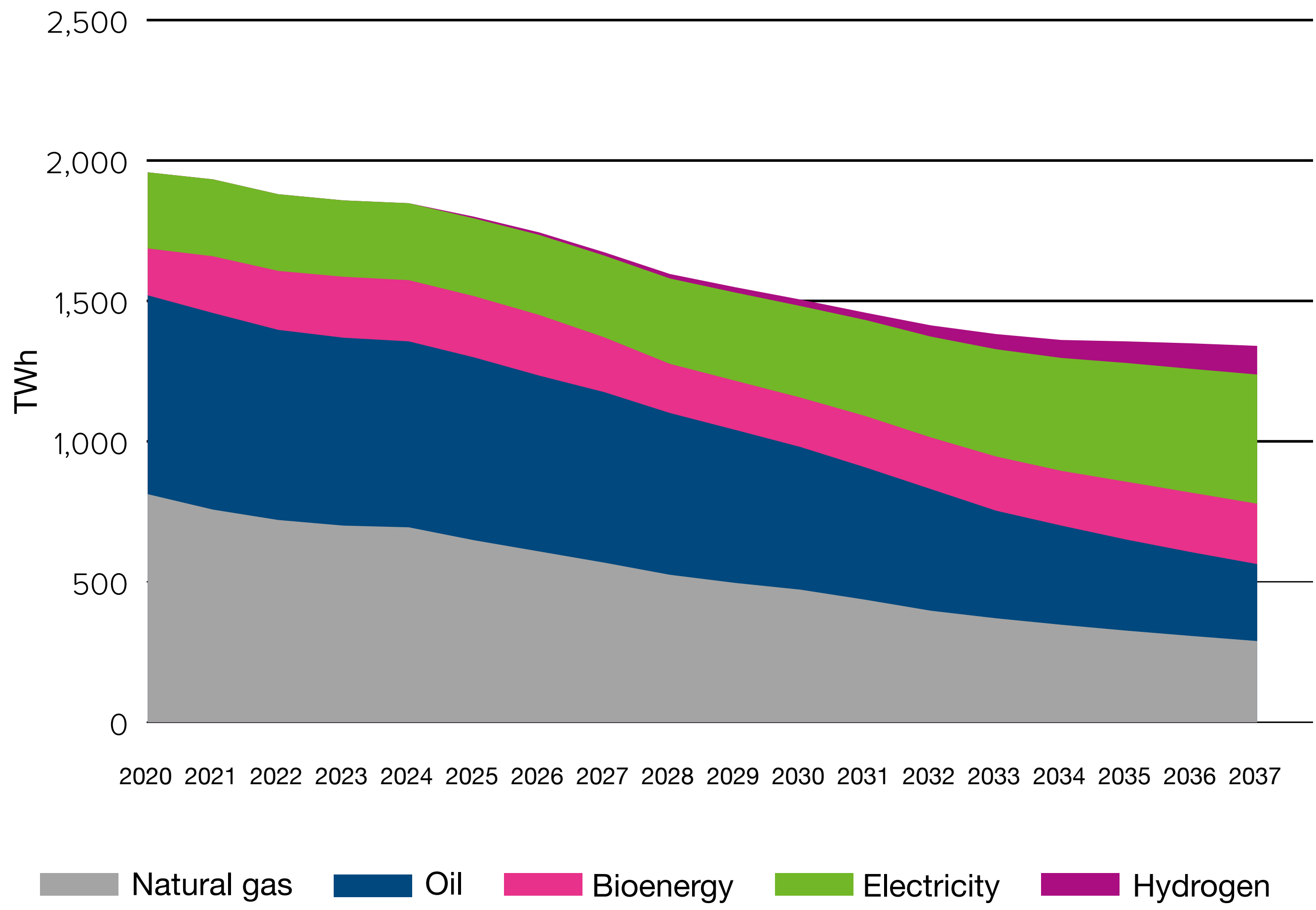
22. The changes we expect in sectors will evolve over time. In some cases, alternative measures within a sector could achieve broadly the same level of emissions abatement. In other cases, we will need to respond to strategic decisions that government makes in the future. One of the most significant decisions that will affect our pathway will be on the balance of types of low carbon heating solutions, mainly electricity and hydrogen, deployed in buildings. The *Heat and Buildings Strategy* commits to strategic decisions on the relative roles of hydrogen and electrification for on-grid homes by 2026 and the relevant sector chapter in this strategy explores alternative options that are consistent with the level of ambition implied by our delivery pathway.

Key energy changes and deployment implied by the delivery pathway

23. Assumed energy demand in our pathway is based on government's central assumptions about required technology uptake, with a variation to reflect the outstanding strategic decision on the potential role of hydrogen to heat buildings. We expect both natural gas and oil demand to more than halve by 2037 while overall, energy demand reduces significantly through increased efficiency and fossil fuels are replaced by new sources of energy. Electricity generation increases to meet a larger share of energy demand, and low carbon hydrogen grows from a near zero base to play a significant role from the 2030s.

24. Decisions in 2026 around hydrogen's role in providing heat in buildings will have a substantial impact on relative hydrogen and electricity demands – Figure 14 shows a scenario where hydrogen is not used to heat buildings, which is predominantly decarbonised via electrification through heat pumps. In a scenario where hydrogen has a more significant role in decarbonising heat in buildings, hydrogen demand would increase by 70 TWh by 2035 and electricity demand would decrease by 20 TWh (due to the high efficiency of heat pumps more hydrogen is required to produce the same amount of heat). Beyond heat, the indicative delivery pathway describes just one scenario for potential hydrogen demand in industry, transport, and power – the *UK Hydrogen Strategy* takes a wider view to consider greater ranges for hydrogen use in all sectors.[13]

Figure 14: Energy demands up to 2037 assumed by delivery pathway



Source: BEIS analysis

Note: for illustrative purposes, this shows energy demands in a scenario in which electricity is predominantly used to heat buildings. See the Technical Annex for hydrogen for heat scenario.

25. Meeting the increasing demand for low carbon energy across the economy relies on scaling up significantly, the new green technologies and energy carriers identified above. While the deployment of these will respond to changes over time, our indicative pathway suggests they are central to decarbonisation over the next 15 years:

- **Electricity** sees an expected 40-60% increase in demand by 2035, all met from low carbon sources to bring forward the government's commitment to a fully decarbonised power system by 15 years, subject to security of supply;
- **Hydrogen** production capacity ambition for 5 GW by 2030, which is expected to increase to around 10 or 17 GW by 2035 (depending on the role of hydrogen for heat);
- **Carbon capture** is expected to need to reach capacity for a total of ~20-30 $MtCO_2$ per year by the early 2030s across the economy – more than double what was set out in the *Ten Point Plan* – and at least ~50 $MtCO_2$ by the mid-2030s;
- **Biomass** is anticipated to need increases in feedstock supply from the 2020s to support BECCS deployment through various routes for use in 'hard-to-decarbonise' areas. These resources will be explored in the *Biomass Strategy.*

26. Figure 15 below shows some wider illustrative deployment of technologies or measures assumed in our pathway to demonstrate a sense of the scale and pace of change required. These are based on modelling assumptions, which are detailed in the *Technical Annex*, and do not represent targets – the delivery of such measures will depend on, and respond to, real-world change.

Figure 15: Illustrative examples of deployment implied by the delivery pathway

	Today	Mid 2020s	Early 2030s	Mid 2030s
Zero emission cars As a proportion of total car fleet 1 icon = 5 % points		●	●●●●●	●●●●●●●●●●
Low carbon homes* Cumulative homes with low carbon heating 1 icon = 1m	◐	●●	●●●●●●	●●●●●●●●●●●●●
Electricity generation Total UK generation 1 icon = 50 TWh	●●●●●●	●●●●●●	●●●●●●●	●●●●●●●●●●
Carbon Capture Total annual CO_2 captured across sectors 1 icon = 5 $MtCO_2$		◐	●●●●●	●●●●●●●●●●●●
Trees Annual area of afforestation in UK 1 icon = 10,000 ha	●◐	●●●	●●●●	●●●●●

Note: For illustrative purposes, icons represent approximate and rounded figures from our modelling. Where there are ranges, an approximate central point has been shown.
** Homes with low carbon heating includes homes heated by heat pumps, hydrogen or connected to heat networks*

Essential activity driving the delivery pathway

27. It is, of course, impossible to predict every possible path to net zero that might arise over the next 30 years – we do not seek to do so. New innovations may emerge, enabling the market to move more quickly or at lower cost than expected, while in other areas progress may be hindered by unexpected deployment challenges as technologies are brought to scale. This Strategy does not attempt to ignore these uncertainties, but rather to plot a path which maintains flexibility in the future, while ensuring we do not delay the action we know is needed in the near-term. This aims to provide the certainty to drive forward investment and change, while allowing the market to respond to new opportunities and challenges which arise from the transition. The UK Emissions Trading Scheme is a crucial way in which we ensure that our pathway is rooted in cost-effective, market-led solutions.

UK Emissions Trading Scheme as a key driver of our path to net zero

The UK ETS, a 'cap and trade' scheme, is a market-based pricing mechanism to incentivise and control the reduction of emissions in a cost-effective way. A cap is set on the total amount of certain greenhouse gases that can be emitted by the sectors covered by the scheme over a given period. The cap is divided into allowances, and participants receive or purchase allowances which they can sell and buy with one another as needed. This UK ETS cap will reduce over time, providing a long-term market signal so companies can plan and invest in abatement accordingly – offering new trade and export opportunities. The cap is initially set 5% below the UK's notional share of the EU ETS cap for Phase IV of the EU ETS. We will consult in the coming months on an appropriate cap consistent with net zero.

The UK ETS acts as a cross-cutting policy lever to drive market-based abatement, incentivising industries to find the most cost-effective solutions to decarbonise. This ensures that, as industries develop lower carbon processes, our path to net zero adapts to cost-effective abatement routed in market-based solutions. We have committed to exploring expanding the UK ETS to the two thirds of uncovered emissions and we will provide a further update in due course. It remains important, however, that we develop policies which actively support and encourage sectors to decarbonise, rather than rely on applying an emissions cap and the consequent carbon pricing as our sole mechanism. Our delivery pathway provides a sound basis to underpin those policies to decarbonise, set out in the chapters that follow.

To mitigate the risk of carbon leakage, in which production and associated greenhouse gas emissions are offshored in ways that would not have happened if the pricing of emissions across jurisdictions was implemented in an equivalent way, we currently give at risk sectors a proportion of their allowances for free to reduce their exposure to the carbon price. We initiated a review of free allocation policy earlier this year with a call for evidence and plan to consult in the coming months, as part of a wider review into the UK ETS. This review will focus on how free allocations can be better targeted in line with a reduction to the overall cap, while still preserving the incentive to decarbonise.

28. Our analysis points to the following essential planks that we can be confident net zero will depend on. These underpin the chapters that follow in this Strategy.

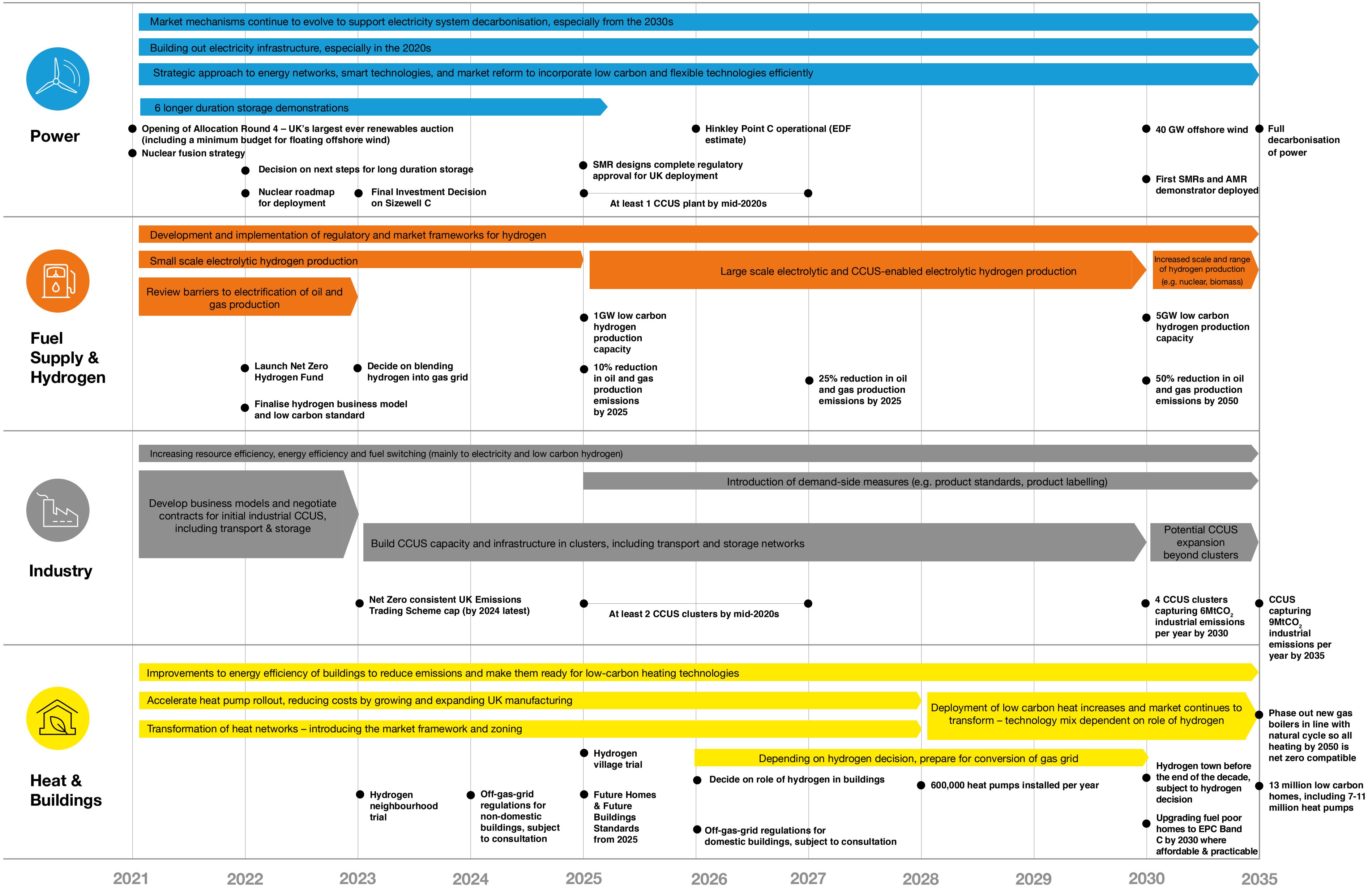
- **Integration of low carbon energy sources in a smart and flexible way.** For example, fully decarbonising our electricity system – in addition to renewables, nuclear, and power CCUS – could also rely on large-scale long duration storage, as well as use of BECCS and hydrogen-fired generation, to manage peaks in demand. Hydrogen could require substantial electricity for production via electrolysis, but in turn could help improve the efficiency of a high-renewables electricity system by using excess supply during periods of high generation and low demand, as well as further energy storage.
- **Increasing diversity of energy sources for end uses.** The removal of unabated fossil fuels from the system which currently supply most of the energy requirements in end use sectors, such as transport and heating, has potential to lead to a greater range of technologies and energy carriers playing a part in future. This could create some resilience, though there may not always be scope for direct substitution.
- **Increasing energy efficiency.** The low carbon energy system depends on overall energy demands reducing significantly. This means all demand sectors becoming far more efficient, through adoption of new technologies, better energy management, and direct investment in energy efficiency measures. Such measures can be considered 'low regret' to pursue throughout the transition and will, in turn, affect the level of energy supply and carbon capture required in the system.
- **Innovation for new technologies.** Green technology, including research and development into new options, is a cornerstone of the net zero journey. As well as the supply-side technologies discussed above, this also means new technologies in end use sectors – for example, installing zero carbon heating and delivering zero emission surface transport, while transforming the way we use natural resources, farm our land, and manage our waste. Different types of public and private support are required to develop nascent technologies and deploy known ones at scale. Government has a role to play in a financing offer, investment signalling, and developing business models.
- **Green investment.** Private investment will provide most of the financing needed to commercialise early technologies and scale low carbon sectors. We need additional net zero investment to reach c. £50-60 billion/year in the late-2020s and 2030s. However, public finance and public finance institutions will provide much of the early investment, intervention, and signalling that will create the conditions for an acceleration of net zero investment. This will also generate significant financial savings if achieved and accompanied by effective policy, thereby lowering the cost of capital for investment.
- **Demand-side changes and public engagement.** The rollout of low carbon solutions relies on positive public reception and demand to adopt them. Consumers need to have access to the right technologies, understand their benefits, and have confidence that they will be protected if they use them. The deployment of technologies should also respond to their reception by consumers, and go with the grain on consumer behaviour and trends. We also need our workforce to have the skills to meet increasing demand, including in areas such as housing retrofit, heat pump installation, electric vehicle manufacturing, charge

point installation and forestry. More widely, low carbon and environmental practices will require people and businesses to make green choices, and government has a role to play in making these as easy, attractive, and accessible as possible. The net zero journey must be a joint one and will be affected by how engaged and supportive the public are.

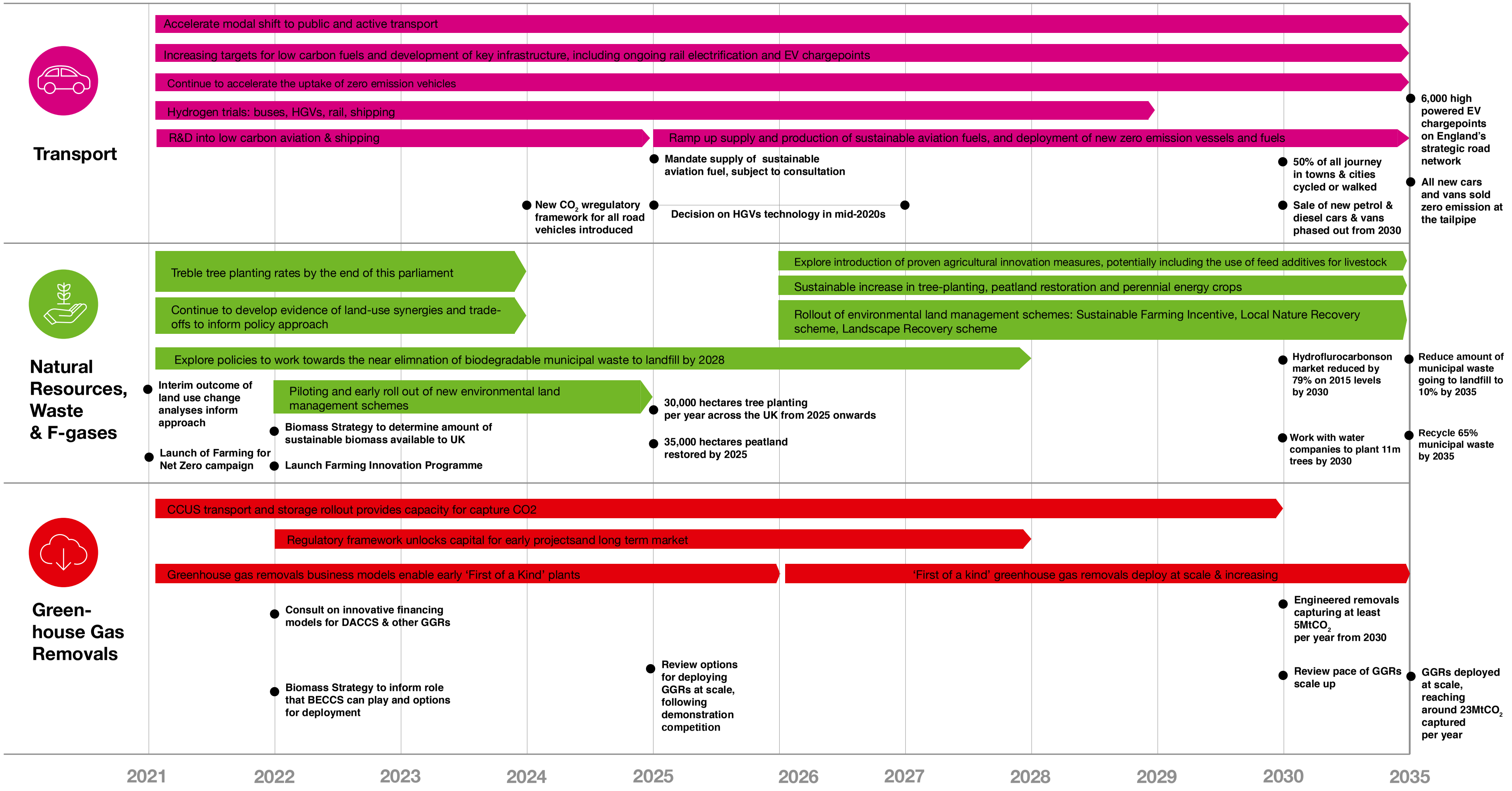
- **New standards and regulation.** In certain areas government will need to support and complement market-led decarbonisation with standards and regulation to ensure that, where appropriate, green options are pursued, while high carbon options are phased out. This will help to accelerate low regrets areas like energy efficiency, such as ensuring our homes are built to new standards, and high impact areas like zero emission vehicles. It will also ensure suppliers of higher-carbon technologies and fuels provide low carbon alternatives, driving deployment at scale.
- **Planning and infrastructure.** Low carbon solutions rely on transforming the infrastructure needed to deliver them. Increasing electricity generation needs to be accompanied by building out a flexible grid. Alongside dedicated hydrogen infrastructure, new CO_2 transport and storage infrastructure is needed for the use of CCUS which will require investment of around £15 billion from now to the end of the Carbon Budget 6 period. We need to ensure that low carbon energy generation can be connected to sources of demand geographically, which means improving knowledge of local circumstances and opportunities for generation. We also recognise the importance of the planning system to common challenges like combating climate change and supporting sustainable growth.
- **Sustainable use of resources.** Net zero will mean maximising the value of resources within a more efficient circular economy. It will need a significant increase in the use of certain types of resources – critical minerals like lithium, graphite, and cobalt, as well an increased demand on resources like copper and steel – from manufacturing green technologies to building large-scale infrastructure. This will require new robust supply chains and provide economic opportunities, but there will be environmental trade-offs, and potential negative impacts on habitats, biodiversity, and water resources to be managed carefully. For example, ammonia emissions from anaerobic digestion, which can use waste as a feedstock, can also affect biodiversity and health.
- **Understanding land use trade-offs.** Like other resources, our land is finite and competition for it will need to be managed as we rely on natural resources and use land for multiple new purposes, such as perennial energy crops and short rotation forestry for energy generation, while allowing for afforestation and peatland restoration to sequester and avoid emissions. We will also need to ensure net zero is compatible with wider uses of land such as agriculture, housing, infrastructure, and environmental goals. These land use challenges are exacerbated by the impact of climate change on the availability of productive land and water in future.

29. These features underpin the critical activity driving decarbonisation across sectors of the economy. A summary is provided below up to 2035, which is not exhaustive but focuses on the new technologies which need to be developed and deployed over the next decade. Policies and proposals to detail *how* this activity is achieved are set out in subsequent chapters.

Figure 16: high-level essential activity across sectors to 2035



Note: Markers indicate the year milestones will occur rather than the precise point in a given year, while arrows of activity are inclusive of the years in which they start and finish



Note: Markers indicate the year milestones will rather than the precise point in a given year, while arrows of activity are inclusive of the year they run to start and finish

Endnotes

[1] BEIS analysis (2021), 'Final UK greenhouse gas emission national statistics: 1990 to 2019', https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019

[2] HM Treasury (2021), 'Net Zero Review: Final Report'.

[3] OBR (2021), 'Fiscal Risks Report', https://obr.uk/frr/fiscal-risks-report-july-2021/

[4] BEIS (2021), 'Impact Assessment for the sixth carbon budget', https://www.legislation.gov.uk/ukdsi/2021/9780348222616/impacts

[5] Production methods include: electrolysis, which splits water into hydrogen and oxygen using electricity; steam methane reformation with CCUS, which uses heat, steam, and catalysts to break methane (from natural gas) into hydrogen and carbon dioxide which is then stored underground; and biomass gasification with CCUS, where heating biomass in special conditions produces a mix of gases including hydrogen and carbon dioxide which is used or permanently stored.

[6] BEIS analysis based on 2019 data from the BEIS, *Digest of UK Energy Statistics*, https://www.gov.uk/government/collections/digest-of-uk-energy-statistics-dukes#2021

[7] These scenarios have been developed using whole system cost-optimisation modelling (UK TIMES) to produce a feasible range of least-cost solutions and deployment requirements for given emissions targets.

[8] Terrawatt-hour is a unit of energy equal to one trillion watts for one hour to indicate energy generation and demand.

[9] Emissions from Greenhouse Gas Removals only include engineered removals. Nature-based solutions, such as afforestation, are included in the Agriculture and LULUCF subsector. For further detail see the Natural Resources, Waste & F-Gases and Greenhouse Gas Removals chapters.

[10] Estimates of historical UK GHG emissions are revised annually to incorporate methodological improvements, updated data and changes to international guidelines. The percentage reductions implied by CB levels are therefore subject to change.

[11] BEIS analysis (2021), 'Final UK greenhouse gas emission national statistics: 1990 to 2019', https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019

[12] Transport emissions include emissions from domestic transport and international aviation and shipping.

[13] BEIS (2021), 'UK Hydrogen Strategy', https://www.gov.uk/government/publications/uk-hydrogen-strategy

Reducing Emissions across the Economy

Chapter 3

3i. Power

Delivering a decarbonised power system by 2035

Our Key Commitments

- Take action so that by 2035, all our electricity will come from low carbon sources, subject to security of supply, bringing forward the government's commitment to a fully decarbonised power system by 15 years.
- Accelerate deployment of low-cost renewable generation, such as wind and solar through the Contracts for Difference scheme by undertaking a review of the frequency of the CfD auctions.
- Deliver 40GW of offshore wind, including 1GW of innovative floating offshore wind by 2030.
- Implement the Dispatchable Power Agreement (DPA) to support the deployment of first of a kind power CCUS plant(s).
- Secure a final investment decision on a large-scale nuclear plant by the end of this Parliament whilst taking measures to inform investment decisions during the next Parliament on further nuclear projects as we work towards our net zero target.
- Adopt a new approach to onshore and offshore electricity networks to incorporate new low carbon generation and demand in the most efficient manner, taking account of the environment and local communities.
- Deliver the actions in our recent *Smart Systems and Flexibility Plan and Energy Digitalisation Strategy* to maximise system flexibility.
- Provide £380m for our world-leading offshore wind sector, investing in supply chains, infrastructure and early-coordination of offshore transmission networks, securing jobs and benefitting communities across the UK.
- Reform system governance so that the whole system can achieve our net zero ambitions and meet consumers' needs.
- Drive market-wide rollout of smart meters with a new four-year policy framework that introduces fixed minimum annual installation targets for energy suppliers from 1 January 2022.
- Consider whether broader reforms to our market frameworks are needed to unlock the full potential of low carbon technologies to take us all the way to net zero.
- Ensure that consumers pay a fair, affordable price for their energy, and can engage with a retail energy market that offers the products and services required to make choices that support net zero.

- Ensure the planning system can support the deployment of low carbon energy infrastructure.
- Explore the system need and case for further market intervention for long duration storage and hydrogen in power.

Progress to date

1. The transformation of the power sector over the last 30 years provides a strong basis on which to move forward, on our way to reaching net zero emissions by 2050 across the UK economy. Decarbonising the power sector has led the UK's efforts to reduce GHG emissions overall.

2. In 2019, net UK GHG emissions from the power sector totalled 58 $MtCO_2e$ and accounted for 11% of total net UK GHG emissions.[1] This is a reduction of 72% between 1990 and 2019. In 1990, the power sector accounted for 23% of UK GHG emissions.[2] This has largely been achieved through natural gas generation and renewables displacing coal, and more energy efficient appliances contributing to the reduction of electricity demand. Today, the country gets over half of its power from low carbon technologies.

3. In 2020, we published the *Ten Point Plan for a Green Industrial Revolution* and the *Energy White Paper*, including commitments to put the power sector on an ambitious decarbonisation pathway over the next decade. Since then we have launched a £17.5 million competition to support innovative floating wind ideas for industry and initiated this year's Contract for Difference allocation round, with a £200 million budget for offshore wind and £24 million for floating offshore wind. On delivering new and advanced nuclear power, we have committed to reaching a final investment decision on a large-scale nuclear plant this parliament, subject to value for money and approvals. We are in negotiations with the developer on Sizewell C project in Suffolk. We have since taken further steps: in June, we announced that phasing out of unabated coal generation will be brought forward by one year, to October 2024.[3] In July, we published the Smart Systems and Flexibility plan 2021 and the UK's first Energy Digitalisation Strategy, jointly developed with InnovateUK. Our approach includes measures to facilitate flexibility from consumers, removing barriers to flexibility on the grid including long duration storage, reforming markets to reward flexibility, and digitalising our energy system.

Net zero transition and opportunities for the sector

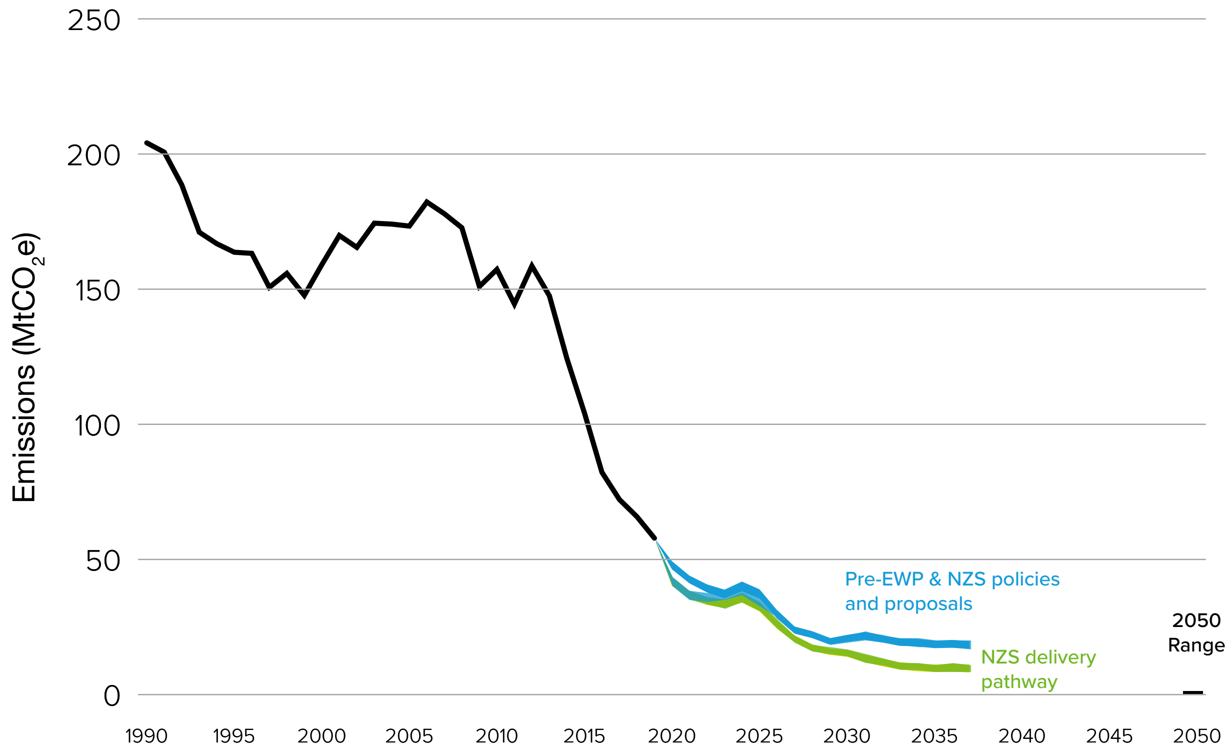
Our 2050 vision and how we get there

4. Reliable and affordable power is a foundation of a modern industrial economy. It is also critical in decarbonising the economy and achieving our net zero goal cost effectively. Although ambitious decarbonisation is required in every sector, deep reductions in emissions from power could offset the need for relatively more expensive decarbonisation efforts elsewhere. Our exposure to volatile gas prices shows the importance of our plan for a strong home-grown renewable power sector to strengthen our energy security into the future.

5. The next 30 years will see a decisive and permanent shift away from the use of unabated oil and gas as the engine of our economy. In the *Energy White Paper*, published in December 2020, we set out what this means for the power sector.[4] Low carbon power is expected to become the predominant form of energy in 2050. It will account for approximately 50% or higher share of final energy consumption, up from 10% in 2019,[5] as it displaces petrol in light vehicles and gas for heat in homes.

6. Based on our whole-system modelling, by 2050, emissions associated with power could need to drop by 95-98% compared to 2019, down to 1-3 $MtCO_2e$. In the interim, to meet our NDC and CB6 targets, we expect emissions could fall by 71-76% by 2030 and 80-85% by 2035, compared to 2019 levels. These figures are based on an indicative power sector pathway contributing to the whole-economy net zero and interim targets (see figure 17 below).

Figure 17: Indicative power emissions pathway to 2037



Source: BEIS analysis

7. Even with major improvements in overall energy efficiency and increased flexibility in the energy system, this could represent a potential doubling of demand. This would require a four-fold increase in low carbon electricity generation and significant expansion of the networks that transport it to where it is needed.

8. We will need to achieve this whilst maintaining a reliable and affordable supply of power. We cannot compromise the essential resilience and reliability of the energy system. It is essential for the critical services we rely on – from hospitals to traffic lights and mobile devices – and its reliability will be fundamental to consumer confidence in adopting new ways of powering their cars or heating their homes.

9. Our understanding of the role of power in 2050, what the system will look like and the level of demand it will need to meet, will evolve over time. This will be informed by the approach to decarbonising other sectors, such as the extent to which hydrogen is used for heat, and what we learn about the cost and achievability of those approaches. It will also be informed by the availability and costs of GHG removal technologies, such as bioenergy with carbon capture and storage (BECCS) and direct air carbon capture and storage (DACCS).

10. The *Energy White Paper* set out our goal of a fully decarbonised, reliable, and low-cost power system by 2050. CB6 represents a very significant increase in the pace of power sector decarbonisation, coupled with increased demand due to the accelerated action in other sectors dependent on low carbon electricity. Although the *Energy White Paper* envisaged achieving an overwhelmingly decarbonised power system during the 2030s, we have since increased our ambition further. By 2035, all our electricity will need to come from low carbon sources, subject to security of supply, bringing forward the government's commitment to a fully decarbonised power system by 15 years, whilst meeting a 40-60% increase in demand.

11. However, the *Energy White Paper's* fundamental approach remains unchanged. A low-cost, net zero consistent electricity system is most likely to be composed predominantly of wind and solar generation, whether in 2035 or 2050. To ensure the system is reliable, intermittent renewables need to be complemented by known technologies such as nuclear and power CCUS, and flexible technologies such as interconnectors, electricity storage, and demand-side response. These flexible technologies can help to minimise the amount of generation and network capacity needed to meet our demand needs, for example, by matching new sources of demand to renewable generation both nationally and locally. To do this, the new critical supply chains for these technologies also need to be resilient to ensure the UK can build the capacity it needs for a reliable system.

12. Our Carbon Budget 6 trajectory suggests that we will need to build all of these technologies at, or close to, their maximum technical limit, to meet the twin challenge of accelerating decarbonisation and servicing increased demand. This represents a considerable delivery challenge. While unabated gas generation currently plays a critical role in keeping the UK electricity system secure and stable, it will be used less frequently in the future, running only when the system most needs it for security of supply.

13. The government is actively taking steps to bring forward low carbon technologies capable of replicating the role of unabated gas in the electricity system, including CCUS-enabled generation, hydrogen-fired generation, BECCS, and flexible storage. We are also bringing forward measures to ensure that any new build combustion power stations, including gas, can convert to clean alternatives in the future. We issued a call for evidence on our plans for *Decarbonisation Readiness* in the summer and subject to feedback on the proposals and parliamentary time, we aim to implement these requirements by 2023.[6]

14. The use of hydrogen to generate electricity can reduce reliance on unabated natural gas. It can also provide additional system flexibility if produced through electrolysis and where there is hydrogen storage. This could contribute to energy security, lowering emissions and system costs. There are trade-offs between the deliverability, optimal fit, and other benefits of emerging technologies versus known technologies. Waiting for emerging technologies before deciding to deploy nuclear and power CCUS at scale could put our CB6 and net zero ambitions at risk. Over the next decade we need to continue to deploy all known low carbon technologies at scale to ensure optionality is maintained, whilst developing new options to mitigate delivery risk and reduce costs.

15. However, a reliable power system is not only about having a balanced mix of generation technologies. We also need to ensure that the networks can transport electricity to where it is required in a cost-effective manner, and to enable crucial system services such as frequency response. Markets should determine the best solution for such a system. We are not targeting a particular solution but will rely on competition to spur investment in technologies which are cheaper and more efficient; and on innovation to reduce the cost of existing options. The government's role is to ensure a market framework which encourages effective competition and delivers an affordable, secure, and reliable system that is, consistent with net zero emissions. We will intervene to address any potential market failures and continue to invest in innovation which helps commercialise new technologies and increase the options available to meet this challenge.

16. The CCC's *Independent Assessment of UK Climate Risk* (June 2021)[7] set out that climate change will likely result in more extreme weather that has the potential to negatively impact GB's power sector. We continue to work closely with industry, regulators, sector bodies, and other stakeholders to ensure that our electricity system is resilient and secure, including to the impacts of climate change.

Seizing new opportunities

17. Transforming the power system offers significant opportunities for UK businesses to exploit technology and know-how in domestic and global markets. Investments in innovation will enable new technologies to deliver benefits to the system and this will be crucial to help us meeting our carbon reduction targets. Innovation will create value by accelerating the commercialisation of low carbon power systems. It can bring costs down, enable us to preserve and develop options and bring forward information to reduce future uncertainty. Renewable energy can also help contribute to our industrial 'SuperPlaces', providing plentiful low carbon electricity to enable the low carbon technologies such as hydrogen, which also offers a renewed era for our industrial heartlands.

18. To fully decarbonise the power sector at the pace we have set out whilst meeting increasing demand, total public and private investment of £280-400 billion is needed in generation capacity and flexible assets – around £150-270 billion of this reflects increased ambition from Carbon Budget 6. The electricity transmission and distribution networks will also both require significant expenditures with an additional £20-30 billion required by 2037 to maintain and reinforce Great Britain's electricity network.

19. The offshore wind sector alone will see over £20 billion in private investment by 2030, and in the last six months around £1.5 billion of investment has already been announced. This includes two purpose-built manufacturing ports and five offshore wind turbine component factories.

20. Decarbonising the power sector will regenerate communities and open up new employment opportunities right around the UK. Based on current estimates, policies and proposals to reduce emissions in the sector could support up to 59,000 jobs in 2024 and up to 120,000 jobs in 2030.

21. For example, the offshore wind sector could support up to 60,000 jobs by 2030, including in the supply chain, with further employment opportunities during construction. Increased deployment of storage and demand side flexibility could support up to 7,000 jobs, levelling up the power sector across Great Britain.

Policies and proposals

Prioritising critical system enablers

22. Crucially, a whole system approach puts more emphasis on addressing critical system enablers. These measures will integrate different low carbon technologies into a coherent, single entity and optimise the system most efficiently and cost-effectively, in the interest of consumers.

23. This means adopting a new approach to developing and delivering electricity networks, both onshore and offshore, to ensure that new low carbon generation can be connected to growing sources of demand. The Offshore Transmission Network Review (OTNR) is transforming how the connections for offshore wind and other offshore transmission infrastructure is planned, designed, and delivered with changes being progressed across the near, medium, and long term. Coordination in how we connect offshore wind can potentially save consumers between £3-6 billion by 2050 and reduce the number of assets and onshore landing points by up to 50%.[8] Ofgem has recently consulted upon regulatory changes to enable offshore coordination for in-flight projects, including potentially allowing anticipatory investment. BEIS is currently consulting on a new long-term policy regime for offshore networks. Onshore, we welcome electricity networks' efforts to invest strategically ahead of need in new capacity, where it is efficient to do so, as well as Ofgem's work to create a price control framework which allows and encourages this. In recognition of the essential role of electricity networks as an enabler of net zero, we will publish, jointly with Ofgem, an Electricity Network Strategy, which will set out how we will facilitate an agile, flexible onshore network that allows the rapid, transformational change required while responding to consumer and energy system needs. This will include our plans to introduce competition in the building, ownership, and operation of onshore network assets, on which we published a consultation in August.

24. We will look to deliver these changes whilst minimising the impacts on citizens and communities. Network companies work closely with local and transport authorities and are incentivised to deliver network upgrades as efficiently as possible both domestically and through the RIIO price control framework, for example by laying larger cables to avoid reopening roads twice. Connection upgrades are becoming increasingly digitalised for domestic customers looking to install a heat pump or electric vehicle chargepoints. In cases where network upgrades require a temporary power disruption, network companies are required to give notice to customers of planned outages. Advice and ongoing information is also provided including support for vulnerable customers, such as providing generators for customers who are medically dependent on electricity.

25. The deployment of smart technologies and flexibility will underpin our energy security and the transition to net zero. Flexibility from technologies such as energy storage, smart and bidirectional charging of electric vehicles, flexible heating systems, and interconnection could save up to £10 billion per year by 2050 by reducing the amount of generation and network needed to decarbonise.[9] These technologies offset the need for more expensive capital investment in traditional infrastructure, as well as help optimise how efficiently the system operates by better integrating intermittent renewables into the system and reducing peak demand.

26. A key enabler for demand side flexibility will be smart meters, which enable innovative products and services such as smart time-of-use tariffs. These tariffs reward consumers financially for using energy outside peak times, when demand is low or when there is excess generation available. Technologies such as electric vehicles and smart appliances can be automatically programmed to take advantage of cheaper rates, cost-effectively integrating them with renewable energy sources and saving consumers money. At the end of June 2021, there were 25.2 million smart and advanced meters in homes and small businesses across Great Britain, representing 46% smart coverage.[10]

27. The *Smart Systems and Flexibility Plan* sets out a vision, analysis, and actions for delivering a smart and flexible energy system. We will facilitate flexibility from consumers and remove barriers to flexibility on the grid, both for small-scale and large-scale long-duration electricity storage, as well as driving policy to increase interconnector capacity. The Plan also sets out actions to improve market design and coordination so that flexibility providers can secure revenues across multiple markets. Data and digitalisation are a core aspect of the future system; we have set out a strategic approach to digitalisation and opening data across the energy sector through the *Energy Digitalisation Strategy*.

28. This transformation of the energy system means our approach to system governance needs to evolve to help the whole energy system achieve our net zero ambitions and meet consumers' needs at the least cost. BEIS and Ofgem have jointly consulted on the future of system operation.[11] We set out proposals for an expert and impartial Future System Operator (FSO) with responsibilities across both the electricity and gas systems, to drive progress towards net zero while maintaining energy security and minimising costs for consumers. These proposals set out how detailed expertise gained from system operation could be used to provide a whole energy system approach to coordination and planning while ensuring that market participants and government has confidence in the impartiality of the FSO's advice and facilitation of markets, competition, and system development. We have also, jointly with Ofgem, consulted on the future governance of energy codes, which set out the detailed technical and commercial rules for the system, building on the government and Ofgem's joint review of code governance and the work of the independent panel on engineering standards.[12]

29. Significant progress towards net zero can happen, and is already happening, within our existing market framework. This combines markets for wholesale power, balancing, and system services with a Contracts for Difference scheme (CfD) for low carbon generation and a capacity market to ensure security of supply. We have recently published a Call for Evidence on actions to better align the capacity market with net zero,[13] including potential actions to encourage the participation of more low carbon capacity. However, it will be necessary to consider whether broader reforms to our market frameworks are needed to unlock the full potential of low carbon technologies to take us to net zero.

30. Throughout the transition, consumers should pay a fair, affordable price for their electricity, and be able to engage with a retail energy market that offers the products and services that allow them to make choices that support net zero. To support these aims, the government is considering what reforms to the retail energy market are needed to support progress to net zero through the 2020s, including the role of suppliers and how they are regulated.[14] In considering these reforms, the government will take account of the lessons of the current market, in which high gas prices have placed financial pressures on suppliers. In the future, the market will need to be resilient and sustainable, and continue to protect consumers as we move to a net zero system. The market will also need to remain competitive, and consumers will need to be engaged with positive choices about their energy supply. To support these choices, consumers should receive accurate information about the carbon content of their energy products, and we will consider the case for reforming the framework which underpins green electricity tariffs and wider environmental carbon accounting schemes.

31. We will also need to address cross-cutting, overarching enablers such as ensuring the planning system has the capacity to support the deployment of low carbon energy infrastructure, while also representing the interests of the environment and of the communities which host this infrastructure. We will do this by updating the energy National Policy Statements to provide greater clarity on the need and urgency for low carbon infrastructure, exploring ways of streamlining processes through the Nationally Significant Infrastructure Projects (NSIP) reform programme and addressing issues at a strategic level, for example through the Offshore Wind Enabling Actions Programme.

32. We will need to consider how low carbon energy infrastructure can be deployed at an unprecedented scale and pace sympathetically alongside the interests of communities and consistent with our obligations to a sustainable environment, both land-based and marine. We will also need to streamline the consenting process to ensure that the deployment needed to stay on track for our 2030 and CB6 targets is delivered.

33. In addition, we will need to grow our supply of skilled workers and further strengthen the UK supply chain to service the demands of energy infrastructure, creating economic opportunity for citizens and communities across the UK. The £160 million announced in the *Ten Point Plan*, has substantially grown our industrial capabilities in the offshore wind sector. To help keep us on track for our Carbon Budget 6 and net zero targets we will need to deploy substantial volumes of floating offshore wind. Our target of 1 GW floating offshore wind by 2030 is a stepping stone to further growth in the UK, which will also develop jobs and opportunities in the associated industrial supply chain putting us at the forefront of this new technology that can utilise our North and Celtic Seas. We will build on this with £380m for our world-leading offshore wind sector, investing in supply chains, infrastructure and early-coordination of offshore transmission networks, securing jobs and benefitting communities across the UK.

Supporting sustained deployment of low carbon generation

34. While our strategic approach to decarbonising power in line with CB6 is predicated on a whole system approach, with a key role for the market in delivering the most efficient solution, part of the CB6 challenge is nonetheless one of deploying low carbon electricity generation infrastructure at an unprecedented scale and pace whilst maintaining optionality for more nascent sources for power generation, such as hydrogen, to help reduce the risk of delivery. In a scenario with higher electricity demand, if there is no hydrogen generation in the power sector, we are likely to need to build all known technologies at or close to their maximum deployment potential by the mid-2030s.

35. In the *Energy White Paper*, we committed to a target of 40 GW of offshore wind by 2030, including 1 GW floating wind, alongside the expansion of other low-cost renewable technologies. We need to continue to drive rapid deployment of renewables, for example offshore wind, so we can reach substantially greater capacity beyond 2030, and accelerate the cost reduction and commercialisation of floating offshore wind. As we decarbonise our electricity system our wholesale prices will become less exposed to fluctuations in global fossil fuel prices, and we would expect wholesale prices to be lower.

36. CB6 also requires a sustained increase to the deployment of land-based renewables such as locally supported onshore wind and solar in the 2020s and beyond. We will seek to ensure a facilitative environment for the deployment of unsubsidised rooftop solar to complement our market-based approach of ensuring exporters receive a fair price through the Smart Export Guarantee. We also have one of the best ocean energy resources in the world and we continue to explore the role of marine technologies in net zero.

37. This step change in renewable deployment will be achieved primarily by providing ongoing support through the CfD scheme, starting with allocation round 4 this December – which will be the biggest-ever round of our flagship renewable energy scheme. The CfD will be key to delivering the levels of generation required by 2030. To support this step change we will undertake a review of the frequency of the CfD auctions. Looking beyond this, ensuring we retain effective means to provide long-term stability will be crucial throughout the 2030s to achieve affordable, scalable deployment.

38. We also need to increase our nuclear capacity, which is why we said in the *Energy White Paper* that we will aim to bring at least one large-scale nuclear project to the point of final investment decision by the end of this Parliament, subject to clear value for money and all relevant approvals. In December 2020 we announced the start of formal negotiations on Sizewell C and those negotiations are ongoing. To facilitate a decision this Parliament, we plan to establish the Regulated Asset Base model to fund new nuclear projects at a low cost of capital, saving consumers money.

39. The government will also take measures to inform investment decisions during the next Parliament on further nuclear projects as we work towards our net zero target. This will include consideration of large-scale and advanced nuclear technologies, including Small Modular Reactors (SMRs) and potentially Advanced Modular Reactors (AMRs). As part of this, we are announcing a new £120 million Future Nuclear Enabling Fund to provide targeted support in relation to barriers to entry. Further details of how this fund will operate will be published in 2022 alongside details of a roadmap for deployment that takes into account value for money.

40. We are also providing funding for a SMR design through our £385m Advanced Nuclear Fund and are progressing plans for an Advanced Modular Reactor demonstrator in the early 2030s. Whether large- or small-scale projects, there remain a number of possible sites available for these options, including Wylfa in North Wales.

41. To help deliver emissions reductions to keep us on track for Carbon Budget 6, we will need significant expansion of power CCUS beyond the *Energy White Paper* commitment of one power plant by 2030. To do this we will implement the Dispatchable Power Agreement (DPA), and seek to bring forward at least one power CCUS plant in the mid 2020's through the CCUS Cluster Sequencing Process, subject to the outcome of that process including value for money and affordability considerations. We will also aim to begin competitive allocation in the 2020's to support a future pipeline of projects and cost reduction via increased deployment and competitive tension. Finally, we will continue to review and evolve the policy framework to stimulate the delivery of future power CCUS projects.

42. Bioenergy has already played a significant role in decarbonising the electricity system, accounting for 12.6% of total renewables generation in 2019.[15] Technological changes mean that biomass usage can now go beyond carbon-neutral and deliver negative emissions by combining it with carbon capture and storage (BECCS). As committed to in the *Energy White Paper*, we will publish a Biomass Strategy in 2022 that will set out how BECCS could be deployed. As is the case with all UK biomass use, any future BECCS projects will need to meet stringent sustainability and air quality requirements for the production and use of biomass, as will be set out in the Biomass Strategy.

Reducing delivery risk

43. Although we need to ensure we can deploy existing low carbon generation technologies at close to their maximum to reach Carbon Budget 6, we also need to de-risk the delivery challenge. We will pursue innovative technology solutions which ease the pressure, including:

- **Exploring the system need and case for market intervention for long duration storage and hydrogen in power –** both technologies have the potential to provide important low carbon peaking capacity during periods of high demand and over extreme events such as long periods of low wind. Long duration storage technologies could provide a range of system stability services such as the provision of inertia. An expansion of hydrogen in power could also reduce the need to build other technologies at the limit of what is technically feasible and could be a form of storage for excess power generated by renewables. We are supporting innovation in longer duration energy storage projects through a £68 million competition for prototypes and demonstrators;[16]
- **Reducing emissions from the energy from waste sector –** emissions from energy from waste plants represent a significant part of the residual emissions in the power sector. We are exploring options to reduce emissions from these plants within the power sector, including whether support for CCUS at Energy from Waste plants could be provided by the Industrial Carbon Capture Business Model. The Government's approach in respect of this is still under consideration and we intend to provide further details later this year;
- **Maximising system flexibility, including through storage technologies, demand side response, and interconnectors –** to integrate renewables, balancing the intermittency of renewables and helping to maintain system operability;
- **Promoting more ambitious and sustained demand reduction and energy efficiency measures to reduce overall power demand –** allowing demand to increase unconstrained as we electrify other parts of the economy could prevent us hitting very low levels of emissions during the 2030s.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government, and Northern Ireland Executive

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action to reduce emissions across the power sector, and across the UK.

Wales

The Welsh Government has supported the development of four regional energy strategies that identify the scale of change needed to reach a low carbon energy system and establish regional priorities for energy. This work models future demand for power, heat and transport, and assesses the economic impact of delivering the proposed ambitions.

In addition, Conwy and Newport local authority areas are piloting local area energy planning. This work will identify the low-regret actions to decarbonise a local energy system and can be used by grid network operators to inform their infrastructure investment.

Scotland

The Scottish Government's £62 million Energy Transition Fund will support Scotland's energy sector and the North East, over the next five years, to make progress on energy transition as Scotland moves toward a net zero society by 2045.

The Emerging Energy Technologies Fund is a £180 million package of funding over five years that will provide capital support to accelerate low carbon infrastructure projects that will be essential to deliver net zero. The Fund will make £100 million available to support hydrogen projects in line with the Scottish Government's Hydrogen Policy Statement.

A further £80 million of this funding will be directed to projects supporting the development of carbon capture, utilisation and storage and negative emission technology projects in Scotland.

The purpose of the hydrogen funding programme is to support the delivery of the Scottish Government's upcoming Hydrogen Action Plan, the development of a hydrogen economy in Scotland, to help overcome challenges to scaling up hydrogen production and to deliver lasting benefits for business and communities.

Northern Ireland

Northern Ireland has already demonstrated its commitment to decarbonisation of the power sector through rolling out renewable electricity generation under the Northern Ireland Renewables Obligation (NIRO) - 45.4% of the electricity consumed in Northern Ireland between 1 July 2020 and 30 June 2021 was generated from renewable sources. Building on this achievement and with a view to meeting the ambition of net zero by 2050, the Minister for the Economy, in considering requirements for the NI Energy Strategy (to be published by end of 2021), has set a renewable electricity target of at least 70% by 2030.

3ii. Fuel Supply and Hydrogen

Transitioning to a low carbon future

Our Key Commitments

- An ambition for 5 GW UK low carbon hydrogen production capacity by 2030.
- We have set up the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme to fund our new hydrogen and industrial carbon capture business models. We will be providing up to £140m to establish the scheme, including up to £100m to award contracts of up to 250MW of electrolytic hydrogen production capacity in 2023 with further allocation in 2024.
- Implement the £240 million Net Zero Hydrogen Fund and finalise the Hydrogen Business Model and the Low Carbon Hydrogen Standard in 2022.
- Work with the sector to help develop a low carbon fuel strategy for transport for publication in 2022, as announced in the recent Transport Decarbonisation Plan, and deliver commitments on sustainable aviation fuels.
- Work with stakeholders to address barriers to electrification of oil and gas production by Q4 2022 and continue to drive down routine flaring and venting.
- Regulate the oil and gas sector in a way that minimises GHG emissions, notably through the revised Oil and Gas Authority strategy, which empowers the OGA to assess operators' plans to reduce their emissions levels against effectively a net zero test, and establish a climate compatibility checkpoint for future licensing on the UK Continental Shelf.

Progress to date

1. In 2019 net UK GHG emissions from fuel supply totalled 26 $MtCO_2e$ and accounted for 5% of total net UK GHG emissions. Emissions today mainly derive from fossil fuels and can be attributed to stages of the supply journey.[17] This chapter covers all aspects of fuel supply emissions:

- Extraction ('upstream') – exploration and production of oil and gas including drilling, surfacing resources and onshore processing at gas plants;
- Transportation ('midstream') – transportation and storage of oil and gas including pipelines, pumping stations, trucks, and transcontinental tankers;

- Refinement ('downstream') – refining oil into products including transport fuels, bitumen, lubricating oils, liquid petroleum gasses, heating oils, marine fuels, polymers, solvents, and alcohols. Refining emissions are counted as part of the industry sector but are discussed in this chapter to take a holistic view of supply.

2. Overall, between 1990 and 2019, net UK GHG emissions from fuel supply have decreased by 61%. North Sea production has fallen; older, more polluting installations have been decommissioned whilst cleaner ones have been brought online; regulatory frameworks have supported efficiency gains; coal mines have closed; and iron pipes have been replaced with plastic to reduce methane leakage across the gas network.

3. We have also made progress in low carbon fuel production. An estimated 10-27 TWh of hydrogen production now exists today but is almost all derived from fossil fuels without carbon capture and for use outside of the energy system.[18] In 2019, renewable fuels supplied under the Renewable Transport Fuel Obligation (RFTO) accounted for 5% of total road and non-road mobile machinery fuel. This mainly consisted of biodiesel and bioethanol but also included biomethane and renewable hydrogen.[19]

4. Building on the *Ten Point Plan*, we recently published the *UK Hydrogen Strategy* and associated consultations on a hydrogen business model, the Net Zero Hydrogen Fund (NZHF) and a low carbon hydrogen standard, outlining our approach to kickstarting the production of low carbon hydrogen and developing a robust UK hydrogen economy.

Net zero transition and economic opportunities

Our 2050 vision and how we get there

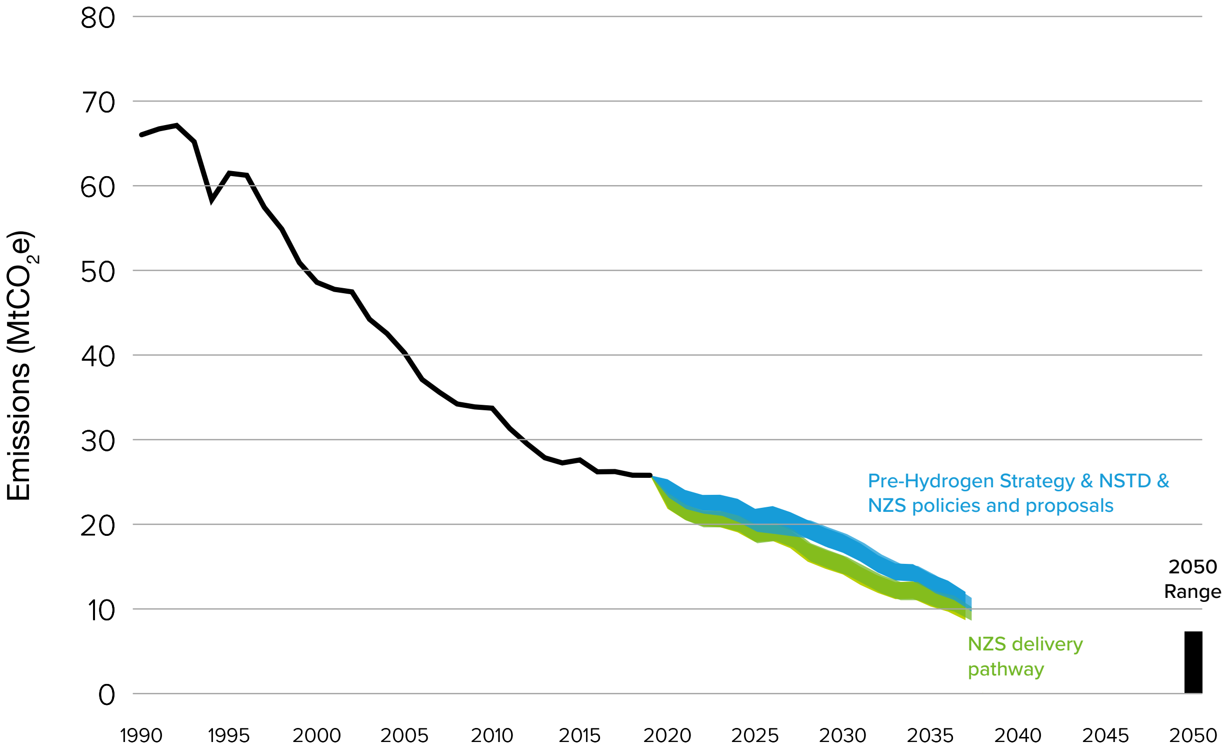
5. There is a need for widespread electrification across the economy, but we cannot rely on electricity alone. Many end use sectors require low carbon energy including those where electrification is not viable or cost-effective, making the supply of cleaner fuels essential to achieving net zero.

6. Our fuel supply will look very different by 2050. Oil and gas production will contract significantly as the UK Continental Shelf matures and investment in the North Sea pivots to new opportunities from CCUS and hydrogen, accelerated by widespread electrification and low carbon fuel switching. This shift away from fossil fuels will protect consumers from volatile gas prices. Remaining oil and gas installations will use low carbon power, with residual emissions minimised. In the *Energy White Paper*, we committed to this, by stating that we will work with the oil and gas sector to transform the UK Continental Shelf into a net zero basin by 2050.

7. Refineries can play an important role in low carbon clusters utilising CCUS and low carbon fuels, and the production of low carbon fuels will increase significantly to meet demand where electrification is not viable. In these areas there will be significant scale up of hydrogen networks and storage, from new and repurposed existing infrastructure.

8. Based on our whole-system modelling, by 2050, emissions associated with fuel supply could need to drop by 71-99% compared to 2019, down to 0-8 $MtCO_2e$. In the interim, to meet our NDC and CB6 targets, we expect emissions could fall by 37-45% by 2030 and 53-60% by 2035, compared to 2019 levels. These figures are based on an indicative fuel supply sector pathway contributing to the whole-economy net zero and interim targets (see figure 18 below).

Figure 18: Indicative fuel supply emissions pathway to 2037



Source: BEIS analysis

9. We have agreed ambitious interim targets for emissions reductions with industry through the *North Sea Transition Deal* (NSTD) including 10% by 2025, 25% by 2027, and 50% by 2030 compared to a 2018 baseline.

10. The *Ten Point Plan* announced our ambition for 5 GW of low carbon hydrogen production capacity by 2030, alongside steps to drive the uptake of sustainable aviation fuels (SAF). Since then we have invested £3 million in kick starting the Tees Valley Hydrogen Transport Hub and announced a £60 million Low Carbon Hydrogen Supply 2 Competition to fund projects to develop innovative low carbon hydrogen solutions. The *UK Hydrogen Strategy* further sets out our comprehensive approach to growing a UK hydrogen economy, indicating that use of low carbon hydrogen enabled by 5 GW of production capacity could deliver total emissions savings of 41 $MtCO_2e$ between 2023 and 2032, the equivalent of the carbon captured by 700 million trees over the same period.

11. Looking across a range of end use scenarios, the *UK Hydrogen Strategy* suggests that we could need 7-20 GW of production capacity in 2035 and 15-60 GW in 2050, depending on developments across heat, industry, transport, and power.[20] Using more specific end use assumptions, the illustrative pathway in this Strategy suggests production capacity in 2035 would need to be 10 GW if heat is electrified, or 17 GW if hydrogen is used widely for heat.[21]

12. As the production of low carbon fuels replaces fossil fuels, we intend to follow the following principles:

- **Integrating a whole system view***.* We will take an economy-wide view, including to balance end-use sector demands with supply side considerations, such as infrastructure and the operation of the electricity and other fuel supply sectors.
- **Taking a portfolio approach**. We will remain flexible to a supply mix of low carbon fuels that could be affected by technologies in early development. As demand grows, we expect innovators, investors and producers will respond with advances delivering further cost or emissions savings. Our hydrogen modelling assumes a combination of electrolysis from renewable electricity, methane reformation with CCUS, and BECCS but we are aware of industry plans involving other production methods and will update our modelling with new technologies as evidence develops.
- **Minimising environmental impacts**. Any impacts from low carbon fuel production on air quality or the environment must be kept under consideration and comply with evolving regulatory standards. We must maintain strict sustainability requirements for fuels to be eligible for government support schemes to achieve genuine emissions savings compared to fossil fuels and minimise environmental impacts.

13. Drawing on the OECD's 'Trade in Embodied CO_2' database, as well as the relative levels of trade openness of UK sectors, our analysis suggests that refineries are currently amongst the areas most at risk of carbon leakage. We are committed to mitigating this risk by engaging with industry to better understand their concerns around carbon leakage. Further analysis and information on the potential mitigations for consideration are set out in HM Treasury's *Net Zero Review*.

Seizing new opportunities

14. To achieve the level of emissions reductions in the fuel supply sector indicated by our delivery pathway to 2037, we will need additional public and private investment of £20-30 billion.

15. Government investment in domestic hydrogen production, to de-risk early projects, could also unlock private sector capital co-investment of over £4 billion by 2030. This could increase to £10-22 billion to meet the 2037 delivery pathway in electrification and hydrogen scenarios for heat respectively.[22]

16. Decarbonising fuel supply and growth of the hydrogen sector will regenerate communities and open up new employment opportunities right around the UK. Based on current estimates, policies and proposals to reduce emissions in fuel supply and growing the hydrogen sector could support up to 10,000 jobs in 2030. We will build on existing commitments in the NSTD to facilitate reskilling and support 40,000 jobs across the supply chain, ensuring everyone employed in the sector can fulfil their potential. Many skills will also be transferable to clean growth industries like offshore wind, CCUS and hydrogen production. Producing low carbon hydrogen at scale will be made possible by carbon capture and storage infrastructure, and we plan to grow both of these new British industries side by side in industrail 'SuperPlaces'.

17. The development of a domestic SAF industry alone could generate support up to 1,000 jobs in 2030, with new jobs as plants are developed as well as opportunities to retain existing fuel expertise across the country. Industry has committed to creating an integrated skills plan to help its transition and diversification with strong support from government, academia, and trade unions.

18. Achieving our 5 GW ambition for hydrogen production capacity could support over 9,000 jobs in 2030, across the full hydrogen value chain. Meeting the delivery pathways set out in the *Journey to Net Zero* chapter could support 13,000-19,000 jobs across the hydrogen economy by 2035.[23]

19. Oil and gas will continue to play an important role as we transform from an economy based on fossil fuels to one based on clean energy. We will manage the transition in a way that protects jobs and investment, uses existing infrastructure, maintains security of supply, and accounts for climate risk.

Case study: The Phillips 66 Humber refinery

The sector can already compete on the world stage and provide domestic resilience by producing products essential for decarbonisation. UK refining includes a global leader and the only European producer of high-grade speciality coke for batteries used in electric vehicles and consumer electronic goods. The Phillips 66 Humber refinery's world scale production capability is equivalent to 1.3 million electric vehicles (EV) per year. . Whilst the majority is currently exported, it has the potential to underpin a domestic UK battery industry and development of a broader EV battery manufacturing base in the UK.

Policies and proposals

Oil and gas supply

20. We have always been clear that as we reduce our dependence on fossil fuels, the North Sea basin has a key role to play. Our approach will ensure that it does contribute to the transition, driving investment in transition technologies and providing the skills needed for net zero. However, we are clear that we do need to reduce our reliance on hydrocarbons as swiftly as possible. The best way to protect British businesses and consumers from volatile international fossil fuel markets is to get our economy off hydrocarbons.

21. Upstream, the North Sea Transition Deal (NSTD) has set us on a transformational path to deliver the long-term skills, innovation, infrastructure, and investment required to decarbonise oil and gas production and industry more widely. The deal will hold the industry to account on commitments it has made to halve its operational emissions by 2030, while supporting up to 40,000 high-quality direct and indirect supply chain jobs in Scotland and our industrial heartlands in the North East, North West and East of England. It also emphasises our shared commitment to achieving 10 $MtCO_2$/year of CCUS capacity, with industry leveraging existing infrastructure to provide key transport and storage capability; and positions the sector to help deliver our 5 GW hydrogen ambition.

22. The Oil and Gas Authority (OGA) published its revised strategy in February, enshrining a range of new net zero obligations for the UK oil and gas industry. This is reflected through the suite of levers available to the OGA, making net zero a key factor in its decisions, including to grant consent for projects. It empowers the OGA to assess operators’ plans to reduce their emissions levels against effectively a net zero test, in accordance with its revised strategy, the OFS can now encourage operators to invest in transition technologies such as CCUS and hydrogen – seizing the economic opportunities available to the sector in a net zero future and living up to the commitments of the Transition Deal. The Strategy also introduces full societal carbon cost assessments into the approvals process.

23. Step-change abatement will be delivered by the electrification of existing and new offshore assets, through connections to onshore networks or offshore renewables. We will work with regulators to review supporting infrastructure in the Offshore Transmission Network Review and to address regulatory barriers. We will support removing further barriers through £1 million of additional funding from 2021 to 2022.

24. Beyond power generation, flaring and venting account for most remaining upstream emissions and we will need to be ambitious to allow us to stay on track for our CB6 target. We have endorsed industry's commitment in the NSTD to accelerate reductions beyond the World Bank's 'Zero Routine Flaring by 2030' initiative and new OGA guidance sets out the expectation that all facilities should have zero routine flaring and venting by 2030 or sooner. Industry is taking steps through its Methane Action Plan for continuous emissions reductions with specific methane emissions reduction targets, whilst setting the expectation that assets will have individual action plans by 2022.

25. Further, following the conclusion of our review into the future of offshore oil and gas licensing earlier this year, we will also introduce a formal climate compatibility checkpoint on future licensing rounds for oil and gas exploration. This will ensure future licences are only awarded following a compatibility assessment against the government's broad climate change ambitions, including reaching net zero by 2050. This checkpoint will be designed by the end of 2021. We will be seeking input on the design through a consultation to be published before COP26.

26. This checkpoint builds on the existing checks within our regulatory system, including the OGA Strategy, and the role of the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED). These checks include a full environmental impact assessment and a public consultation.

27. Additional work is being carried out by the government and regulators to review what action can be taken to further reduce emissions. Improved measurement, reporting and verification will play a critical role in this. The government, including the Offshore Petroleum Regulator for Environment and Decommissioning, is working closely with the OGA to collect robust industry data which will enable effective implementation of their strategy. The OGA's tracking of overall emissions reductions and benchmarking of flaring and venting data will also improve performance across industry. Government and regulators will continue to work with industry to drive emissions reductions, including through improved process efficiency, to stay on track for CB6.

28. Midstream, the gas network must be effective at minimising gas leakage and associated emissions by replacing iron pipes with plastic, even with gas demand decreasing leading to 2050. Through network price controls, Ofgem has set gas distribution companies a target to replace 15,500km of iron mains and associated services in 5 years, from April 2021. This will reduce leakage by 17% and emissions by 0.5 $MtCO_2e$. Additional financial incentives will encourage further action through pressure management and gas conditioning. We continue to work with Ofgem and HSE to review how best to continue to reduce methane leakage to 0% in all future decarbonisation scenarios.

29. Blending hydrogen into the gas grid could also support initial steps to decarbonise heating. This will consider the air quality impacts of hydrogen combustion in domestic settings. Government is working closely with key delivery partners to explore options to blend hydrogen up to 20% by volume into the gas distribution network, and up to 2% into the gas transmission network, along with biomethane and natural gas. Subject to both the economic and safety case for blending being demonstrated, we are aiming to make a final decision on blending by the end of 2023.

30. We recognise that industry will need early sight of decisions should blending proceed and propose five principles for delivery:

- **Safety.** Blending must remain within safe limits set by the Health and Safety Executive and changes to gas quality and infrastructure must meet all safety requirements;
- **Operability.** Changes to gas quality and infrastructure must maintain existing system, pipeline, and consumer appliance operability;
- **Security of Supply.** Blending must not prevent consumers' secure gas supply;
- **Affordability.** Costs to consumers should be affordable and value for money; and
- **Temporary.** Blending could support initial development of the hydrogen economy but is not a preferred long-term solution.

31. Acknowledging that the future demand for gas will decline as we decarbonise, means that the gas system will need to change to meet the net zero targets. We will publish a call for evidence this autumn, seeking views from stakeholders on the future of the gas system, with a focus on infrastructure and markets. This will enable us to determine how the gas market will need to evolve to ensure the right market and regulatory signals are in place to offer the necessary level of investment and maintenance throughout the transition. Gathering evidence on the amount of natural gas, biomethane, and hydrogen available and the ongoing role for gas will inform what action we must take.

32. Downstream, UK refineries already underpin major CCUS and hydrogen projects in key industrial clusters. These include Gigastack (Phillips 66), Humber Zero (Phillips 66) and HyNet (Essar Oil UK). The Industrial Energy Transformation Fund recently awarded £7 million and £800,000 to Essar Stanlow and Phillips 66 respectively, in support of hydrogen focussed net zero projects. We are also encouraged to see operators investing in the production of low carbon fuels and will continue to work with the sector to encourage innovation, maximise economic opportunities from net zero, and remove regulatory barriers which hinder the transition away from fossil fuels.

Case study: Fulcrum BioEnergy

Fulcrum BioEnergy has announced plans to develop its first UK residual waste to low carbon SAF plant. The 'Fulcrum NorthPoint' biorefinery will be located at the Essar Oil (UK) Limited refinery at Stanlow, Ellesmere Port in the North West of England.

33. We have also published the draft Downstream Oil Resilience Bill which will give the government the powers it needs to ensure secure fuel supplies are maintained during the transition to net zero.

Low carbon fuel supply

34. The UK has a unique opportunity to be a leader in low carbon fuel production and this will be captured in strategies that we will publish in 2022.

35. A new *Biomass Strategy* will set how sustainable biomass could be best used across the economy to help achieve net zero, including to produce low carbon fuels. It will also assess our existing sustainability standards, already some of the world's most stringent, and set out where and how we can improve them further. When coupled with carbon capture and storage, it is possible that sustainable biomass can not only enable production of low carbon fuels but could also deliver vital negative emissions. Any future BECCS project will need to meet stringent sustainability requirements for the production and use of biomass, as will be set out in the *Biomass Strategy*.

36. This will be complemented by a long-term strategy for low carbon fuels as announced in our recent *Transport Decarbonisation Plan*. The strategy will consider how to maximise emissions savings from low carbon fuels used across different transport modes in the period to 2050.

37. The latter of the two strategies will build on the success of the Renewable Transport Fuel Obligation (RTFO), which has supported the market for low carbon fuel supply since 2008. Fuels supported under the RTFO need to comply with sustainability criteria such as minimum GHG thresholds, and by incentivising fuels produced from wastes, it saved 5.37 $MtCO_2e$ in 2019 alone. Further to sub-targets for so-called development fuels of strategic importance, we have recently widened support to more diverse fuels and announced more ambitious targets for the RTFO to 2032 set at 14.6% of total liquid fuel supply.

38. To accelerate the development of UK plants to produce advanced fuels we have provided grant funding through schemes including the Future Fuels for Flight and Freight Competition (F4C) and Advanced Biofuels Demonstration Competition (ABDC). Delivering on the *Ten Point Plan* we also recently announced the shortlist for the £15 million Green Fuels, Green Skies Competition (GFGS) supporting eight companies pioneering new SAF technologies. To accompany this announcement, we published a consultation on proposals for a new UK SAF blending mandate aiming for introduction in 2025. It included design questions on which feedstocks and technologies should be eligible and welcomed views on what our SAF ambition and targets should be. We are currently reviewing the responses to the SAF mandate consultation, but our ambition is for a comprehensive policy framework, including the mandate, to enable the delivery of 10% SAF by 2030. Further detail can be found in the *Transport* chapter.

Hydrogen production

39. The UK's skills, capabilities, assets, and infrastructure mean that we have the potential to excel in both CCUS-enabled and electrolytic low carbon hydrogen production. Alongside the scale of production that CCUS-enabled methane reformation or 'blue' hydrogen can bring, our renewables can support the growth of electrolytic or 'green' hydrogen, bringing down costs and increasing production capacity whilst new production technologies such as hydrogen from nuclear and biomass are developed. Supporting a variety of different production methods will enable us to develop low carbon hydrogen rapidly at scale during the 2020s and 2030s to deliver what is needed for CB6 and net zero.

40. Our approach to scaling up the UK hydrogen economy in the 2020s is set out in our recent *UK Hydrogen Strategy*, which describes our key policies and proposals to overcome key barriers to development. Alongside the Strategy, we published a package of documents consulting on proposed policy support mechanisms for new hydrogen production. This approach, subject to further policy development following these consultations, and together with the ambition shown by proposed hydrogen projects, provides confidence we can achieve low carbon production sufficient to deliver on our targets under the Climate Change Act. We know there will be more to do and will keep our policy approach under review as the use of hydrogen in the energy system develops and production methods evolve.

41. The UK is already at the forefront of innovation across the hydrogen value chain, reducing technological barriers to production and end use cases. We recently launched a new £60 million Low Carbon Hydrogen Supply 2 Competition, which will develop novel hydrogen supply solutions for a growing hydrogen economy.[24]

42. Low carbon hydrogen is not yet competitive with traditional fuels as production projects face additional costs compared to existing energy sources. Investors cannot currently justify upfront capital investments without visibility or predictability of revenue and returns. Lessons learnt from the success of UK offshore wind deployment suggests government intervention to address this cost difference is a key requirement to bring forward hydrogen supply at scale.

43. In August this year we published our consultation on our preferred hydrogen business model[25] to provide revenue support to hydrogen producers and help overcome the cost challenge to bring through investment in new low carbon hydrogen projects. As set out in the *Industry* chapter, and Hydrogen Revenue Support (IDHRS) scheme to fund our new hydrogen and industrial carbon capture business models. We will be providing up to £140 million to establish the scheme, including up to £100 million to award contracts of up to 250 MW of electrolytic hydrogen production capacity in 2023 with further allocation in 2024. The IDHRS will fund the allocation of the hydrogen business model contracts to both electrolytic and CCUS-enabled projects from 2023, resulting in up to 1.5 GW of low carbon hydrogen contracts awarded to projects.

44. As set out in the August consultation,[26] our Net Zero Hydrogen Fund (NZHF) will provide up to £240 million for government co-investment to support new low carbon hydrogen production out to 2025. The aim of the Fund is to support commercial deployment of new low carbon hydrogen production projects during the early 2020s, by helping to address barriers related to commercial risk and high upfront costs relative to fossil fuel alternatives, unlocking private sector investment in projects. We intend to launch the NZHF in early 2022.

45. In August we also published a consultation[27] on the proposed UK low carbon hydrogen standard which will define what is meant by low carbon hydrogen, allowing us to incentivise and support the right production for supply across the energy system. It will establish a threshold for greenhouse gas emissions allowed in the production process for hydrogen to be considered low carbon and be eligible for support.

46. The RTFO has supported the supply of renewable hydrogen into transport since 2018 and has been successful in launching small-scale renewable hydrogen supply. In July, the Department for Transport announced changes to the RTFO which could further encourage the uptake of renewable hydrogen in transport, including in rail and shipping. The original consultation, published in March, also proposed to make evidencing the provision of renewable electricity for hydrogen production easier through power purchase agreements and recognising the importance of regional grids. The final decision on these changes will be published shortly.

47. *The UK Hydrogen Strategy* sets out the initial steps being undertaken to develop the hydrogen economy over the 2020s, to deliver our 2030 5 GW production capacity ambition and position the hydrogen economy for further ramp up needed to support CB6 and net zero. But we know there will be more to do beyond this. That is why we committed in the strategy to say more on the mix of production technologies and supporting network and storage infrastructure that could help meet future hydrogen demand following conclusion of our consultations and further work. Similarly, we set out our plans to develop appropriate regulatory and market frameworks to support an expanding hydrogen economy throughout the 2020s and beyond. We will publish a Hydrogen Sector Development Action plan in early 2022.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government and Northern Ireland Executive

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action to reduce emissions across the fuel supply and hydrogen sectors, and across the UK.

Wales

In December 2020 the Welsh Government commissioned a report on hydrogen that included baseline reporting on related activities and expertise, and a pathway for developing the sector.[28] The proposed pathway contains ten objectives covering both supply and use of hydrogen, including the establishment of at least one 10+ MW renewable production site and the deployment of 200 fuel cell buses. The Welsh Government consulted on the pathway earlier this year and following analysis of the responses it will finalise a pathway for hydrogen development over the second Welsh carbon budget period (2021-25).

Scotland

In December 2020, the Scottish Government published a Hydrogen Policy Statement which sets a vision for Scotland to become a leading Hydrogen Nation with an ambition to generate 5 GW of renewable and low-carbon hydrogen by 2030, committing to £100 million funding to accelerate the hydrogen economy in Scotland over the next five years.

The Hydrogen Policy Statement has provided the framework for the development of a Hydrogen Action Plan in 2021 which will provide further detail on the planned approach and necessary actions to implement the policy positions outlined in the Policy Statement. The Hydrogen Action Plan will be published later this year.

The Scottish Government has led the way in supporting world-leading hydrogen demonstration projects in Scotland that are helping to determine the role of hydrogen in Scotland's future energy system. This includes the provision of £7 million funded support towards the cost of a world first £28 million demonstration of an end-to-end 100% hydrogen energy system. The project will construct and operate a hydrogen heat network system in Fife able to service around 300 houses and will be of UK-wide significance to evidence the role that hydrogen can play in decarbonising heat, using the gas network.

Northern Ireland

A new Northern Ireland Energy Strategy is expected to be published by the end of 2021, with proposals on phasing out coal, solid fuels and heating oil alongside decarbonising our gas network, including the future injection of biomethane and potential hydrogen blending.

Northern Ireland is uniquely positioned to become a leader in the hydrogen economy and secure these benefits locally. This is already gathering momentum, with NI Water trialling an innovative new hydrogen electrolyser at its wastewater treatment works – the first such project of its kind across the UK. Translink, the public transport service provider in Northern Ireland, is also introducing three new hydrogen buses to its fleet and is procuring a new hydrogen fuelling station for these and an anticipated 20 more under a new contract. The GenComm project, led by Belfast Metropolitan College, will trial hydrogen production via electrolysis for hydrogen buses. They are also engaged with a range of potential complementary projects to build on this momentum and contribute to the growth of an indigenous hydrogen economy in Northern Ireland.

3iii. Industry

Stretching our ambition for net zero

Our Key Commitments

- Ambition to deliver 6 $MtCO_2$ per year of industrial CCUS by 2030, and 9 $MtCO_2$ per year by 2035.
- Set up the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme to fund our new industrial carbon capture and hydrogen business models.
- Support the deployment of CCUS through the £1 billion CCS Infrastructure Fund.
- Following Phase 1 of the Cluster Sequencing process, the Hynet and East Coast Clusters have been confirmed as Track 1 clusters.
- Support the installation of energy efficiency and on-site decarbonisation measures through the £315 million Industrial Energy Transformation Fund (IETF) (£289 million for England, Wales and Northern Ireland, £26 million for Scotland).
- Support the increased requirement for fuel switching to low carbon alternatives, with an ambition to replace around 50 TWh of fossil fuels per year by 2035.
- In collaboration with the Steel Council we will consider the implications of the recommendation of the Climate Change Committee to set targets for ore-based steelmaking to reach near-zero emissions by 2035, and the business environment necessary to support the transition.
- Develop several Resource and Energy Efficiency (REEE) measures with ambition of achieving the anticipated requirement of 11 $MtCO_2e$ worth of savings by 2035, including up to 3 $MtCO_2e$ of potential abatement in the Iron and Steel sector.
- Incentivise cost-effective abatement in industry at the pace and scale required to deliver net zero, through the UK ETS by consulting (in partnership with the Devolved Administrations) on a net zero consistent cap.
- Explore opportunities for faster decarbonisation of dispersed sites in the 2020s.

Progress to date

1. The UK's manufacturing and refining sector plays an essential role in society. It contributes £180 billion to the overall economy,[29] directly accounting for 8% of GDP[30] and provides 2.5 million direct jobs across the country[31] as well as over 5 million across the value chain.[32]

2. However, industry[33] is also a major source of CO_2 emissions, producing 15% (78 $MtCO_2e$)[34] of the UK's current total. Around half of industrial emissions are concentrated in specific clusters – geographical areas with large concentrations of industry.

3. Industry emissions have more than halved since 1990, due mainly to the changing structure of the UK's manufacturing sector, improved energy efficiency, and a shift to low carbon fuels. Despite this progress, the overall pace of reductions is slowing, and more action is needed to achieve our net zero commitments.

4. The *Industrial Decarbonisation Strategy* (IDS), published in March 2021, was the first of its kind in a major economy. It sets out how industry can decarbonise in line with net zero while transforming industrial regions by attracting inward investment, future-proofing businesses, and securing the long-term viability of jobs.

5. This followed previous work including the landmark *Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050*, published in 2015, which set out a series of pathways for emissions reductions for energy-intensive sectors.

6. We plan to have the world's first net zero industrial cluster by 2040, awarded grants from the £315 million Industrial Energy Transformation Fund (IETF), announced a £1 billion Carbon Capture and Storage Infrastructure Fund, and a £240 million Net Zero Hydrogen Fund. Additionally, as part of the Industrial Decarbonisation Challenge (IDC), we recently announced £171 million of funding, matched by over £200 million industry investment, for nine projects within five clusters.

7. Growing new industries in low carbon hydrogen alongside CCUS and renewable energy will put our industrial 'SuperPlaces' at the forefront of technological development. Together this will develop resilient supply chains, support jobs, and position UK companies at the forefront of an exciting growing global market, as well supporting industrial processes, industrial heat, power, shipping and trucking to make the shift to net zero.

8. Energy intensive industry in the UK has been covered by a cap-and-trade policy since 2005. The UK government and Devolved Administrations successfully launched the UK Emissions Trading Scheme (UK ETS) on 1 January 2021. The UK ETS cap, which sets the limit on emissions for sectors covered by it, will be aligned with a net zero consistent trajectory by January 2023, or January 2024 at the latest. In the coming months, we will be publishing a consultation on the level of the cap and other elements of UK ETS evolution.

9. We recognise the importance of addressing the risk of carbon leakage so policy interventions do not lead to increased emissions elsewhere, and to ensure that UK industry has the confidence needed to fully decarbonise. The IDS and the *Net Zero Review* set out the potential options available to address this, including regulatory standards and Carbon Border Adjustment Mechanisms (CBAMs), as well as the ongoing review of our current carbon leakage mitigation policy of free allowances under the UK ETS. Government will continue to explore options to mitigate carbon leakage, with emphasis on an international, multilateral effort to tackle carbon leakage at source through global action on industrial decarbonisation and climate regulation, with continued monitoring of related global policy developments.

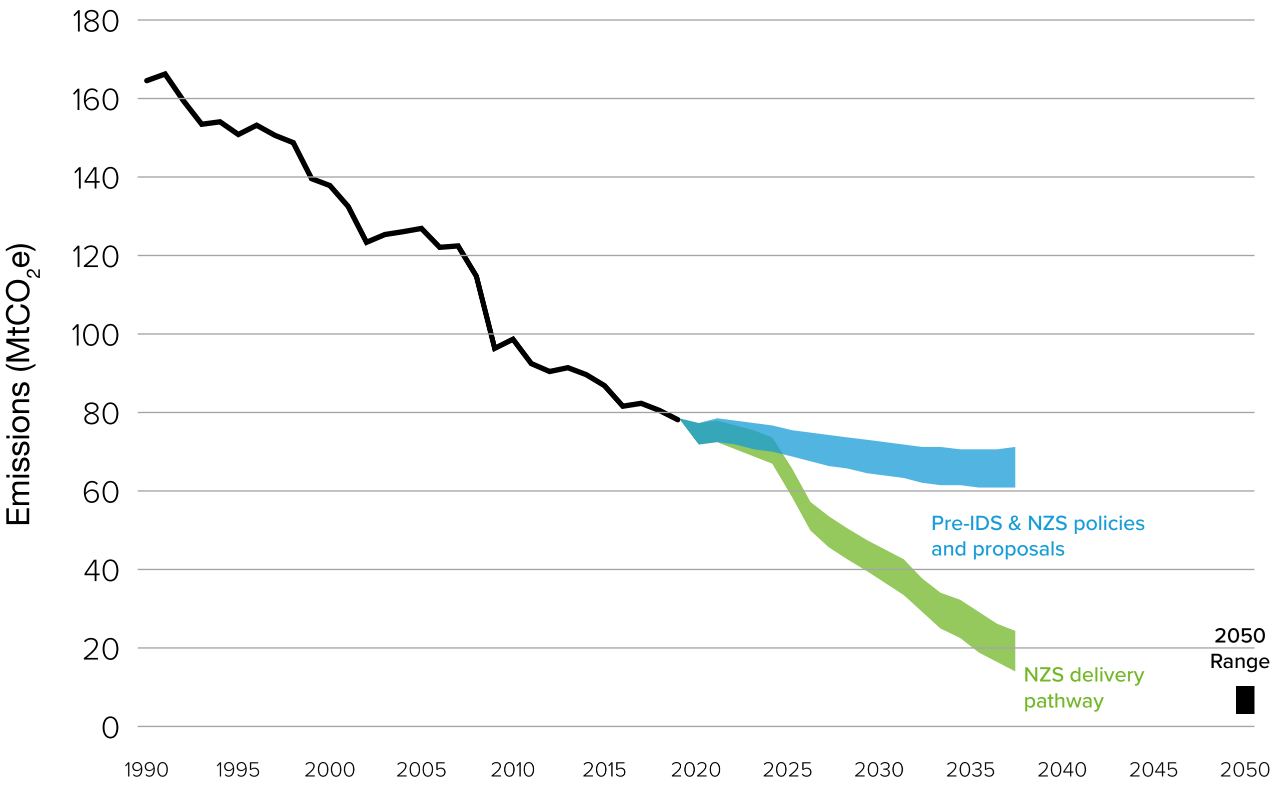
Net zero transition and economic opportunities

Our 2050 vision and how we get there

10. To stay on track for net zero, industrial emissions will need to fall significantly, with residual emissions being compensated for by Greenhouse Gas Removal methods. All industrial sectors will need to act to meet this challenge and to ensure they are resilient to climate changes that are already inevitable. To do this, we need to transform how industry uses energy and makes products and rethink the type of industrial products consumers buy.

11. Based on our whole system modelling, by 2050, emissions associated with industry could need to drop by 87-96% compared to 2019, down to 3-10 $MtCO_2e$. In the interim, to meet our NDC and Carbon Budget 6 targets, we expect emissions could fall by 43-53% by 2030 and 63-76% by 2035, compared to 2019 levels. These figures are based on an indicative industry pathway contributing to the whole-economy net zero and interim targets (see figure 19 below).

Figure 19: Indicative industry emissions pathway to 2037



Source: BEIS analysis

12. The IDS sets out the policy foundations to deliver net zero for industry, including immediate actions in the 2020s. The initial reduction target of around two thirds (67%) of industrial emissions by 2035 was informed by sector-specific modelling developed in conjunction with the CCC. Our new ambition of 63-76% is consistent with, and builds on, the pathways we set out in the IDS, but with, amongst other things, increased levels of fuel switching and iron and steel decarbonising in the 2020s and early 2030s.

13. Our Carbon Budget 6 delivery pathway aims to give long-term clarity to industry, going further than the IDS in several areas:

- **Going further and faster on fuel switching and carbon capture, utilisation and storage (CCUS).** These are critical for our overall pathway, requiring both infrastructure decisions and revenue support, via the IDHRS scheme. Modelling suggests fuel switching to low carbon alternatives could reach 50 Twh per year by 2035, along with an increase in capturing and storing industrial emissions, from 3 $MtCO_2$ per year to 6 $MtCO_2$ by 2030, and 9 $MtCO_2$ per year by 2035.

- **Working towards more resource and energy efficiency savings.** We anticipate the need for regulatory, fiscal, and wider measures targeted at industrial products and supply chains to achieve 11 $MtCO_2e$ worth of savings by 2035, including up to 3 $MtCO_2e$ of potential abatement in the iron and steel sector, as estimated by the Climate Change Committee.
- **Realising the benefits of demand-side measures and carbon pricing.** An increasing carbon price will help to incentivise action on decarbonisation by industry, whilst demand side measures, such as product labelling, regulatory standards, and changes to public and private procurement approaches, can play a key role in helping the development of the market, and mitigating the risk of carbon leakage.

Seizing new opportunities

14. To achieve the level of emissions reductions in the industry sector indicated by our delivery pathway to 2037, we will need additional public and private investment of at least £14 billion and significant operating expenditure from the expected increase in CCUS, hydrogen use and other fuel switching technology. Energy and resource efficiency will also play a key role in offsetting some of these costs.

15. Due to challenges faced by industry, such as the level of capital investment required to commercially scale essential low carbon technologies, it will be important to drive the decarbonisation of industry at a pace that allows technology to develop and companies, large and small, to adapt their working practices, and retrain their workforces.

16. Many industrial sectors also have low profit margins, so their ability to invest in some decarbonisation technologies is limited and has been exacerbated by the pandemic. Short-to-medium term capital funding and revenue support will therefore be required to overcome these investment hurdles, reduce the risk of carbon leakage, and stimulate long term private investment.

17. Decarbonising the industry sector will regenerate communities and open up new employment opportunities right around the UK. Based on current estimates, policies and proposals to reduce emissions in the industry sector could support up to 54,000 jobs in 2030. This figure is driven by CCUS, which could support up to 50,000 jobs in 2030[35], split across industry, power, and the transport and storage network.[36] In addition, the manufacture and installation of on-site energy efficiency and fuel switching measures to achieve a net zero pathway for industry could support up to 4,000 jobs in 2030.

18. We have the opportunity to future-proof industrial sectors and take advantage of future low carbon markets. This will include creating resilient supply chains that ensure we exploit our strengths and have diverse supply sources for critical goods, as well as supporting those areas that could be vulnerable to global shocks. The UK is already a world leader in new clean technology, as seen in our growing hydrogen and CCUS sectors, and we can develop new markets for low carbon goods and support further innovation. As highlighted in the IDS, wider environmental and air quality impacts will be kept under consideration, in line with evolving regulatory standards.

19. CCUS will be critical to achieving net zero, alongside low carbon alternatives such as low carbon hydrogen and electricity. These technologies offer a renewed era for our industrial heartlands. Connecting locally, for instance positioning hydrogen train trials near blue hydrogen clusters means we can start to bring higher skilled, higher paid jobs and expertise to cluster in these area. The engineers, fabricators, and geologists currently working in industrial clusters and the oil and gas sector will be able to make use of local skills programmes such as Skills Bootcamps or Free Courses for Jobs to support new emerging industries in renewables, CCUS, and low carbon hydrogen to help build SuperPlaces. As the demand pulls through these lower carbon technologies, the costs fall. And these industrial clusters, our potential 'SuperPlaces', will foster and lead internationally on the development and roll out of these technologies.

Policies and proposals

Fuel switching and carbon capture

Low carbon hydrogen

20. Fuel switching to hydrogen is likely to be technically feasible for most industrial processes and our modelling indicates it is the least-cost option to decarbonise harder to electrify sites, processes, and sectors.

21. The IDS sets out that a low regret level of deep decarbonisation infrastructure should be installed in industrial clusters this decade. This will give industry the confidence to invest in switching to low carbon fuels, such as hydrogen. Industrial users located in clusters are therefore expected to provide the most significant new demand for hydrogen by 2030, with the greatest potential from chemicals and iron and steel sectors. A significant proportion of this demand could arise from a small number of sites acting as 'pathfinders', proving the viability of hydrogen at a commercial scale and fostering the initial market for low carbon hydrogen.

22. The *UK Hydrogen Strategy* indicated that in 2030 consumption of low carbon hydrogen as an industry fuel could range from around 10 TWh per year if supply is limited to clusters, and up to around 20 TWh per year if pipelines are connected to some dispersed sites. While supply is likely to come mostly from large scale cluster-based CCUS-enabled hydrogen production sites, there could also be industrial demand for low carbon hydrogen from electrolysis, which can be produced at a smaller scale on a more localised level. To stay on track for our Carbon Budget 6 delivery pathway, hydrogen demand from industry may need to increase up to 50 TWh by 2035. This increase would be driven by a growing number of sites having access to low carbon hydrogen, further technology development to enable an expanding range of processes to switch to hydrogen, and a shift in the associated costs, such as the price of carbon, to make hydrogen an increasingly competitive fuel option.

23. The *UK Hydrogen Strategy* also set out the actions we are taking to support industry to realise the potential of this new technology. It is critical that we demonstrate fuel switching to low carbon hydrogen on industrial sites during the 2020s so we will provide further support for research and innovation through the Net Zero Innovation Portfolio and initiatives led by the Industrial Decarbonisation Research and Innovation Centre (IDRIC).

24. Demand-side measures and carbon pricing could help to drive demand for hydrogen and will be supported by grant funding, such as the £55 million Industrial Fuel Switching Competition under our Net Zero Innovation Portfolio and the Phase 2 of the IETF, to support on-site fuel switches. Regulatory measures can also support industry to switch to low carbon hydrogen, with the *Hydrogen Strategy* announcing calls for evidence on hydrogen-ready industrial equipment and decarbonising existing high carbon hydrogen production. Alongside this, hydrogen production measures in the *fuel supply* chapter of this strategy will bring forward low carbon hydrogen supply for use across the economy and help make hydrogen a price competitive decarbonisation option to encourage end users to switch.

Carbon capture, usage and storage (CCUS)

25. Carbon Capture, Usage & Storage (CCUS) will be an exciting new industry to capture the carbon we continue to emit and revitalise the birthplaces of the first Industrial Revolution. The Prime Minister's *Ten Point Plan* established a commitment to deploy CCUS in a minimum of two industrial clusters by the mid-2020s, and four by 2030 at the latest. Our aim is to use CCUS technology to capture and store 20-30MtCO2 per year by 2030, forming the foundations for future investment and potential export opportunities. Developed alongside hydrogen, we can create these transformative 'SuperPlaces' in areas such as the Humber, North East, North West and southern England, as well as in Scotland and Wales.

26. Developed alongside hydrogen, CCUS will be part of creating transformative "SuperPlaces" in areas such The Humber and North East, North West, and Southern England as well as in Scotland and Wales. Our £1 billion CCS Infrastructure Fund will provide industry with the certainty required to deploy CCUS at pace and at scale and will form part of a package of government support, which will also include the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme and the £240 million Net Zero Hydrogen Fund supporting both CCS-enabled 'blue' and electrolytic 'green' hydrogen.

27. Following the completion of Phase 1 of the Cluster Sequencing process, the Hynet and East Coast Clusters have been confirmed as track 1 clusters for the mid-2020s and will be taken forward into Track-1 negotiations. If the clusters represent value for money for the consumer and the taxpayer then subject to final decisions of Ministers, they will receive support under the government's CCUS Programme. We are also announcing the Scottish Cluster as a reserve cluster if a back-up is needed; we will continue to engage with this cluster as well as the track 1 clusters, throughout the next stage of the process. This puts these places - Teesside, the Humber, Merseyside, North Wales and the North East of Scotland - among the potential early SuperPlaces which will be transformed over the next decade.

28. We remain committed to helping all industrial clusters to decarbonise as we work to reach net zero emissions by 2050, and we are clear that CCUS will continue to play a key role in this process. Consequently, the government continues to be committed to Track-2 contributing capacity of 10Mt per year to help achieve our 2030 ambition. Deploying CCUS will be a significant undertaking, these are new major infrastructure projects for a new sector of the economy and carry with them significant risks to deliver by the mid-2020s.

Government will need to play a role in providing long-term certainty to these projects to manage these risks and bring forward the UK's first CCUS clusters.

29. CCUS will be critical to achieving net zero, alongside low carbon alternatives such as low carbon hydrogen and electricity. These technologies offer a renewed era for our industrial heartlands. Connecting locally, for instance positioning hydrogen train trials near blue hydrogen clusters means we start to bring higher skilled, higher paid jobs and expertise to cluster in these areas. The engineers, fabricators and geologists currently working in industrial clusters and the oil and gas sector will be able to make use of skills programmes such as Skills Bootcamps and Free Courses for Jobs to support new emerging industries in renewables, CCUS and low carbon hydrogen to help build SuperPlaces. As the demand pulls through these lower carbon technologies, the costs fall. And these industrial clusters, our potential SuperPlaces, foster and lead internationally on the development and roll out of these technologies.

30. Industrial CCUS is fundamental to decarbonising of industries such as chemicals, oil refining, and cement. This is because options for decarbonising industry are limited and fuel switching is sometimes only a partial solution. CCUS is not currently investable for most industrial sectors as deployment costs are higher than the current carbon price can support, and businesses are unable to pass these through to consumers. Additionally, businesses may face challenges raising capital finance to invest in CCUS until it has been more widely deployed in the UK. Therefore, an investable business model is needed, alongside clear commitments to provide certainty to industry.

31. The IDS set out the ambition to capture 3 $MtCO_2$ per year by 2030. Our delivery pathway for Carbon Budget 6 requires an increased ambition of 6 $MtCO_2$ per year by 2030 and 9 $MtCO_2$ per year by 2035. We envisage these emissions to be captured from industries in clusters as well as from more dispersed sites, where non-pipeline transport solutions such as the shipping of CO_2 may be required.

Revenue support for industrial carbon capture and hydrogen production

32. CCUS and hydrogen deployment will play a central role in our green industrial revolution and ensuring that the UK's businesses are competitive in a net zero future. We have been working with industry to develop business models for industrial carbon capture and hydrogen production to give investors the long-term revenue certainty they require. We are now setting up the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme to fund these business models and enable the first commercial scale deployment of low carbon hydrogen and industrial carbon capture. This will unlock by 2030 up to £6bn private sector capital, create thousands of jobs in key levelling up regions, grow the UK supply chain and achieve cost reductions, and deliver carbon savings to allow us to stay on track for our carbon budgets.

33. The IDHRS scheme will initially commit to providing up to £100 million to support initial electrolytic hydrogen projects, as set out in the Fuel Supply chapter. We will also be announcing a funding envelope in 2022 that will enable us to award the first contacts to industrial carbon capture facilities and CCUS-enabled hydrogen production projects from 2023 through the Cluster Sequencing process, to deliver up to 3 MtCO2/yr of industrial carbon capture and up to 1GW of CCUS-enabled hydrogen by the mid-2020s.

34. Subject to costs falling, we are also committing to further allocation rounds for all types of eligible low carbon hydrogen production and industrial carbon capture from 2025. We will announce further allocation rounds in due course which will enable us to meet our 2030 deployment ambitions of 6MtCO2/year of industrial carbon capture, 5 GW hydrogen production capacity, and four CCUS clusters, while continuing to grow the UK supply chain and achieve cost reductions. Once established, this framework could also be used in the future for other critical decarbonisation technologies.

35. From 2025 at the latest, all revenue support for hydrogen production will be levy funded, subject to consultation and legislation being in place. Further details on this will be set out in 2022 through the Government's response to the ongoing Hydrogen Business Model consultation. This will include parallel work to ensure fairness and affordability, such as exemptions for energy intensive industries at risk of carbon leakage.

Electrification

36. Electrification has the potential to abate between 5 $MtCO_2e$ and 12 $MtCO_2e$ of industry emissions per year by 2050. Electrification will play a more significant role (12 $MtCO_2e$) if hydrogen is unavailable in dispersed sites. This equates to an increase demand of electricity by 15-44 TWh. Additional electricity demand is consistent under our delivery pathway for Carbon Budget 6, albeit the demand comes at a faster pace due to the possible adoption of electrification in the iron and steel sector.

37. Electrification technologies for low temperature processes are technologically mature and could be applied to less energy intensive sites today. However, industry faces barriers to adoption such as high electricity costs. We have seen the impact of overreliance on gas pushing up prices for hardworking people but our plan to expand our domestic renewables will push down electricity wholesale prices. Applications for higher temperature processes are currently limited due to the low maturity of technologies. We are currently assessing these barriers and will set out initial steps that we will take to support the uptake of electrification by the end of 2021. Some initial grant funding support will be available via Phase 2 of the IETF from Autumn 2021. We are also working with Ofgem, network operators, and stakeholders on the approach to delivering low carbon electricity networks with the capacity to meet increased demand from industry.

Biomass

38. Initial support for sustainable use of biomass fuel switching and BECCS is available via Phase 2 of IETF. As set out in the IDS, current evidence strongly suggests that given limited sustainable biomass supply, we may need to prioritise the use of biomass where it can be combined with carbon capture and storage (BECCS), resulting in negative emissions. The Biomass Strategy, due to be published in 2022 will review the amount of sustainable biomass available to the UK, how this could be best used across the economy, and establish a role for BECCS in reducing carbon emissions across the economy.

Industrial non-road mobile machinery (NRMM)

39. NRMM covers a wide variety of machinery across the economy (e.g. diggers, combine harvesters, generators, cranes), with total emissions of around 12 $MtCO_2e$ per year. Industrial NRMM accounts for around 6 $MtCO_2e$,[37] coming from construction, mining, and manufacturing, with the remaining emissions largely attributed to agriculture (see *Natural Resources* chapter), and some to buildings and transport. New technologies have begun to penetrate markets for some NRMM uses, for example electrification technologies, particularly for small, light duty equipment. Government intervention is likely to be necessary to ensure low carbon technologies continue to be developed and ensure uptake at the level needed to reach carbon budgets and net zero.

40. The first stage in government support will involve innovation funding to prepare key low carbon technologies for commercialisation. The £40 million Red Diesel Replacement competition will provide grant funding to develop and demonstrate low carbon alternatives to red diesel for the construction and mining and quarrying sectors, to help these sectors to decarbonise.

41. Further cross government work is required to develop policies to support the deployment of technological solutions and required infrastructure in specific sectors, including agriculture, transport and buildings. Relevant government departments will work together to ensure a coherent approach.

Steel

42. UK steel plays a critical role in the economy as a foundation industry supporting local economic growth and our levelling-up agenda. Steel employs around 32,500 people and supports up to a further 40,000 jobs through its supply chains, providing high value employment in economically deprived areas.[38] The IDS contains commitments to work with the newly constituted Steel Council to consider the implications of the recommendation of the Climate Change Committee to ‘set targets for ore-based steelmaking to reach near-zero emissions by 2035’. Hydrogen-based steelmaking, CCUS and electrification are some of the technological approaches being considered as part of this process.

43. The Steel Council offers the forum for government, industry, and trade unions to work in partnership on the shared objective of creating an achievable, long-term plan to support the sector’s transition to a competitive, sustainable, and low carbon future.

44. Steel accounts for 14% of industry emissions,[39] with 95% of this coming from two blast furnace sites, Scunthorpe, and Port Talbot.[40] Decarbonising these sites and the wider steel sector through switching to Electric Arc Furnace applying industrial carbon capture technology to existing blast furnaces or in the future using hydrogen-based DRI.

45. The UK recognises the importance of coordinating international activity on steel sector decarbonisation, to reduce the costs and risks of unilateral action. This includes working with international partners to collaborate on measures to mitigate carbon leakage, increase the effectiveness of R&D spending, and create larger, international markets for low emission steel products. The UK is taking a leading role in driving forward this activity, championing a number of key initiatives in this area at COP26, and beyond. This includes the Clean Energy Ministerial’s Industrial Deep Decarbonisation Initiative, which the UK co-leads with India. This focuses on aligning approaches to data measurement, standards and procurement, to ensure there is a coordinated approach to market creation across borders. We are also supporting the Net Zero Industry Mission, under Mission Innovation, which aims to foster deeper collaboration on industry decarbonisation.

Resource efficiency and energy efficiency (REEE)

46. The Climate Change Committee estimate that REEE measures could contribute 11 $MtCO_2e$ of annual emissions reductions by 2035.[41] Various policies exist to incentivise and regulate action on REEE, but we need to ensure the right frameworks are in place to end clear investment signals and drive rapid action.

Resource efficiency

47. Resource efficiency and material substitution measures could save 9 $MtCO_2e$ per annum in industry within the UK by 2050.[42] Resource efficiency measures reduce emissions from industrial processes by keeping products and materials in circulation for longer by way of reuse, repair, remanufacture and recycling as well as reducing material usage. These activities enable the retention of value, and in some cases the creation of new value for both the producer and customer, at a much-reduced environmental impact.

48. The approach in driving the transition to a more resource efficient economy is set out for England in the Government's 2018 *Resources and Waste Strategy*, to be supplemented by a new Waste Prevention Programme, which outlines how we will maximise the value of our resources and minimise waste to increase the circularity of our economy. We will formalise joint working arrangements across government departments to promote collaboration on resource efficiency approaches, ensuring we are using all the policy tools available in working towards shared emissions and environmental targets.

49. The Climate Change Committee (CCC) balanced pathway estimates that 3 $MtCO_2e$ of potential savings per year could be driven by consumer-side measures by 2035. Government aims to support this shift in the 2020s through policy measures that inform consumers of the embodied carbon of industrial goods and empower them to make choices that support more efficient use of resources. Measures across different sectors will be explored, but opportunities have been identified in the construction, automotive and electronics sectors.

50. Government aims to support action in the construction sector by improving reporting on embodied carbon in buildings and infrastructure with a view to exploring a maximum level for new builds in the future. We recognise there is potential to reduce embodied carbon by way of material substitution where appropriate, such as in timber usage (see *Natural Resources, Waste and F-gases* chapter) and resource efficiency approaches, amongst others. We have also supported the Green Construction Board to produce a *Routemap to Zero Avoidable Waste*, published in July 2021.

51. Government is identifying opportunities to reduce the substantial embodied carbon footprint of the automotive sector, beyond the reduction and then elimination of emissions at the tailpipe.

52. We are building on the successful introduction this year of the first wave of right to repair measures for certain appliances and equipment. Alongside the review of Waste from Electrical and Electronic Equipment (WEEE), we will explore the use of labels that inform consumers of durability, repairability and recyclability. Other options under consideration include enhancing and extending producer responsibility schemes to incentivise sharing and renting.

53. To realise the wider emissions saving potential of resource efficiency measures will require establishing frameworks which minimise virgin resource use and maximise recycled, reused, or remanufactured content. We will continue to assess all, fiscal and non-fiscal, policy options to meet these objectives.

54. Knowledge can be a barrier preventing the value in waste resources from being realised, including the sharing of secondary resources across different industrial processes. We will support companies to identify these Industrial Symbiosis opportunities through facilitation of a cross sector network to boost take-up of circular economy initiatives. We will support inter-disciplinary approaches and strengthen the evidence base on resource efficiency initiatives by collaborating with the UKRI funded National Interdisciplinary Circular Economy Research (NICER) programme, and through the development of data systems to connect energy, waste, and water flows from industrial sites.

Energy efficiency

55. Energy efficiency measures in industry range from simple, bill-saving measures to complex retrofits of industrial equipment with long payback periods and replacement cycles. We intend to explore regulatory measures to drive greater, earlier uptake of energy efficiency measures in line with Carbon Budget targets, supported by a wider package of policies to enable a smooth industry transition. We intend to consult on the development of a package of measures.

56. The heterogeneity of manufacturing industry means that processes are very varied, so codifying them for regulation across the whole sector may be challenging. We are currently exploring potential new regulatory options to address this challenge. This includes consideration of whether Energy Management Systems can provide a tailored, technology-neutral approach, and we would seek to minimise burdens imposed by regulation, possibly by using digital tools.

57. Energy intensive industry (EII) firms are already covered by energy efficiency regulations and many have adopted efficiency measures. We are examining how existing schemes can be enhanced (e.g. reforming Climate Change Agreements) and/or expanded (e.g. to non-EIIs and SMEs). For non-EIIs and SMEs, we are reviewing existing policies to ensure financial support is accessible and minimum standards are clear.

58. For smaller businesses, behaviours (awareness, prioritisation, maintenance) are often a further barrier to improving energy efficiency and we are considering new policies to respond to these barriers. Building on behavioural insights approaches in other areas of government policy, we are keen to explore how local networks – such as growth hubs, Local Enterprise Partnerships (LEPs), the local net zero hubs, and chambers of commerce – can be used to drive energy-efficient behaviours amongst businesses. We will consider which levers could work best to support, interconnect and scale-up these networks.

59. Funding for complex industrial retrofits with high payback periods will remain available via the IETF Phase 2 from Autumn 2021. These would be further supported by any future extension to the IETF, reflecting the government's manifesto commitment to increase funding to £500 million to 2028. Work will be undertaken to ensure sustainable financing measures are available long-term.

Demand-side measures

60. The IDS sets out our ambition to create demand for low carbon products, growing the associated market and supporting industry to share the costs of decarbonisation with consumers.

61. The IDS committed to exploring a range of policy options that can support this ambition including improved transparency of embodied emissions data, product labelling, regulatory standards, and agreeing public and private procurement approaches. The government has committed to developing detailed policy proposals in this area, beginning with a call for evidence on demand-side policy by Spring 2022. The call for evidence will investigate how we can define low carbon products and the emissions reporting that will be required to support those definitions. It will also explore the design of demand-side policy levers, with a view to the potential introduction of voluntary standards and labelling as early as 2025, and regulatory standards being introduced in the late 2020s.

62. Across these approaches, the IDS recognises the significant benefits which can be achieved through international cooperation, and the UK is leading the new Clean Energy Ministerial Industrial Deep Decarbonisation Initiative (IDDI), which aims to develop shared approaches to embodied emissions reporting and definitions for green steel and cement to drive public and private procurement.

Dispersed sites

63. Dispersed sites[43] account for approximately half of the UK's industrial emissions[44], and therefore form a major part of industry's pathway to net zero. These sites are highly diverse in terms of location, sectors, and industrial processes, ranging from energy-intensive processes such as clinker production in cement to less energy-intensive processes like pasteurisation in food and drink manufacturing.

64. The IDS indicated that emissions reductions in the early 2020s would focus on energy efficiency. Deeper decarbonisation potential is expected to be reached in the 2030s onwards, when uptake of low carbon technologies in dispersed sites is expected to be rapid.

65. Whilst the broad trajectory on decarbonising dispersed sites remains valid, the more ambitious Carbon Budget 6 targets mean we will explore opportunities for faster decarbonisation in dispersed sites in the 2020s. Going further on dispersed sites in the 2020s could help industry avoid technological lock-in through offering decarbonisation opportunities to align with investment cycles; and spread the benefits of green technologies beyond the clusters, supporting the levelling up agenda.

66. To achieve this, we intend to advance work in the following main areas:

- **Accelerated decarbonisation across dispersed sites:** We will investigate the potential for securing earlier emissions savings from segments of emissions where the technological pathway is more straightforward, or where economies of scale can be developed. This could include areas such as heat pumps for low temperature processes, and electrification of off-gas grid sites.
- **Preparing sites for key infrastructure decisions in the mid-2020s:** For most sites, more clarity on optimal decarbonisation options depends on key infrastructure decisions, such as the future of hydrogen in the gas grid by 2026. We will work with stakeholders to ensure that these sites understand their decarbonisation options once these decisions have been made. This would include funding for Mini-Cluster Industrial Decarbonisation Plans in the early 2020s, to develop shared infrastructure and intergrated decarbonisation solutions in local areas. This would be supplemented by continued funding via Phase 2 of the IETF for site-level studies and deployment.[45]

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government, and Northern Ireland Executive

Wales

A collaboration between researchers at Swansea University and cement producer Hanson UK has seen the installation of a new demonstration unit at the company's Regen Ground Granulated Blast Furnace Slag (GGBS) plant in Port Talbot. The demonstration unit replaces some of the natural gas in the Regen process with green hydrogen. The carbon footprint of Regen GGBS is about one tenth of Portland cement and it is used as a replacement for up to 80% of the cement in concrete. The project is part of the £9.2 million Reducing Industrial Carbon Emissions (RICE) project which has been part-funded by the European Regional Development Fund through the Welsh Government.

Scotland

The Scottish Government has announced a major fund to decarbonise industry and manufacturing opening opportunities to develop negative emissions technologies (NETs). The Scottish Industrial Energy Transformation Fund commits £34 million for projects at industrial sites for energy efficiency or deeper decarbonisation, including on feasibility and conceptual studies into the role of NETs.This is supported by a £180 million Emerging Energy Technologies fund to support Hydrogen, CCS and NETs projects.

The Scottish Government has also launched the Grangemouth Future Industry Board in recognition of the continued commitment to Scotland's largest industrial manufacturing cluster, now and in our net zero future. Supporting a just transition to net zero is at the heart of the Board's work, designing the collaborative approach to planning for the transition of this core manufacturing region and harnessing the significant assets, technical and engineering,, skills, and significant opportunities presented by the cluster.

Northern Ireland

Invest Northern Ireland delivers a suite of support, including specialist advice and investment capital to enable Northern Irish businesses to become more efficient and resilient through green efficiencies. Support includes:

- Technical Consultancy: Available to all businesses with an annual energy and resource spend above £30,000, this support includes fully funded technical audits, feasibility studies and advice to help businesses identify cost and carbon savings.
- Resource Matching through Industrial Symbiosis: fully funded support that offers opportunities to convert redundant materials of one business into a resource for another business, utilising a circular economy approach to add value and to reduce costs and carbon for all parties.
- Resource Efficiency Capital Grant: Available to eligible businesses, grants of up to £50,000 to help with the purchase of new resource efficient technologies that reduce the consumption of water, raw materials and waste produced leading to reduced carbon emissions.
- COVID-19 Energy Efficiency Capital Grant: Available to eligible businesses to build resilience through green efficiency, grants of up to £80,000 are available for the installation of energy efficiency equipment that offers cost and carbon savings through the reduction of energy consumption.

3iv. Heat & Buildings

Decarbonising the way we heat and power our buildings

Our Key Commitments

- Levelling up through supporting 175,000 green skilled jobs by 2030 and 240,000 by 2035 – resulting in £6 billion additional GVA by 2030 and with a focus on the areas that need investment most.
- Making the transition to low carbon buildings affordable and achievable for all by:
    - Aiming to phase out the installation of new and replacement natural gas boilers by 2035 in line with the natural replacement cycle, and once costs of low carbon alternatives have come down, including any hydrogen-ready boilers in areas not converting to hydrogen, to ensure that all heating systems used in 2050 are compatible with net zero.
    - Making heat pumps as cheap to buy and run as a gas boiler by growing the heat pump market to support 600,000 installations per year by 2028 and expanding UK manufacturing – with the ambition of working with industry to reduce costs by at least 25-50% by 2025 and to parity with gas boilers by 2030 at the latest.
    - Supporting households in making this transition with a new £450 million Boiler Upgrade Scheme providing £5,000 capital grants and a new market-based incentive for heating system manufacturers, whilst investing £60 million in heat pump innovation – making them beautiful, smaller, easier to install.
    - Consulting on phasing out the dirtiest and most expensive fossil fuels first - new oil, coal and liquefied petroleum gas heating - and replace with low carbon alternatives in non-domestic buildings from 2024 and homes from 2026, following natural appliance replacement cycles.
    - Committing to action on addressing distortions in fuel prices to ensure that low carbon technologies are no more expensive to run than fossil fuel boilers.
- Helping households and businesses reduce their energy bills while making buildings healthier and more comfortable benefiting from warmer, comfier, more valuable buildings through:
    - Upgrading fuel poor homes to EPC Band C by 2030 where reasonably practicable and providing additional funding to the Home Upgrade Grant and the Social Housing Decarbonisation Fund – investing £1.75 billion.

  - Consulting on phasing in higher minimum performance standards to ensure all homes meet EPC Band C by 2035, where cost-effective, practical and affordable.
  - Setting long-term regulatory standards to upgrade Privately Rented Homes to EPC C by 2028 and considering setting a long-term regulatory standard for Social Housing, subject to consultation.
  - Reducing the energy consumption in commercial and industrial buildings in England and Wales by 2030, using measures including regulations and a performance-based measurement scheme.
  - Investing a further £1.425 billion in the Public Sector Decarbonisation Scheme, with the aim of reducing direct emissions from public sector buildings by 75% by 2037.
  - Setting a minimum energy efficiency standard of EPC Band B by 2030 for privately rented commercial buildings in England and Wales.
- Establishing large scale trials of hydrogen for heating to take decisions in 2026 on the role of hydrogen in decarbonising heating, and consult on the case for enabling or requiring hydrogen-ready boilers and broader heating system efficiencies.
- Continuing to grow and decarbonise the UK Heat Network market through the £338 million Heat Network Transformation Programme of which at least £270m will go towards the Green Heat Network Fund, introducing sector regulation and new heat network zones by 2025.
- Launching a new world-class policy framework for energy-related products to ensure products use less energy, reducing emissions and household bills.

Progress to date

1. The UK has around 30 million buildings[46] and includes some of the oldest building stock in Europe.[47] In total, buildings are responsible for around 17% of our national emissions.[48] Currently, 1.7 million fossil fuel heating systems are installed per year (gas, oil, and coal).[49] The vast majority of emissions from buildings result from heating. Including indirect emissions (e.g. from electricity generation) emissions from heating buildings make up around 78% of all buildings emissions and about 21% of all UK emissions.[50] Overall, between 1990 and 2019, net UK greenhouse gas emissions from heat and buildings decreased by 17%.

2. The package of measures presented here, and in our *Heat and Buildings Strategy* (HBS) and associated consultations, delivers on commitments made in the *Ten Point Plan* for a *Green Industrial Revolution* and the *Energy White Paper*. In the *Ten Point Plan*, we committed to deliver greener buildings. Since then, we have announced £60 million to support decarbonisation of Social Housing and have allocated over £1 billion from the Public Sector Decarbonisation Scheme, in doing so, supporting up to 30,000 jobs.

3. Homes: The UK already has a strong track record improving energy performance, with 40% of our homes now above Energy Performance (EPC) Band C, up from just 9% in 2008. There are approximately 28 million households in the UK,[51] and 86% of homes in England use natural gas boilers.[52] Across the UK, 9% of the energy consumed to heat homes is provided by other fossil fuels, such as oil and coal, generally in homes that do not have access to the gas grid.[53] In 2019, approximately 15 million (60%) of homes in England had a lower energy performance, with ratings of EPC band D and below.[54] The largest proportion of homes in England are owner-occupied (64% in 2019), with a much smaller proportion being socially rented (17% in 2019), or privately rented (19% in 2019).[55] Owner-occupied homes are now the worst performing tenure, with the greatest proportion of homes below EPC band D.[56] Improving the energy performance of all homes and taking a 'fabric first' approach, by improving the energy efficiency will be key to ensuring the transition to low carbon heating is cost effective.[57]

4. Non-domestic buildings: There are approximately 1.7 million non-domestic (commercial, industrial and public) properties in England and Wales.[58] Non-domestic buildings account for around a quarter of UK building emissions.[59] Commercial and industrial buildings over 1,000 m^2 are responsible for over half of the energy used by commercial and industrial buildings (excluding process heat) but account for only 5% of the stock.[60] Public sector buildings account for about 9% of building emissions.[61]

Net zero transition and economic opportunities

5. By 2050, buildings will need to be almost completely decarbonised, by making use of a combination of technologies to minimise their carbon emissions and maximise their energy performance. The scale of this challenge is significant, but we will take an approach that goes with the grain of consumer behaviour and maximises consumer choice, to ensure a smooth and gradual transition for households and businesses. Much like the move to electric vehicles, the move to low carbon options such as electric heat pumps will be a gradual transition from niche product to mainstream consumer option. To ensure that we all benefit from cleaner, warmer and comfier buildings, will need to improve the energy efficiency of our buildings and products, end the use of fossil fuel heating systems and switch to low carbon sources, and integrate the use of smart technologies that give more control to consumers.

Seizing new opportunities

6. The decarbonisation trajectory of the sector presents significant potential for investment and export opportunities for goods and services. Deployment of energy efficiency measures and low carbon heating in domestic and non-domestic buildings, in line with the ambitions and outcomes in the Heat and Buildings Strategy, will drive up to £6 billion gross value added (GVA) per year by 2030.[62]

7. This will be investment not just in the buildings themselves, but in the infrastructure that supplies them. Government support will stimulate this investment and will need to be focussed on growing key markets for low carbon heat and supporting vulnerable and low-income households, the social housing sector, and the public sector.

8. Decarbonising the heat and buildings sector will regenerate communities and open up new employment opportunities right around the UK. Based on current estimates, policies and proposals to reduce emissions from buildings could support up to 100,000 jobs by the middle of the 2020s and up to 175,000 in 2030. Jobs will be supported across a range of areas – from manufacturing to services, and from installation to research and development.

9. Decarbonising buildings will deliver a range of benefits:

- **Levelling up**. Decarbonisation will support clean, local growth in every region of the UK, while investing in equality of living standards and job creation. Reducing heat and buildings emissions will require installing energy efficiency measures and new heating systems, which rely on local supply chains and businesses.
- **Reducing energy bills and business operating costs**. Inefficient homes are more expensive to run. The Energy Efficiency Infrastructure Group estimate that upgrading all UK homes to EPC band C could provide annual energy cost savings of £7.5 billion.[63]
- **Tackling fuel poverty**. In 2014, the Government introduced a statutory fuel poverty target for England, to improve as many fuel-poor homes as is reasonably practicable to a minimum EPC rating of band C by the end of 2030. Tangible, targeted support for more deprived areas can be achieved through action to upgrade poor-performing buildings, leading to warmer, healthier homes and lower energy bills. We recently published an updated fuel poverty strategy for England.[64]
- **Improving health**. COVID-19 has highlighted the importance of good ventilation in buildings. Improving the energy performance of our buildings, whilst ensuring good ventilation, will ensure they are efficient and healthy environments. This can help avoid many physical illnesses, including heart and lung conditions[65]. Reducing the number of fossil fuel boilers will also significantly reduce the various pollutants emitted, including nitrous oxides, which negatively impact human health. Improved thermal comfort also leads to better health and wellbeing as well as reducing the likelihood of condensation and mould.
- **Increasing property value**. Studies indicate that more energy efficient properties typically have a higher value than less efficient ones. Evidence from a study commissioned by BEIS indicated that properties with an EPC C rating were worth around 5% more than those currently at EPC D rating, after controlling for other factors such as property size and archetype.[66]

Our 2050 vision and how we get there

10. Our approach to this transition must be affordable and achievable for all and, following successes in power and electric vehicles, we will utilise long-term signals alongside early investments to bring down costs and improve consumer offers:

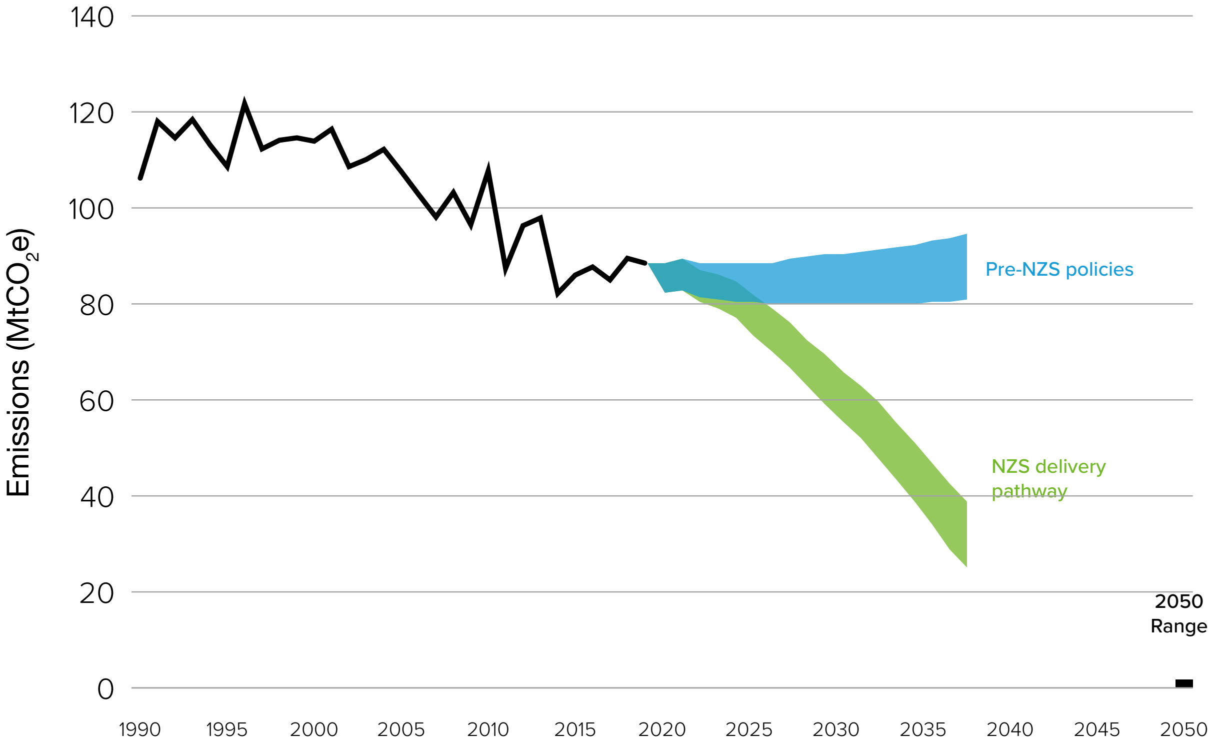
- **Investing in innovation**. Continuing to work with industry to refine processes and technologies to deliver value-for-money and value for the UK economy – with an emphasis on making technology cheaper, easier to install and designed to appeal to consumers. We are investing in technology now, in trialling hydrogen ahead of strategic decisions on the role of hydrogen for heating in 2026; and £60 million in heat pump innovation – making them beautiful, smaller and easier to install.

- **Prioritising no or low regrets actions**. Reducing bills through a fabric-first approach to improving building thermal efficiency through, for example, insulation, draught-proofing and increasing the energy performance and capability of products and appliances.[67]
- **Growing supply chains and bringing down costs**: Making heat pumps as cheap to buy and run as a gas boiler by growing the heat pump market to support 600,000 installations per year by 2028 and expanding UK manufacturing – reducing costs by at least 25-50% by 2025 and to parity with gas boilers by 2030. To help achieve this we are announcing a new £450 million Boiler Upgrade Scheme – offering households £5,000 grants when they install an air source heat pump.
- **Continuing to support those most in need**. Supporting the vulnerable through the transition to low carbon buildings and meeting our statutory fuel poverty target. We will continue to ensure financial support is available for those who need it most. We are investing a further £1.75 billion in funding for our Home Upgrade Grant and Social Housing Decarbonisation Fund schemes, which provide support for low-income households in installing energy efficiency and low carbon heating.
- **Balancing certainty and flexibility**. Providing stability for investment through clear long-term signals that work with the grain of the market and minimise impact on consumers. For example, aiming to phase out the installation of new and replacement natural gas boilers by 2035, in line with the natural replacement cycle and only once costs of low carbon alternatives have come down.
- **Ensuring buildings are resilient to the impacts of climate change**. Implementing measures to ensure homes and buildings are well ventilated and protected against rising temperatures.
- **Taking a whole-sector and whole-system approach**. Considering the heating system in the context of what is most appropriate for the whole building to minimise costs, as well as accounting for local suitability, environmental impacts, and air quality.

11. The benefits of more efficient, low carbon buildings for consumers are clear: smarter, better performing buildings, reduced energy bills and healthier, more comfortable environments. Households and businesses will need to play their part in decarbonising their buildings, but we need to ensure that the costs of doing so fall fairly across society.

12. Based on our whole-system modelling, by 2050, emissions associated with heat and buildings could need to drop by 98-100% compared to 2019, down to 0-2 space between digit and unit $MtCO_2e$. In the interim, to meet our NDC and CB6 targets, we expect emissions could fall by 25-37% by 2030 and 47-62% by 2035, compared to 2019 levels. These figures are based on an indicative heat and buildings pathway contributing to the whole-economy net zero and interim targets (see figure 20 below).

Figure 20: Indicative heat and buildings emissions pathway to 2037



Source: BEIS analysis

13. We have developed **three high-level illustrative scenarios to reflect different technology mixes** that would allow us to decarbonise heating of buildings, contributing towards meeting our Carbon Budget 6 target. We are committed to taking strategic decisions on the role of hydrogen for heating in 2026, following trials, which will further inform out pathway to 2050. Realising these scenarios would be consistent with our trajectory to net zero in 2050. These are: a high hydrogen scenario, a high electrification scenario and a dual energy system scenario.

14. In all scenarios the following will be important:

- Improving the energy performance of buildings to keep buildings warm and comfortable, keep bills down, minimise the impacts of transition on the energy system, and make switching to low carbon heating easier.
- Phase out of heating appliances that are only capable of burning fossil fuels, consistent with our ambition to phase out the installation of new and replacement natural gas boilers by 2035, and phase out the installation of high-carbon fossil fuel boilers in properties not connected to the gas grid by 2026 (and 2024 for non-domestic buildings).

- Heat pumps: these will be the best low carbon heating option for some types of buildings, for example, if they are new buildings or off the gas grid. We have set a target of 600,000 heat pump installations per year by 2028, from roughly 35,000 currently. We expect this to be the minimum number of heat pumps that need to be deployed each year after 2028 across any scenario, and all scenarios other than high hydrogen will require much higher deployment. Of the 600,000 heat pumps per year, we expect about 200,000 to be in new build properties.
- Heat networks: they use hot water in pipes to deliver heating (and in some cases cold water for cooling) to many consumers from a centralised heat source. Heat networks could supply up to 20% of UK heat demand by 2050, up from 3% of UK heat supply today.[68]

15. To achieve the level of emissions reductions in the heat and buildings sector indicated by our delivery pathway to 2037, we will need additional public and private investment of approximately £200 billion.

High electrification scenario

16. In this scenario, we assume there is no significant use of hydrogen for heating in buildings. This may be because hydrogen is not proven to be feasible, cost-effective, or preferable as a solution for low carbon heating, or because its deployment has been significantly delayed. In this scenario, we would need to continue the rapid growth of the heat pump market beyond 600,000 per year in 2028 to up to 1.9 million per year from 2035, resulting in roughly 13 million homes using low carbon heating systems by 2035 – around 11 million with heat pumps and around 2 million using heat networks.

17. To ensure we drive this level of heat pump deployment, further policy would be required to phase out installation of new fossil fuel heating faster. We could grow the heat pump market and transition consumers in stages, while continuing to follow natural replacement cycles to work with the grain of consumer behaviour. For homes, we could focus initially on key segments of the domestic building stock, for example based on tenure, property age or fabric efficiency.

18. The increased deployment of heat pumps will be accompanied by investment in the infrastructure we need to meet increased electricity demand, including the generation of low carbon electricity and additional grid capacity.

High hydrogen scenario

19. In this scenario, hydrogen has proven feasible and preferable as a solution for heating most UK buildings, and decisions taken in 2026 set the UK on a path to converting most of the national gas grid to hydrogen. We would expect to begin the transition by converting a pilot hydrogen town by the end of the decade and then accelerate rollout. The conversion would likely start by building out from existing hydrogen production and use in industrial clusters, and roll-out would involve switchover on an area-by-area basis in different locations.

20. Due to the infrastructure and supply chain requirements of a hydrogen conversion we estimate that in this scenario, we would convert around 4 million homes to using low carbon hydrogen by 2035. New heating system installations should be low carbon or hydrogen-ready, meaning ready for a planned future conversion, from 2035. We estimate that by 2035 roughly 13 million homes will have low carbon heating, comprising around 7 million with heat pumps, 4 million using hydrogen, and around 2 million homes using heat networks.

Dual energy system scenarios

21. In this scenario, both hydrogen and electrification prove feasible and preferable as heating solutions to large numbers of consumers. This could arise in several forms:

- All or most of the gas grid is converted to low carbon hydrogen, but the costs and benefits of switching to hydrogen versus installing a heat pump are viewed differently by different consumers. This could result in a high switchover to both hydrogen and heat pumps on the gas grid.
- There is partial but still extensive conversion of the gas grid to hydrogen, based on differing geographical or built environment factors. This would require careful consideration of which parts of the grid would be converted and where responsibility for decisions about the costs and benefits of converting different areas should lie.
- There is widespread consumer demand for hybrid systems that utilise a mix of energy sources.

22. It is too early to determine the policy framework that might support this mixed transition. Any scenario in which hydrogen is an available option for consumers will require public policy decisions to enable cost-effective and co-ordinated investment in infrastructure and supply chains, and ensure consumer choice and other public interests are protected. If the case for converting the network to hydrogen differs strongly from area to area, more of the preparation may need to take place at a regional or local level.

Future scenarios - what factors we are going to consider in making decisions for mass decarbonisation of heating

Over the 2020s, we will need to start taking more decisive steps about which technologies and infrastructure should be rolled out, where and when, and accordingly, where we need to target investment, skills, and other enabling actions. We aim to make decisions about the role of hydrogen in heating by 2026, and commit to reviewing existing institutional arrangements, as stated in our Heat and Buildings Strategy, helping ensure that we have an appropriate framework in place to facilitate decision making at all levels.

Upfront costs

The cost of installing a heat pump is currently significantly more expensive than gas boilers and installation often requires additional ancillary works, such as upgrading radiators. This can result in total installed costs of around £10,000 for the average home. However, the cost of installing heat pumps should fall significantly as the market scales up, and the Heat and Buildings Strategy has set ambitions on reducing the installed cost of heat pumps over this decade. We are also providing subsidy for first movers: through the Boiler Upgrade Scheme, which will provide grants of £5,000 towards the cost of installing an air source heat pump and £6,000 for Ground Source Heat Pumps. We will look to help the market drive down the upfront costs, which leading market participants believe can make heat pumps as cheap to buy and run as a gas boiler by 2030. This ambition reflects the opportunity for innovation and economies of scale across the value chain and has been seen in other technologies such as solar PV, wind and electric vehicles. Conversely, it is likely hydrogen appliances will cost approximately the same as natural gas appliances (around £3k).

Running costs

Heat pumps are significantly (2.5 – 3x) more efficient than gas boilers and may get even more efficient, therefore requiring much less energy to run. Currently, on average heating a home with a heat pump costs more than with a gas boiler. This is, in part, due to policy and social costs charged on electricity bills. However, by addressing existing distortions between electricity and gas prices, we will ensure heat pumps will be no more expensive to run than gas boilers.

It is too early to properly estimate the running costs of hydrogen heating. The cost of producing hydrogen is currently higher than fossil fuels. Though the future production costs of hydrogen will not be the same as the ultimate cost to consumers, using hydrogen for heating could cost more than natural gas heating. There remains uncertainty on other issues that will impact on hydrogen costs, such as, new and innovative means of production, the cost to store it, new and innovative business models, and the cost of any changes to the gas grid that may be required.

Consumer journey

Heat pumps, unlike most traditional fossil fuel boilers, tend to work by providing an ambient temperature, rather than short blasts through very hot radiators. Evaluation and research have shown that the majority of consumers are happy with the performance of their systems, and smart controls help consumers with this change. Installing heat pumps at the same time as carrying out building energy efficiency and heating system improvements allows for a single intervention and could prove more efficient for many households or businesses.

Hydrogen boilers will likely work in a similar way to gas boilers. Some adaptive measures might be needed to enable hydrogen, but requirements for this and associated costs are still uncertain and could vary significantly between different types of buildings. When switching over to hydrogen, the initial grid conversion process is likely to require streets or areas to be converted at the same time. It is expected that an engineer will need to have access to homes to do the changeover in a particular timeframe, and building residents are unlikely to have control over when this happens.

Policies and proposals

Decarbonising heat

23. Much like the move to electric vehicles, the move to heat pumps will be a gradual transition from niche product to mainstream consumer option. Our core commitment is that we will aim to phase out the installation of new and replacement natural gas boilers in homes and buildings by 2035 at the latest, once costs have come down. This would be in line with the natural replacement cycle, and include hydrogen ready boilers in any areas not converting to hydrogen, to ensure all heating systems used in 2050 are compatible with net zero.

24. Accelerating heat pump deployment. We will grow the UK heat pump market to support 600,000 installations per year by 2028. As part of this, and working with industry to do so, we will aim for cost parity between heat pumps and gas boilers by 2030 with significant cost reductions of at least 25-50% by 2025. To achieve this, we will introduce a range of new policies to support heat pump deployment, including a new £450 million Boiler Upgrade Scheme over 2022/23 to 2024/25 with grants of £5,000 for an air source heat pump. In addition, we will consult on phasing out the installation of new oil, coal, and LPG heating, and replace with low carbon alternatives such as heat pumps in off gas grid non-domestic buildings from 2024 and homes from 2026, and we will launch a new market-based incentive for heating system manufacturers, similar to that for CO_2 in cars. Subject to strategic decisions on the pathways and market conditions, we would look to grow the heat pump market beyond 600,000 per year in 2028 and potentially up to 1.7 million a year by 2035, and we will consult on our proposed approach to doing this.

25. We are investing £60 million in a 'Heat Pump Ready' Programme which will support the development of innovative solutions to improve deployment, tools and technologies across the heat pump sector. These new opportunities will build on our previous Energy Innovation Programme activities, such as the Electrification of Heat Demonstration Project.

26. Heat networks. Under the £338 million Heat Network Transformation Programme, we will launch the £270 million Green Heat Network Fund to grow the market for low carbon heat networks. We will also pass new legislation to regulate the sector for consumers, give heat networks the statutory powers they need to build, and regulate the carbon emissions of projects from the early 2030s. We will also deliver new heat networks zones in England by 2025 where heat networks are the default solution for decarbonising heating. Finally, we will work with industry to increase the capacity and capability of the UK supply chain to support the sector to reach its growth potential and look to improve performance of legacy networks through the Heat Network Efficiency Scheme.

27. Hydrogen heating. We will work in partnership with industry and other key stakeholders to thoroughly assess the feasibility, safety, consumer experience and other costs and benefits, of hydrogen as an option for heating our homes and workplaces. We will support industry to develop and deliver large scale trials of hydrogen for heating, including a neighbourhood trial by 2023 and a village scale trial by 2025, and develop proposals for a possible 'hydrogen town' before the end of the decade. We will develop the evidence base and frameworks necessary to take strategic decisions on the role of hydrogen in decarbonising heat in 2026. In the shorter-term, we will work with the Health and Safety Executive and industry partners to enable up to 20% hydrogen blending in suitable areas of the GB gas networks subject to the success of testing and trials, and value for money assessment.

28. Hydrogen-ready boilers and boiler standards. We are aiming to consult shortly on the case for enabling or requiring new gas boilers to be readily convertible to use hydrogen ('hydrogen-ready') by 2026. We will also use this consultation to test proposals on the future of broader boiler and heating system efficiency and explore the best ways to reduce carbon emissions from our gas heating systems over the next decade.

29. Biomethane in the gas grid. We will deliver a new Green Gas Support Scheme (GGSS) to support the injection of biomethane from anaerobic digestion (expected to deliver 2.8TWh of renewable heat per year in 2030/31), and we will explore the development of commercial-scale gasification and the replacement of the GGSS with a long-term biomethane support scheme.

Improving buildings

30. Our core commitment is to reduce bills, whilst improving comfort, health and home value, through ensuring as many homes as possible to achieve EPC Band C by 2035 at the latest, where cost-effective, practical, and affordable.

31. New Buildings. We will introduce regulations from 2025 through the Future Homes Standard to ensure all new homes in England are ready for net zero by having a high standard of energy efficiency and low carbon heating installed as standard. This should mean that all new homes will be fitted with a low carbon heat source such as a heat pump or connected to a low carbon heat network. To reinforce this, we will consult on whether it is appropriate to end new gas grid connections, or whether to remove the duty to connect from the Gas Distribution Networks. As an interim measure to the Future Homes Standard, we plan to introduce an uplift in standards, effective from June 2022, for England that would result in a 31% reduction in carbon emissions from new homes compared to current standards. We will also respond to our consultation for the Future Buildings Standard for new non-domestic buildings.

32. Domestic private rented sector. We will build on our 2020 consultation on strengthening the Minimum Energy Efficiency Standards to EPC band C by 2028 to set long term minimum regulatory standards consistent with our net zero commitment for private rental sector. We are aiming to publish a response to this consultation by the end of the year We have provided significant additional support to local authorities to ensure compliance and enforcement of these regulations, building on earlier compliance and enforcement pilots. This includes providing £4.3m to 57 local authorities to support activity in these areas. We plan to scale up activity further in the coming years. We have also set out proposals to strengthen the compliance and enforcement framework under our recent EPC Band C consultation. This includes the introduction of a compliance and exemption database to support local authority enforcement of the Regulation.

33. Owner occupied homes. We are also exploring opportunities to improve the energy performance of owner-occupier homes. We have conducted a series of stakeholder workshops on the case for action, with over 50 representatives from the housing sector, landlord representatives, retrofit supply chain, NGOs, and consumer organisations. We plan to consult on options to upgrade homes in the owner occupier sector. We will work with owner-occupiers to help them improve the liveability of their homes. The provision of green finance will be an important step in making this easier and more accessible.

34. Social housing. We will provide £800 million additional funding to the Social Housing Decarbonisation Fund (SHDF) over 2022/23 to 2024/25, which will deliver energy performance improvements to social housing. We will also consider setting a long-term regulatory standard to improve social housing to EPC Band C and consider levers required to decarbonise the stock in line with net zero. We will consult the sector before setting any regulatory standard.

35. Low Income/Fuel Poor Consumers. We will ensure as many fuel-poor homes as reasonably practicable achieve a minimum energy efficiency rating of C by the end of 2030. To help achieve this, we will provide £950 million additional funding over 2022/23 to 2024/25 for off-gas-grid properties through the Home Upgrade Grant (HUG) to provide ongoing support for low-income households living off the mains gas grid with energy efficiency and low carbon heating upgrades. We will also expand and extend the Energy Company Obligation Scheme and the Warm Homes Discount Scheme until 2026.

36. Net zero backstop for homes. We will consider on an ultimate backstop date to ensure that all homes meet a net zero minimum energy performance standard before 2050, where cost effective, practical, and affordable.

37. Public Sector. We have committed to halve direct emissions from public sector buildings by 2032, against 2017 levels, and we aim to further reduce emissions from public sector buildings by 75% by 2037. To help achieve this, we will provide £1.425 billion additional funding for the Public Sector Decarbonisation Scheme (PSDS) over 2022/23 to 2024/25, and through our Greening Government Commitments (GGCs) which sets targets to reduce emissions from central government departments and arms-length bodies. We have also initiated the Public Sector Low Carbon Skills Fund which provides complementary funding alongside the PSDS to enable public sector organisations to acquire expert skills in order to unlock decarbonisation projects.

38. Non-domestic buildings. The *Energy White Paper* set a minimum energy efficiency standard of EPC Band B by 2030 for privately rented commercial buildings in England and Wales. Later this year we plan to consult on regulating the non-domestic owner-occupied building stock, and we are considering whether this should align with the private rented sector minimum energy efficiency standards. We will also respond to the 2021 consultation on introducing a performance-based policy framework in large commercial and industrial buildings and pilot the scheme in 2022.

39. We will look to consult stakeholders on the Small Business Energy Efficiency Scheme (SBEES) later this year. The scheme will aim to remove barriers for SMEs in accessing energy efficiency measures, drive forward better buildings performance and aid SMEs in meeting regulatory standards. Finally, we have consulted on strengthening the Energy Savings Opportunity Scheme (ESOS), which is a mandatory energy assessment scheme for large businesses' energy use and opportunities to improve energy efficiency.

- **Energy-related products.** We have published a policy framework setting out illustrative proposals for raising minimum energy performance standards and improving consumer information for a range of high potential products, including but not limited to space heating, cooking, taps and showers and lighting. We plan to consult on more concrete proposals between 2022 and 2023 ahead of implementing measures from 2025.

Enabling actions

40. There are a range of barriers to home energy performance improvements, which we will also need to address to help people act:

- **Advice & information**. Our existing Simple Energy Advice service has received over 1.5m users to date. We will enhance our digitally led service, and are considering options to support tailored retrofit advice in local areas. The aim is to create a Government-led home energy advice journey, supported by tailored local advice. This includes moving our Simple Energy Advice service to GOV.UK, which will improve user experience, and supporting local advice provision. This will help households to improve the energy performance of their homes, and move towards net zero.
- **Green finance**. Catalysing the market for Green Finance is a priority. We are working with mortgage lenders to support homeowners to improve the energy performance of their properties and will publish our response to our lenders consultation in due course. Government is also exploring the case for a further green home finance innovation programme, focussed on supporting lenders to develop green finance products targeted at consumer types who will be impacted by future regulation, and which the market is unlikely to develop on its own in the short term. BEIS has invited the UK Infrastructure Bank (UKIB) to help steer this work, and we will work further with the UKIB to explore whether they can play a wider role in scaling up green home finance.

41. Rebalancing energy prices: Clean, cheap electricity is an everyday essential. We have seen the impact of overreliance on gas pushing up prices for hardworking people but our plan to expand our domestic renewables will push down electricity wholesale prices. However, current pricing of electricity and gas does not incentivise consumers to make green choices, such as switching from gas boilers to electric heat pumps. We want to reduce electricity costs so we will also look at options to shift or rebalance energy levies (such as RO and FiTs) and obligations (such as ECO) away from electricity bills over this decade. This will include looking at options to expand carbon pricing and remove costs from electricity bills while ensuring that we continue to limit any impact on bills overall. We know that in the long run, green products are more efficient and cheaper, and we are putting fairness and affordability at the heart of our approach. We will launch a Fairness and Affordability Call for Evidence on these options for energy levies and obligations to help rebalance electricity and gas prices and to support green choices, with a view to taking decisions in 2022.

42. Developing a workforce pipeline with the skills to meet the requirements of net zero transition:

- The increase in deployment of low carbon heating systems over the coming decade will require a significant escalation in the number of trained, high-quality installers. With this in mind, we have launched the independent Green Jobs Taskforce with key industry bodies to advise on how we can have the skilled workforce to deliver net zero and support people in high carbon sectors with the transition.
- We will encourage current gas engineers, electricians, and those with transferrable skills in complementary sectors, to retrain and specialise in smarter, greener, and cleaner technologies. There are over 140,000 plumbers and heating and ventilation engineers in the UK. Approximately 90% of builders stated they would be willing to retrain to meet the demand for new roles and skills' changes in the future.[69] Attracting new entrants to the sector also provides a great opportunity to diversify the workforce. We will work with industry to support training and new routes of entry to help boost heat pump installer numbers and other areas of skills shortage to support the decarbonisation of homes. We will also work with industry and the low carbon projects supported through the Green Heat Network Fund to increase opportunities to gain skills in the heat networks sector.
- We will also continue to work with Ofgem, distribution network operators, and other local actors on the approach to planning the network in Great Britain and delivering smart, secure, cost-effective solutions. This will include considering the potential for storage and hybrid technologies in combination with flexible tariffs.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government and Northern Ireland Executive

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action to reduce emissions across the heat and buildings sector, and across the UK.

Wales

The Optimised Retrofit Programme is testing a new approach to decarbonising homes, based on the recommendations of the Jofeh Report.[70] The programme is delivering fabric improvements, heating technology and intelligent use of energy supplies to more than 1,500 homes across Wales. Significant Welsh Government investment is supporting social landlords to decarbonise 230,000 social homes over the next decade, and the learning from the programme will be used to help decarbonise Wales's 1.2 million private-rented and owner-occupier homes.

Scotland

The Scottish Government published its Heat in Buildings Strategy on 7 October 2021. This sets out a vision and actions for the decarbonisation of heat in homes and buildings in line with Scotland's statutory climate targets. The Scottish Government will allocate at least £1.8 billion over the next five years to support the accelerated deployment of heat and energy efficiency measures in homes and buildings. This investment will help to cut emissions, create jobs, strengthen supply chains, and tackle fuel poverty. The Scottish Government offers cashback grants to all homeowners as part of the Home Energy Scotland (HES) Loan Scheme, up to £6,000 for energy efficiency improvements and up to £7,500 for new renewable heating. It is also bringing forward the requirement for all homes to be upgraded to meet at least EPC C standards or equivalent by 2033 with the majority meeting this standard by 2030.

Subject to devolved competence, the Scottish Government has committed to phasing out the need to install new or replacement fossil fuel boilers, in off gas areas from 2025 and in on gas areas from 2030, subject to technological developments and decisions by the UK Government in reserved areas. It is currently developing regulations which will require new buildings receiving a warrant from 2024 to use zero emissions heating and cooling.

Northern Ireland

A phased programme is planned to uplift Northern Ireland's building regulations, taking developments in other administrations into account, to provide ultra-high energy efficient building fabric and services with low carbon heating standards for new buildings as soon as is practicable and no later than 2026/27. Consideration may be given to earlier uptake of requirements for low carbon heating solutions from 2022/23, if deemed feasible following consultation with industry.

There are several schemes currently available to support energy efficiency improvements and the installation of lower carbon heating, including the Boiler Replacement Scheme, Affordable Warmth, and the Northern Ireland Sustainable Energy Programme (NISEP). A new Northern Ireland Energy Strategy is expected to be published by the end of 2021, which will provide further information on proposals to phase out coal and solid fuels, along with fossil fuel home heating oil. The Energy Strategy will also provide further information on proposals to decarbonise the natural gas network, including through future injection of biomethane and potential hydrogen blending. Further detail will also be provided on the transition to low carbon heating options, such as heat pumps, and future proposed support schemes, including energy efficiency and low carbon heating pilot schemes, which are intended to be launched in 2022/23.

3v. Transport

Setting the pace for greener, better transport

Our Key Commitments

- End the sale of new petrol and diesel cars and vans from 2030; from 2035, all new cars and vans must be zero emission at the tailpipe.
- Introduce a zero emission vehicle mandate setting targets for a percentage of manufacturers' new car and van sales to be zero emission each year from 2024.
- Take forward our pledge to end the sale of all new, non-zero emission road vehicles by 2040, from motorcycles to buses and HGVs, subject to consultation.
- Ensure the UK's charging infrastructure network is reliable, accessible, and meets the demands of all motorists. Later this year, we will publish an EV infrastructure strategy, setting out our vision for infrastructure rollout, and roles for the public and private sectors in achieving it.
- Building on the £1.9 billion from Spending Review 2020, the Government has committed an additional £620 million to support the transition to electric vehicles. The funding will support the rollout of charging infrastructure, with a particular focus on local on-street residential charging, and targeted plug-in vehicle grants.
- Build a globally competitive zero emission vehicle supply chain and ensure our automotive sector is at the forefront of the transition to net zero.
- Lead by example with 25% of the government car fleet ultra low emission by December 2022 and all the government car and van fleet zero emission by 2027.
- Take action to increase average road vehicle occupancy by 2030 and reduce the barriers to data sharing across the transport sector.
- Maximise carbon savings from the use of low carbon fuels, including by increasing the main Renewable Transport Fuel Obligation (RTFO) target.
- Increase the share of journeys taken by public transport, cycling and walking.
- Support decarbonisation by investing more than £12 billion in local transport systems over the current Parliament.
- Invest £2 billion in cycling and walking, building first hundreds, then thousands of miles of segregated cycle lane and more low-traffic neighbourhoods with the aim that half of all journeys in towns and cities will be cycled or walked by 2030. As announced in the *Transport Decarbonisation Plan*, we will create at least one zero emission transport city.

- Invest £3 billion in the National Bus Strategy, creating integrated networks, more frequent services, and bus lanes to speed journeys, and support delivery of 4,000 new zero emission buses and the infrastructure needed to support them.
- Electrify more railway lines as part of plans to deliver a net zero rail network by 2050, with the ambition to remove all diesel-only trains by 2040.
- Plot a course to net zero for the UK domestic maritime sector, phase out the sale of new non-zero emission domestic shipping vessels and accelerate the development of zero emission technology and infrastructure in the UK. We will engage with industry to explore establishing a UK Shipping Office for Reducing Emissions (UK-SHORE) to transform the UK into a global leader in the design and manufacturing of clean maritime technology.
- Become a leader in zero-emission flight, kick-starting commercialisation of UK sustainable aviation fuels (SAF), and developing a UK SAF mandate, to enable the delivery of 10% SAF by 2030, and we will be supporting UK industry with a £180m funding to support the development of SAF plants.

Progress to date

1. Domestic transport has the largest share of UK greenhouse gas emissions of any sector across the economy, at 23% in 2019. The majority (55%) of these emissions are from passenger cars, contributing 68 $MtCO_2e$. This is followed by heavy goods vehicles and light goods vehicles contributing 19 $MtCO_2e$ (16%) and 19 $MtCO_2e$ (16%) respectively. The remaining emissions in domestic shipping, road transport, rail, and domestic aviation contribute a combined further 16 $MtCO_2e$ (13%).[71]

2. We must deliver a step change in the breadth and scale of our ambitions and, to this end, in July 2021 we published our world leading *Transport Decarbonisation Plan.* This covered all areas of transport and set out an ambitious but deliverable pathway to reaching net zero and delivering against carbon budgets along the way. The pathway we have set out is not about stopping people from doing things. Rather, it's about doing the same things differently. We want to be a world leader in green technologies, and encourage more sustainable travel choices.

3. Removing tailpipe emissions from road transport is a clear priority and we must continue the progress we have made to date. We have expanded our commitments in this area and will set ambitious but achievable phase out dates for every type of road vehicle. Alongside the *Transport Decarbonisation Plan*, we published the *2035 Delivery Plan* outlining the key timelines, milestones, and progress towards the *Ten Point Plan* commitment to accelerate the shift to zero emission vehicles.

4. There are now over 600,000 plug-in electric vehicles in the UK. In September 2021, more than one in five new cars sold had a plug. Additionally, more than 300 walking and cycling schemes have been delivered since 2020. For public transport, our *National Bus Strategy for England*, published in March, sets out a vision of a transformed bus industry and a green bus revolution. Rail is already the greenest form of motorised transport, with almost 38% of the network electrified and significantly more to come as set out in the *Great British Railways White Paper* in May.

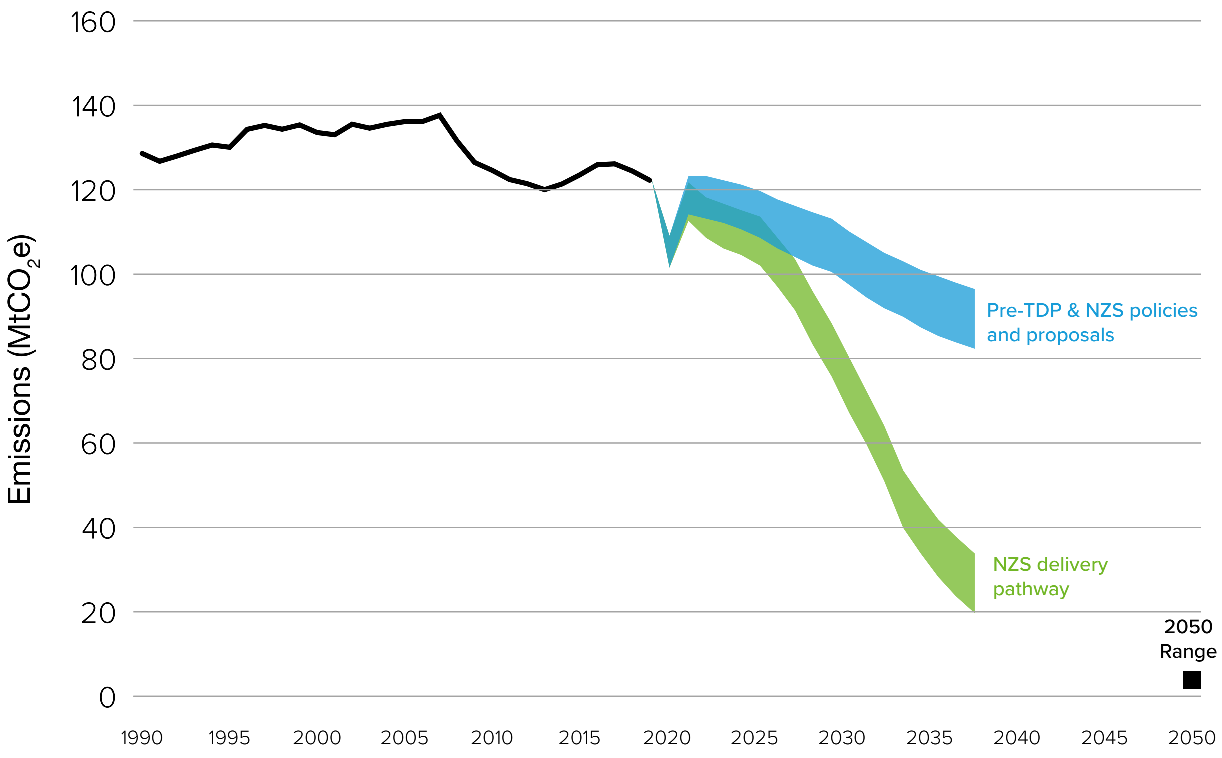
Net zero transition and economic opportunities

Our 2050 vision and how we get there

5. Every place in the UK will have its own net zero emission transport network before 2050, serving the unique needs of its communities. Sustainability will be at the heart of levelling up. People everywhere will feel the benefits – villages, towns, cities, and countryside will be cleaner, greener, healthier, and more prosperous and pleasant environments in which to live, work and enjoy.

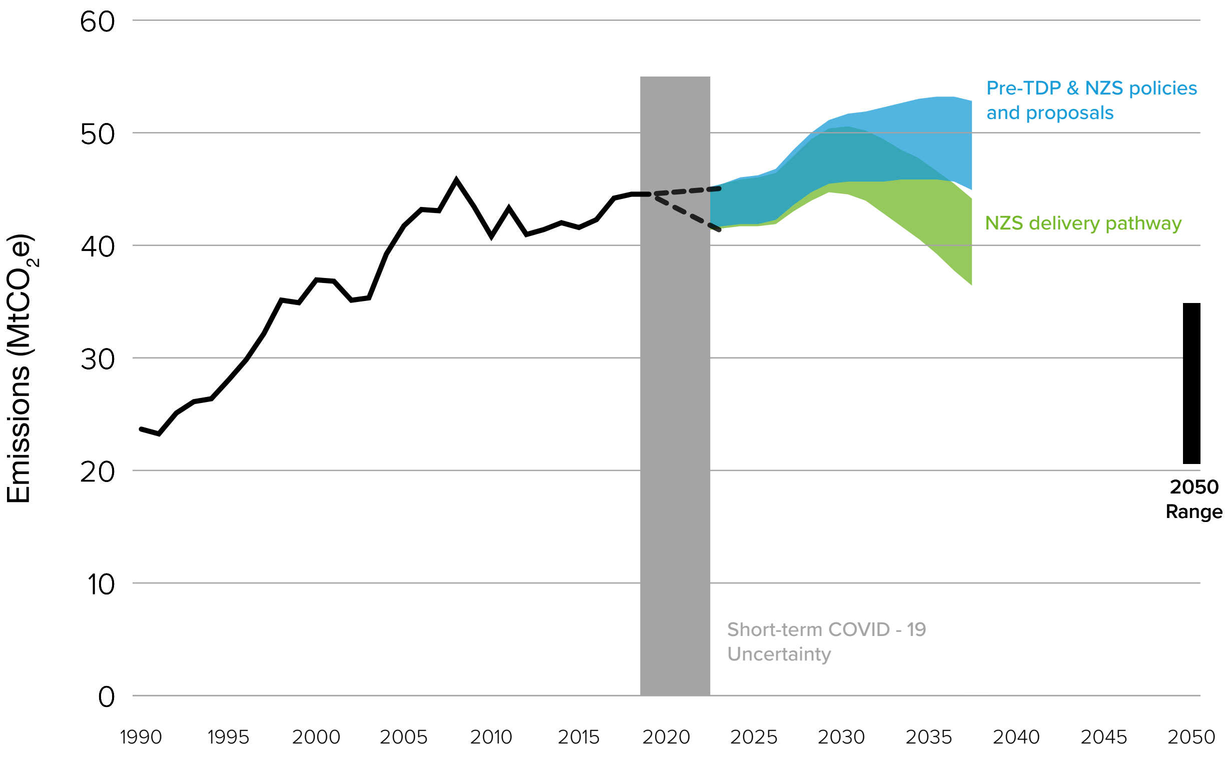
6. Based on our whole system modelling, by 2050, total transport emissions, including international aviation and shipping, could need to drop by 76-86% compared to 2019, down to 23-40MtCO$_2$e. In the interim, to meet our NDC and CB6 targets,[72] we expect they could fall by 22-33% by 2030 and 46-59% by 2035, compared to 2019 levels. These figures are based on an indicative transport sector pathway contributing to the whole-economy net zero and interim targets. Our potential pathway also indicates residual emissions from domestic transport could need to fall by around 34-45% by 2030 and 65-76% by 2035, relative to 2019 levels (see figure 21). We anticipate that international aviation and shipping emissions could need to fall by up to 12% by 2035, relative to 2019 levels (see figure 22).

Figure 21: Indicative domestic transport emissions pathway to 2037



Source: BEIS analysis

Figure 22: Indicative international aviation and shipping emissions pathway to 2037



Source: BEIS analysis

7. Much of the change needed to deliver net zero for the transport sector is already underway and makes sense even without the global imperative of climate change. Decarbonisation will deliver fundamentally better transport, for everyone, every day. It will make it faster and more efficient, as well as cleaner, and provide benefits including increased reliability and better connectivity. This is also a huge industrial opportunity, a once in a generation chance to increase economic growth and future prosperity – using electricity, low carbon hydrogen, sustainable low carbon fuels and pedal power – to invest in new jobs across our country.

8. Our *Transport Decarbonisation Plan* sets out this 'green print' in detail.

- The technology transformation started in cars and vans will spread to all road transport, from motorcycles to buses, coaches and HGVs. Over time, the use of zero emission vehicles will become even cleaner, as the use of renewable energy in the UK's electricity mix continues to increase. An extensive network of charging and refuelling infrastructure for all vehicles will enable the transition and meet growing demand.

- Low carbon fuels will continue to play a crucial role in maximising carbon savings from road vehicles during the transition, whilst increasingly being required in other transport modes such as aviation and maritime. This includes low carbon hydrogen, which is likely to be fundamental to achieving net zero in heavy transport applications and represents a major industrial opportunity.
- We cannot simply rely on the electrification of road transport, or believe that zero emission cars and lorries will solve all our problems. As we build back better from the pandemic, it will be essential to avoid a car-led recovery. Alongside road vehicle decarbonisation, we must increase the share of trips taken by public transport, cycling and walking. We want to make these modes the natural first choice for all who can take them. As more journeys are cycled or walked, and taken by public transport, the carbon, air quality, noise and congestion benefits will be complemented by significant improvements in public health and wellbeing.
- We will support and encourage modal shift of freight from road to more sustainable alternatives, such as rail, cargo bikes and inland waterways. We will transform last mile deliveries, with zero emission HGVs and decarbonised deliveries made possible through the adoption of new delivery models, supported by accurate data and digital innovations which drive greater efficiencies.
- The rail network will be net zero emissions by 2050 through a sustained, long-term programme of investment in rail electrification, supported by deployment of battery and hydrogen-powered trains.
- UK aviation and shipping will achieve net zero emissions by 2050. Ahead of that, our domestic lead will act as a showcase to the world and bolster our call to action internationally, where cooperation and collaboration through the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO), will continue to be vital to decarbonise these industries.
- The Government has set CB6 to formally include the UK's share of international aviation and shipping emissions, as recommended by the CCC, which allows these emissions to be accounted for within CB6.
- We will address aviation emissions through new technology such as electric and hydrogen aircraft, the commercialisation of sustainable aviation fuels, increasing operational efficiencies, developing and implementing market-based measures and GHG removal methods, while influencing consumers to make more sustainable choices when flying.
- The UK will play an important role in developing zero emission maritime technology, such as alternative fuel powered vessels using ammonia or methanol produced from low carbon hydrogen, or highly efficient batteries, particularly where we can build on domestic expertise to capture early market share.
- As we have stated in the Ten Point Plan and the Transport Decarbonisation Plan, we need to ensure that the taxation of motoring keeps pace with the change to electric vehicles to ensure that we can continue to fund the first-class public services and infrastructure that people and families across the UK expect.

Zero emission vehicles (ZEVs)

The transition to zero emission cars and vans is leading the way in our effort to decarbonise transport. The car and van sector is easier to decarbonise compared to other sections of the economy, through the combination of a proven low carbon technology that has significant advantages over the existing high carbon technology it replaces, reducing costs and growing consumer demand. Strong progress is already being made towards our 2030/2035 phase out commitments:

- **Demand is rising:** Industry figures show over 650,000 new plug-in cars registered in the UK since 2010, and over 1 in 7 cars sold so far in 2021 had a plug.
- **Range is increasing as costs are falling:** There are 20 EV models that come with a range of over 200 miles compared to the early Nissan Leaf models that delivered 60 miles, and battery prices are little more than a tenth of what they were in 2010.
- **The charging infrastructure market is growing:** There are now over 25,000 public chargepoints in the UK, which includes over 4,700 rapid devices according to industry sources. This is one of the largest networks of rapid chargers in Europe.

Seizing new opportunities

9. Across every form of transport, decarbonisation and growth will go hand in hand. The UK will play a leading role in this modern-day industrial revolution, consolidating our position as a world leader in green technology, science, and research. The imperative to decarbonise brings with it a host of other benefits, including new business models, new modes, increasing levels of autonomy, far better integration, and a blurring of the distinction between traditional forms of transport, as well as public and private travel coming together to offer greater choice and flexibility. We will use research and development to build on the expertise of business and academia, maximising opportunities for growth, exports and hundreds of thousands of new high-quality jobs.

10. To achieve the level of emissions reductions in the transport sector indicated by our delivery pathway to 2037, we will need additional public and private investment of around £220 billion.

11. Decarbonising the transport sector will regenerate communities and open up new employment opportunities right around the UK. Based on current estimates, policies and proposals to reduce emissions in the sector could support up to 22,000 jobs in 2024 and up to 74,000 jobs in 2030. Development of road transport sector technologies as the economy transitions to net zero could support up to 71,000 jobs in 2050.

12. We need a skilled workforce capable of developing, implementing and operating mobility solutions in a way that maximises the huge potential benefits they offer. The government launched the Green Jobs Taskforce, to advise the government, industry and the skills sector on the action required to deliver the jobs and skills required for the net zero transition. Our approach on green jobs and skills is set out in the *Green Jobs, Skills and Industries* chapter of the Net Zero Strategy.

13. Decarbonising transport will also help achieve other benefits:

- It will improve health by removing a source of air pollution. There will still be particulate emissions associated with road, rail, tyre, and brake wear, and we are working to tackle those too, but the toxic by-products of burning hydrocarbon fuels will be eliminated from the roadside and rail;
- Physical inactivity costs the NHS up to £1 billion per annum, with further indirect costs of £8.2 billion – active travel can reduce that; and
- Over half the UK population is exposed to daytime noise levels above recommended limits. Zero emission vehicles – extremely quiet at low, urban speeds – will help address this. This will support levelling-up and help reinvent high streets as enjoyable places to live, work, visit and spend leisure time.

Policies and proposals

14. As the *Transport Decarbonisation Plan* and this Strategy are implemented, we will continue to consider the views of stakeholders from across the UK. We will engage closely with Devolved Administrations, respecting areas of devolved competency, as we work towards our shared goal of achieving net zero. We will also continue to collaborate with local authorities and other regional bodies to identify and support local solutions.

15. Depending on progress in the sector, at some points additional targeted action maybe be required, such as steps to reduce use of the most polluting cars and tackle urban congestion, to enable these targets to be met. We will regularly review progress against our targets – publishing the next transport decarbonisation plan within five years – and continue to adapt and take further action if needed to decarbonise transport.

Cycling and walking

16. Cycling and walking can help us tackle some of the most challenging issues we face as a society, not just climate change, but improving air quality, health and wellbeing, addressing inequalities, and tackling congestion and noise pollution on our roads. Increased levels of active travel can improve everyday life for us all.

17. We will deliver the Prime Minister's bold vision for cycling and walking, investing £2 billion over five years with the vision that half of all journeys in towns and cities will be cycled or walked by 2030. We will also deliver thousands of miles of safe, continuous, direct routes for cycling in towns and cities, physically separated from pedestrians and volume motor traffic along with more low traffic neighbourhoods and school streets.

18. We will deliver a world class cycling and walking network in England by 2040. This will include comprehensive cycling and walking networks in all large towns and cities, with measures to enable cycling and walking, such as cycle training for all children and adults that want it. We will enable behaviour change through targeted personal incentives, such as GP prescribing of active travel, existing tax reliefs, and rewards programmes.

Buses and coaches

19. We will deliver the *National Bus Strategy*'s vision of a transformed bus industry and a green bus revolution. We will make buses more frequent, more reliable, more comprehensive, easier to understand and use, better co-ordinated and cheaper – to dramatically increase passenger numbers and reduce congestion and carbon emissions.

20. We will support delivery of 4,000 new zero emission buses, either battery electric or hydrogen, and the infrastructure needed to support them. This will be the single largest investment ever made in zero emission buses, representing the replacement of nearly 12% of England's local operator bus fleet.

21. We will deliver the first All-Electric Bus City. This will demonstrate what can be achieved when there is a real commitment to move all buses in a place to electric zero emission. Coventry has now been announced as the UK's first all-electric bus city, with £50 million to fund up to 300 electric buses and charging infrastructure.

22. We are consulting on a phase out date for the sale of new non-zero emission buses and coaches. We have already begun consulting on an appropriate date to end the sale of new non-zero emission buses and on the appropriate supporting policy and regulatory framework. We will also consult on a phase out date for the sale or purchase of new non-zero emission coaches.

Railways

23. We will deliver a net zero rail network by 2050, with sustained carbon reductions in rail along the way. Our ambition is to remove all diesel-only trains (passenger and freight) from the network by 2040. We will deploy new low-carbon technologies on the network such as hydrogen and battery trains, where they make operational and economic sense. We will incentivise the early take up of low carbon traction by the rail freight industry.

24. We will build extra capacity on our rail network to meet growing passenger and freight demand and support significant shifts from road and air to rail. This includes new high-speed lines, reopening lines closed under the Beeching cuts and significant improvement to regional city public transport networks with the aim of making them as good as London's.

25. We are working with industry to modernise fares ticketing and retail and encourage a shift to rail and cleaner and greener transport journeys. *Great British Railways* set out a transformation in how people will pay for their journeys, to encourage a shift to rail and cleaner, greener journeys. Greater provision of walking and cycling routes to and from stations, and supporting infrastructure, will be introduced to support healthier greener journeys. *Great British Railways* will encourage more rail freight by providing the right conditions for industry growth, with better coordination, modern contracts, and new safeguards.

Cars, vans, motorcycles, and scooters

26. We will end the sale of new petrol and diesel cars and vans by 2030. From 2035 all new cars and vans must be fully zero emission at the tailpipe. Between 2030 and 2035, new cars and vans will only be able to be sold if they offer significant zero emission capability.

27. To provide certainty to consumers, energy providers, the chargepoint industry, vehicle manufacturers and supply chains during this transition, we will introduce a zero emission vehicle mandate setting targets requiring a percentage of manufacturers' new car and van sales to be zero emission each year from 2024.

28. We will continue to regulate the tailpipe CO2 emissions of new non-zero emission cars and vans to limit their emissions until 100% of new sales are zero emission. This framework could subsequently be applied to all forms of new road vehicles sold in the UK.

29. Between 2030 and 2035, new cars and vans will only be able to be sold if they offer significant zero emission capability and we will provide further detail on the outcome of our recent consultation on this shortly. We will then publish a further consultation in early 2022 on:

- The design of the ZEV mandate (including uptake trajectories) and CO2 emissions regulation (as a backstop to ensure standards in the remainder of the fleet are maintained); and
- How and when targets will be set and enforced.

30. We are building a globally competitive UK zero emission vehicle supply chain to ensure our automotive sector is at the forefront of the transition to net zero. Since 2020, the government has been actively supporting the transformation of the automotive supply chain to electrification through the Automotive Transformation Fund (ATF). We are allocating a further £350 million of our up to £1 billion ATF commitment to support the electrification of UK vehicles and their supply chains. We will also continue to invest in R&D through the Advanced Propulsion Centre (APC) competition to ensure the UK remains at the forefront of the development and industrialisation of zero emission vehicle technologies.

31. We will consult this year on a phase out date of 2035, or earlier if a faster transition appears feasible, for the sale of new non-zero emission powered two and three wheelers (and other L category vehicles).

32. We will lead by example with 25% of the government car fleet ultra low emission by December 2022 and all the government car and van fleet zero emission by 2027.

33. We will ensure the UK's charging infrastructure network meets the demands of its users. We have already announced £1.3 billion of investment to accelerate the rollout of charging infrastructure on motorways, on streets, in homes and workplaces. The Government has committed an additional £620 million of funding to support the transition to electric vehicles. Further details will be published in due course. Later this year, we will publish an EV infrastructure strategy, setting out our vision for infrastructure rollout, and roles for the public and private sectors in achieving it.

Smart Charging

Amir is self-employed and uses a van for work. His work involves a lot of journeys locally, totalling around 250-300 miles per week. He usually plugs into charge every few evenings, with his vehicle fully charged by the morning. He has a chargepoint installed on his driveway so he can charge on his domestic energy tariff. The chargepoint is smart, which means it shifts charging to off-peak times, which saves Amir money. He has also signed up to a vehicle-to-grid scheme with his electricity supplier. By keeping his van plugged in during the week when he doesn't need to use it, he's able to sell energy back to the grid when demand is high.

Maritime

34. We will plot a course to net zero for the UK domestic maritime sector, with indicative targets from 2030 and net zero as early as is feasible. We will establish, after public consultation in 2022, an ambitious 'Course to Zero'. Following consultation, we will establish ambitious indicative targets and embed this course in our Clean Maritime Plan.

35. We will consult on a potential phase-out date for the sale of new non-zero emission domestic vessels. Following the conclusion of the current Clean Maritime Demonstration Competition and the Course to Zero consultation, we will consult in mid-2022 on the potential for accelerated decarbonisation through carefully designed, well signposted measures to phase out the sale of new, non-zero emission domestic vessels.

36. We are assessing how economic instruments could be used to accelerate the decarbonisation of the domestic maritime sector. Building on Maritime 2050, the Clean Maritime Plan and our published research, we will further investigate the use of economic instruments to drive decarbonisation.

37. We will extend the Renewable Transport Fuel Obligation to the maritime sector. Following consultation earlier this year, we will make renewable fuels of non-biological origin used in shipping eligible for incentives under the RTFO.

38. This year we will be consulting on the appropriate steps to support and, if needed, mandate the uptake of shore power in the UK. We will consult in winter 2021 on how government can support wider deployment of shore power, including potential regulatory interventions, for both vessels and ports.

39. We are accelerating the development of zero emission technology and infrastructure in the UK. We have launched the £20 million Clean Maritime Demonstration Competition (CMDC) to fund feasibility studies and technology trials. We will engage with industry to explore establishing a UK Shipping Office for Reducing Emissions (UK-SHORE) in cooperation with UKRI and Innovative UK. UK-SHORE aims to transform the UK into a global leader in the design and manufacturing of clean maritime technology.

Aviation

40. Earlier this year we consulted on our Jet Zero Strategy, which will set out the steps we will take to reach net zero aviation emissions by 2050. We have also consulted on a target for UK domestic aviation to reach net zero by 2040.

41. We are supporting the development of new and zero carbon UK aircraft technology through the Aerospace Technology Institute (ATI) programme and fund zero emission flight infrastructure R&D at UK airports. As part of the Jet Zero ambition, the Aerospace Technology Institute (ATI) provides R&D funding, matched by industry, to support the design and development of new aerospace technologies, with particular focus on zero carbon technologies, that are most likely to grow the UK's share in the global market. We are also investing £3 million in 2021/22 through the Zero Emission Flight Infrastructure competition to accelerate R&D into infrastructure requirements at airports and airfields to handle new forms of zero emission aircraft.

42. We will accelerate the commercialisation of UK sustainable aviation fuels (SAF). Our ambition is to enable delivery of 10% SAF by 2030 and we will be supporting UK industry with a £180 million funding to support the development of SAF plants. This builds on our recently launched £15 million Green Fuels, Green Skies competition. We will also establish a SAF clearing house, the first of its kind announced in Europe, to enable the UK to certify new fuels.

43. We are currently reviewing the responses to the SAF mandate consultation. Ahead of a second consultation in 2022, we will continue to engage with industry to ensure our policy can support the delivery of any future mandate ambitions.

Freight and logistics

44. We recently consulted on phase out dates for the sale of all new non-zero emission HGVs - that is, on ending the sale of new non-zero emission HGVs by 2035, for vehicles 26 tonnes and under, and 2040, for vehicles over 26 tonnes, with the government's response due to be published in due course.

45. We will support and encourage modal shift of freight from road to more sustainable alternatives, such as rail, cargo bike and inland waterways. This will be supported by a package of policies including:

- Investing in the capacity and capability of the rail network for freight, including infill electrification schemes;
- The Mode Shift Revenue Support and Waterborne Freight Grant Schemes;
- Introducing a rail freight growth target; and
- 'Last mile' measures to support more sustainable freight in urban areas.

Delivering decarbonisation through places

46. We will support transport decarbonisation by investing more than £12 billion in local transport systems over the current Parliament. We will deliver this through existing funding streams where decarbonisation sits alongside other core government objectives.

47. We are driving decarbonisation and transport improvements at a local level by making quantifiable carbon reductions a fundamental part of local transport planning and funding. Local Transport Plans (LTPs) – statutory requirements that set out holistic place-based strategies for improving transport networks and proposed projects for investment – will need to set out how local areas will deliver ambitious carbon reductions in line with carbon budgets and net zero.

48. We will embed transport decarbonisation principles in spatial planning and across transport policy making. Last year, the government set out proposals for a new and improved planning system, central to our most important national challenges, including combating climate change and supporting sustainable growth. The *National Model Design Code*, published in July this year, guides local planning authorities on measures they can include within their own design codes to create environmentally responsive and sustainable places. The *National Model Design Code* provides tools and guidance for local planning authorities to help ensure developments respond to the impacts of climate change, are energy efficient, embed circular economy principles and reduce carbon emissions.

Maximising the benefits of sustainable low carbon fuels

49. As announced in July 2021, and subject to parliamentary approval, the RTFO main obligation will increase from 9.6% in 2021 to 14.6% in 2032. This is estimated to achieve additional carbon savings of up to 20.8 $MtCO_2e$ over this period. The ‘development fuels’ sub-target, which incentivises specific fuels of strategic importance, is already set to increase from 0.5% in 2021 to 2.8% by 2032, and by 2023 we will review whether there is scope to be more ambitious. We also committed to additional measures to promote the uptake of low carbon fuels in the freight, maritime and aviation sectors and we will work with stakeholders to develop a longer-term low carbon fuel strategy for the deployment of low carbon fuels across different transport modes to 2050.

Hydrogen in a decarbonised transport system

50. We expanded the RTFO to incentivise the use of renewable hydrogen in maritime and rail in 2018. As set out clearly in the recent *Hydrogen Strategy* and *Transport Decarbonisation Plan*, hydrogen is likely to play a significant role in transport applications, particularly where energy density requirements or refuelling times make it the most suitable low carbon energy source. Our dedicated hydrogen R&D funding and support is focussed on heavier applications, such as rail, maritime, aviation and heavy road freight, where hydrogen offers in-use advantages and the largest global market potential. The government remains technology neutral and acknowledges that there will be other transport applications where hydrogen may be well suited, including the potential for hydrogen to be utilised within combustion engines, where it can be shown to produce zero harmful emissions at the tailpipe.

51. We are investing £3 million in 2021 to establish the UK's first multi-modal hydrogen transport hub in Tees Valley. The funding is kick-starting activity across the region, supporting collaborative R&D pilot projects and pop-up trials that demonstrate hydrogen technology solutions across transport modes and forge new industry and academic partnerships.

Future transport – more choice, better efficiency

52. We will take action to increase average road vehicle occupancy by 2030. Increasing car occupancy from 1.55 to 1.7 could save nearly 3 Mt of carbon a year by 2030. We are building our evidence base to understand the barriers and potential policies to increase the uptake of shared mobility and will work with industry and local authorities to understand where further action can be taken.

53. We will reduce the barriers to data sharing across the transport sector. Better data can provide new policy and operational insights, drive new products and services and 'nudge' people towards lower emission journeys. We recently published a new annual statistical release, drawing together various data sources on transport's environmental impact. Data consumers can use these data, without restrictions on use or disclosure, for journey planning applications, products and services enabling users to plan green end-to-end journeys.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government and Northern Ireland Executive

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action to reduce emissions across the transport sector, and across the UK.

Wales

The Welsh Government's vision is that by 2025 all users of electric cars and vans are confident that they can access electric vehicle charging infrastructure when and where they need it.[73] Its *Electric Vehicle Charging Strategy* identified a need for 30,000-55,000 fast chargers and up to 4,000 rapid chargers by 2030. The forthcoming EV Charging Action Plan will include further details on the specific support for the roll out of a comprehensive network.

Scotland

The transport measures in the updated 2018 *Climate Change Plan* contain action across all modes. The Scottish Government will phase out the need for new petrol and diesel cars and vans by 2030, and will work with public bodies to lead the way to do this by 2025. It will also work with the freight industry to remove the need for new petrol and diesel heavy vehicles by 2035, supported by its work with Scottish Enterprise to establish a Zero Emission Heavy Duty Vehicle programme to remove the majority of fossil fuel buses in public transport by 2023.

The commitment set out in the Climate Change Plan to reduce car kilometres by 20% by 2030 demonstrates the level of ambition in meeting Scotland's statutory targets. To encourage modal shift to public transport the Scottish Government is investing over £500 million in bus priority infrastructure and extending nationwide free bus travel to all young people resident in Scotland under 22 years old from 31 January 2022. On active travel, the Scottish Government will support transformational active travel projects with over £500 million of investment over 5 years and has committed to ensuring that at least £320 million or 10% of all the transport capital budget is spent on supporting walking, cycling and wheeling by 2024-25.

On public transport, Scotland's rail services will be decarbonised by 2035, and the Scottish Government is working with its Bus Decarbonisation Taskforce to create a pathway to zero emission buses. This is supported by its long-term investment of over £500 million in bus priority infrastructure.

Northern Ireland

In Northern Ireland, £74 million has been invested in the purchase of zero and low emission vehicles (hydrogen and electric) and associated infrastructure in the public transport sector. A £20 million Blue/Green infrastructure investment fund was launched in 2020/21 and has continued in 2021/22, which has supported a range of initiatives including active travel schemes across Northern Ireland. An Executive Energy Strategy is currently being developed which will include measures focusing on informing transport choices and behaviours, and establishing a sustainable transport hierarchy that will support changes in how we travel, reduce the distances travelled in private vehicles, and decarbonise transport.

3vi. Natural Resources, Waste & F-Gases

Harnessing nature for net zero

Our Key Commitments

- 75% of farmers in England will be engaged in low carbon practices by 2030, rising to 85% by 2035. Government is introducing farming schemes, including the new environmental land management schemes, which will provide a powerful vehicle for achieving net zero, and goals of the *25 Year Environment Plan*.
- Increase investment in industry-led research and development into solutions to help deliver net zero in agriculture and horticulture, including through the Farming Innovation Programme.
- Treble woodland creation rates by the end of this Parliament, reflecting England's contribution to meeting the UK's overall target of increasing planting rates to 30,000 hectares per year by the end of this Parliament and maintain new planting at least at this level from 2025 onwards. We will explore a long-term statutory tree target in England within the public consultation on Environment Bill targets.
- We will boost the existing £640 million Nature for Climate Fund with a further £124 million of new money, ensuring total spend of more than £750 million by 2025 on peat restoration, woodland creation and management. This will enable more opportunities for farmers and landowners to support net zero through land use change.
- Restore at least 35,000 hectares of peatlands in Englad by 2025, through the Nature for Climate Fund. Restore approximately 280,000 hectares of peat in England by 2050, including via funding from the new environmental land management schemes.
- Mobilise private investment into tree planting, including through the Woodland Carbon Code, with the support of government's Woodland Carbon Guarantee, and into peat restoration through implementing a package of reforms to the Peatland Code.
- We will work with key stakeholders to develop a policy roadmap to increase the use of timber in construction in England, and will create a cross-government and industry working group tasked with identifying key actions to safely increase timber use and reduce embodied carbon.

- To support our commitment to explore options for the near elimination of biodegradable municipal waste to landfill from 2028, we are bringing forward £295 million of capital funding which will allow local authorities in England to prepare to implement free separate food waste collections for all households from 2025.
- Complete a review of the F-gas Regulation and assess whether we can go further than the current requirements and international commitments, including by looking at what additional reductions in F-gas use can be made to help the UK meet net zero by 2050.
- Through the Environment Bill we will legislate for Local Nature Recovery Strategies – a new system of spatial strategies that will map proposals for improving or creating habitat for nature and wider environmental benefits, helping to deliver net zero objectives.
- Biodiversity co-benefits and other environmental objectives are maximised alongside decarbonisation.

Progress to date

1. This chapter covers natural resources including agriculture, forestry, and other land use (AFOLU), (inclusive of peatlands and soils), as well as resources, waste, wastewater, and fluorinated gases (F-gases). In 2019, net UK greenhouse gas (GHG) emissions from these sectors, referred to as NRWF (natural resources, waste, and F-gases), reflected 103 $MtCO_2e$ or 20% of the UK total, having decreased by 45% between 1990 and 2019.[74]

2. In the *Ten Point Plan*, we committed to protecting our natural environment. Since then we have launched the floods investment programme to better protect 336,000 properties from flooding. We also awarded 90 projects grants under round 2 of the £80 million Green Recovery Challenge Fund (GRCF). In total, the GRCF is set to plant almost over 1 million trees.

Agriculture, forestry, and other land use (AFOLU)

3. AFOLU were responsible for 63 $MtCO_2e$ (12%) of UK net GHG emissions in 2019, having risen slightly in the last 2 years but reduced by 24% since 1990.

4. Emissions from agriculture, mainly stemming from livestock, agricultural soils, and farm machinery, added up to 55 $MtCO_2e$ (11%) of UK emissions in 2019. Although rising by 1% from 2018 to 2019, agricultural emissions have fallen by 13% since 1990. The *Agriculture Transition Plan* (2020) sets out how we will move away from the EU's Common Agricultural Policy to use public money to reward farmers and land managers for delivering environmentally sustainable outcomes in England.[75]

5. Forestry and woodlands currently act as carbon sinks and, in 2019, captured about 4% of our emissions.[76] Since 2010, 123,000 hectares of new woodland has been planted across the UK, an area equivalent to Bedfordshire. The *England Tree Action Plan* (2021) committed to increasing tree planting rates from 13,410 hectares across the UK in 2020/21, to 30,000 hectares each year by the end of this Parliament. The plan is supported by £500 million of the Nature for Climate Fund. In 2020-21 we funded new partnerships with Northumberland County Council, Trees 4 Cornwall, and England's network of ten Community Forests. Two new community forests were launched, Plymouth and South Devon in June 2021 and North-East, in July 2021.

6. Although peatlands are the UK's largest terrestrial carbon store, in a degraded condition they represent a net source of emissions. In 2019, peatlands emitted 4% of UK net GHG emissions, having become degraded due to drainage for agricultural use, overgrazing and burning. We have rewetted around 100,000 hectares of peatland across the UK and set out further plans for peatland restoration and responsible management in the *England Peat Action Plan* (May 2021).

Resources, waste, and F-gases

7. Waste management emissions consist of waste disposed to landfill sites, waste incineration without energy recovery, and the treatment of wastewater. In 2019, waste management accounted for 25 $MtCO_2e$ (5%) of UK emissions, a significant decrease of 71% since 1990, largely driven by a reduction in biodegradable waste to landfill. The *Resources and Waste Strategy* (RWS), (2018) set out how we will transition to a more circular economy, and included key reforms to enable us to manage our waste more efficiently, reduce the amount of waste we create as a society, and ensure we use resources more efficiently.[77]

8. F-gases (GHGs which can be used in systems such as heat pumps and air conditioning units) accounted for 15 $MtCO_2e$ (3%) of UK emissions in 2019, with 93% of these coming from hydrofluorocarbons (HFCs). F-gas emissions have fallen by 10% since 1990.[78] In 2017, the UK was one of the first countries to commit to cutting HFC consumption by 85% by 2036, ratifying the Kigali Amendment to the UN Montreal Protocol.[79] We have cut HFC consumption even faster than that, reducing levels placed on the market by 55% since 2015, through quota limits.[80]

Net zero transition and economic opportunities

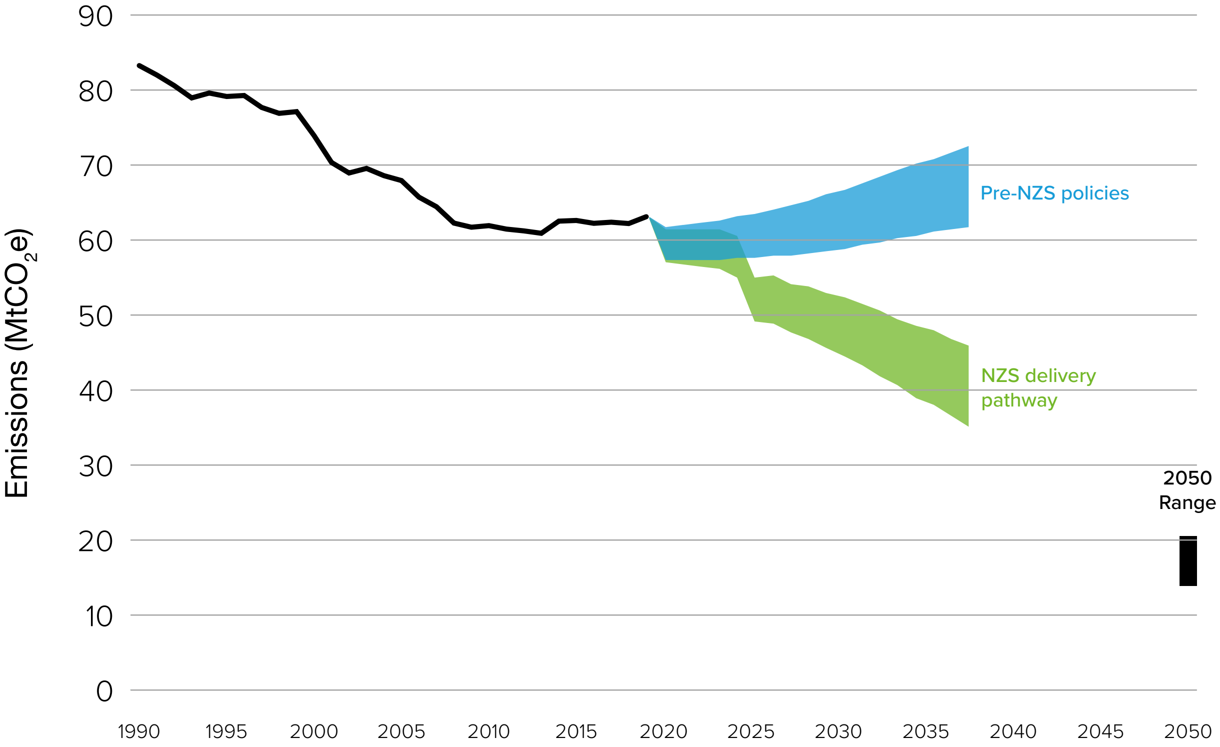
Our 2050 vision and how we get there

9. A systemic transformation across the UK economy, including NRWF sectors, is required to achieve net zero by 2050. While we will significantly reduce emissions across the NRWF sectors, some residual emissions from agriculture, waste, and F-gases will remain. These will need to be compensated for by both nature-based and engineered greenhouse gas removals (GGRs) as a last resort. On our journey to net zero, we will maximise opportunities to adapt to climate change and the extreme weather it brings, and to maximise the co-benefits for other environmental objectives.

10. By 2050, emissions associated with the NRWF sectors could need to drop by 67-75% compared to 2019, down to 26-34 $MtCO_2e$. In the interim, to meet our NDC and Carbon Budget 6 targets, they are expected to fall by 30-40% by 2030 and 39-51% by 2035, compared to 2019 levels. These figures are based on the indicative NWRF sectoral pathway to help us reach net zero and interim targets. Our potential pathway also indicates residual emissions in AFOLU sectors could need to fall by 17-30% by 2030 and 24-40% by 2035, relative to 2019 levels; waste and F-gas emissions could need to fall by 50-57% by 2030 and by 62-69% by 2035, relative to 2019 levels.

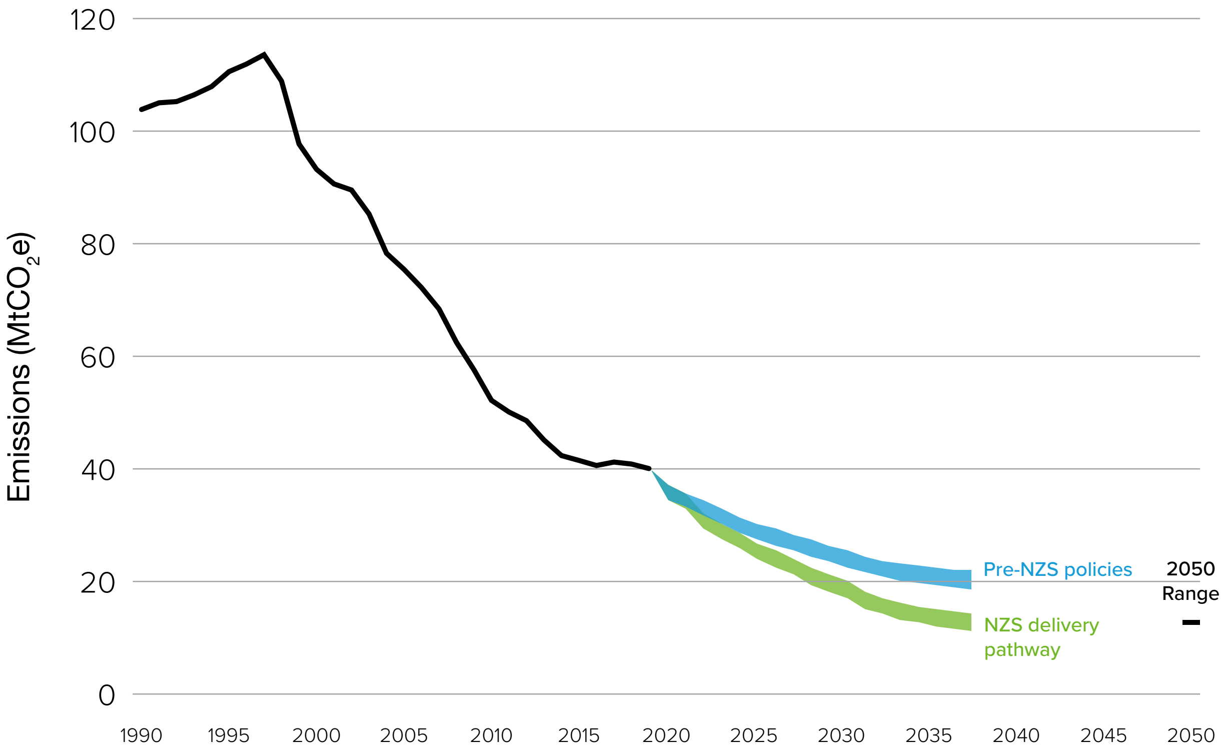
11. We are working closely with Devolved Administrations to deliver this ambition. This includes frequent engagement at Ministerial and official levels through existing and new forums, and allows us to think practically about how we deliver across the UK. We will also consider the interdependencies between land use sectors and other goals.

Figure 23: Indicative agriculture, forestry and other land use emissions pathway to 2037



Source: BEIS analysis

Figure 24 Indicative waste and F-gas emissions pathway to 2037



Source: BEIS analysis

Agriculture, forestry, and other land use (AFOLU)

12. By 2050, we will have a resilient and prosperous countryside, where farmers and land managers are supported to reduce emissions and deliver a range of environmental outcomes. 75% of farmers in England will be engaged in low carbon practices by 2030, rising to 85% by 2035. Emissions mitigation in agriculture is complex and diverse, with no silver bullets. It is difficult to establish a single metric to track progress, but government monitors engagement with low carbon farming practices through our Farm Practice Survey. We will continue to improve this metric in future years to address what we consider to be key limitations in the current approach.

13. We will support farmers to adopt low carbon farming practices, and increase the carbon stored on their farms, helping to improve business productivity and profitability gains. Schemes that support environmental land management will help drive this change and will also help compensate for residual emissions that are harder to reduce, such as from livestock. The Farming Investment Fund will offer funding for equipment, technology, and infrastructure that improves farm productivity and benefits the environment. We are also providing funding to help farmers produce healthier animals, reduce GHG emissions and enhance welfare through the Animal Health and Welfare Pathway. Additionally, Defra will develop a Farming for Net Zero resource, providing advice to farmers on good practice techniques to understand, manage and abate GHG emissions.

14. We also recognise the importance of other policy levers with potential climate benefits, for example Environmental Permitting for dairy and intensive beef herds which is planned under the *Clean Air Strategy*. There is also an important role for emerging markets in nature-based solutions. For example, the Woodland Carbon Code, which incorporates robust standards and accreditation processes. We will seek to establish a robust market framework, with arrangements to ensure additionality, transparency, and traceability of carbon credits, so that regulators and the public can be confident that carbon savings are verified and also guaranteed against future issues such as forest fires or disease. Additionally, we continue to consider the impact that climate change will have on the suitability of our land for different uses, such as the impact of hotter, drier summers and warmer, wetter winters on agriculture, habitat creation and restoration, and forestry.

15. Biomass will also be an important component of our pathway to net zero. It is likely that the UK will be producing more domestic perennial energy crops (such as miscanthus and short rotation coppice) and short rotation forestry than today, but the exact role is yet to be determined. The *Biomass Strategy*, due in 2022, will look to address this. The sustainability, and wider environmental impact of growing and using biomass, including on air quality, will be key factors in establishing its role.

Resources and waste, and F-gases

16. By 2050, we will have met the *25 Year Environment Plan* (25YEP) commitments to eliminate all avoidable waste, including plastic, and to double resource productivity.[81] A circular economy will be part of everyday life: reusing, repairing, and remanufacturing goods will be standard practice. Goods will be designed to last for longer and be more efficient. At end of life, the vast majority of products will be sent for recycling, with food, garden, and dry materials collected separately and used as lower carbon inputs for new products. Producer responsibility schemes will be embedded across the economy. Any non-recyclable residual waste will be treated to enable the processing of waste into valuable outputs, such as energy. Where possible, these processes would include carbon capture and storage. (See the *Power* chapter for more on energy from waste.) Only where no such treatment is possible may landfill be permitted.

17. By 2050, current F-gas use will have been predominantly replaced by alternative gases or technologies. HFC importers, equipment manufacturers and servicing technicians will have taken steps to reduce their use in favour of alternatives, not only in line with the current phasedown, but also with further measures implemented following the F-gas Regulation review and future international changes.

Other sectors

18. Protecting, restoring, and sustainably managing other natural resources such as soils or blue carbon habitats like saltmarsh and seagrass, can provide benefits for biodiversity and climate adaptation, as well as for carbon sequestration. We do not currently have the required data to include these habitats in the UK GHG Inventory or to accurately quantify their potential contribution to net zero but are doing further work to close these evidence gaps.

Reducing emissions while balancing other climate and environmental objectives

While reducing emissions, we must also adapt to the inevitable changes in our climate, ensuring that policies supporting net zero are resilient to current and future climate risks, and preventing locking in future vulnerabilities or maladaptation. The second *National Adaptation Programme* sets out how we are addressing, and will address, climate risks between 2018 and 2023 and further detail on adaptation is included in the Climate Science Annex of this strategy.

Delivering net zero creates opportunities to benefit other environmental objectives too. For example, climate change and biodiversity loss are closely related, and policies to tackle climate change can help to improve biodiversity. Likewise, net zero policies can support further environmental goals, such as water quality, natural beauty, and the delivery of the 25YEP. For example, we will ensure afforestation across England and that the right species of tree is planted in the right place, benefitting flood management, soil health and biodiversity, while also sequestering carbon. In some cases, however, we know it will be important to manage potential misalignments: for example, ammonia emissions from digestate, a by-product from the process of anaerobic digestion, can negatively impact human health and cause biodiversity loss. We are working to mitigate ammonia emissions through the Green Gas Support Scheme, which will require participants to take additional steps to mitigate ammonia emissions, and by researching technologies that can help reduce the negative environmental impacts of digestate. The relationship between net zero and wider environmental objectives, including air quality, is set out in more detail in the *Technical Annex*.

The UK has a limited amount of land and delivering net zero will require changes to the way this land is used, for example, for afforestation, biomass production, and peat restoration. Opportunities for land to be used for multiple purposes, such as agroforestry will help to make sure land use for decarbonisation purposes is balanced with other demands, such as housing development and food production. These changes are likely to have varying effects on wider environmental outcomes and may completely alter the character of some landscapes and rural livelihoods (see section below). Land use change must be designed in a systemic, geographically targeted way with appropriate local governance and delivery structures which consider the complex range of interacting social, economic, and demographic factors. To support this, government is developing a Net Zero Systems Tool which aims to allow key decision makers to gain new insights and understanding, by highlighting dependencies and trade-offs within the land use system, as well as by demonstrating the knock-on effects of proposed policies. In addition, through the Environment Bill, the Government is introducing Local Nature Recovery Strategies (LNRS), a spatial planning tool for nature, allowing local government and communities to identify priorities and opportunities for nature recovery and nature-based solutions across England. The Bill includes a specific duty on all public authorities to "have regard" to relevant LNRSs and the spatial information they provide will support the development of local plans and other land use change incentives. Delivery of priorities and opportunities identified in LNRS will be supported by a range of delivery mechanisms including our environmental land management schemes, and in particular, the Local Nature Recovery scheme. By 2028, Defra's current plans are for total spend to be evenly split between farm-level, locally tailored, and landscape-scale investment within ELM

Seizing new opportunities

19. Reducing emissions will create growth and employment opportunities across NRWF sectors, and it is important that these opportunities are evenly felt and realised by all. Achieving net zero will require innovation from businesses and landowners, investment from government and the private sector, and changes in our choices as consumers. We want to create domestic and international demand for our low carbon, high welfare and world-renowned produce, whilst supporting international markets for sustainably produced commodities.

20. To achieve the level of emissions reductions in the NRWF sector indicated by our delivery pathway to 2037, we will need additional public and private investment of approximately £30 billion. Given the importance of R&D to deliver our pathway, we are committing to spend £75 million on net zero related R&D across the NRWF sectors over the next three years.

21. Decarbonising the NRWF sectors will regenerate communities and open up new employment opportunities right around the UK. For example, an increase in afforestation across England could support up to 1,900 jobs in 2024 and up to 2,000 jobs in 2030. By investing in rural infrastructure and skills development we will seek to ensure rural communities and rural businesses, including the most disadvantaged, benefit from net zero. There will be significant opportunities for upskilling, reskilling, and starting new career paths, alongside expanding current sectors. For example, nature-based solutions create entry-level opportunities for people just starting out, as well as requiring specialist skills such as hydrology, ecology and forest management. By delivering long-term policy certainty, we will unlock the private investment necessary to deliver these green jobs.

22. Innovation will also be vital to delivering net zero and maximising benefits for the UK. In agriculture, farmers will be able to adopt new emission saving technologies, produce lower carbon foods and steward the land in new ways, such as through vertical farming. This will allow them to diversify income streams and produce high quality, low carbon produce for domestic and international markets, boosting the rural economy. Investment in agricultural innovation, through schemes like the Farming Innovation Programme, will drive development of new precision technologies, explore the potential of robotics and artificial intelligence, and take advantage of developments in breeding technologies, including the potential of gene editing. This can also make our agricultural sector more resilient to the impacts of climate change and safeguard our food security. We also know other technological solutions, such as those to reduce emissions from non-road mobile machinery in the agricultural sector require further development. Cross government work is required to develop non-road mobile machinery policies to support the deployment of technological solutions and required infrastructure in specific sectors, including industry, transport, and buildings. Relevant government departments will work together to ensure a coherent approach (see the *Industry* chapter). A significant market share for innovations such as alternative proteins will take time to materialise, but will align with consumer dietary trends, and the UK already has a lively and growing domestic market that could grow to become another great British food export that competes internationally. These and other novel methods of food production could create significant opportunities to further promote high quality British food internationally.

23. Innovation is key to other NRWF sectors too. Industry is responding to the HFC phasedown by switching to alternative gases and technologies in areas such as refrigeration, air conditioning, and heat pumps, and will continue to innovate in this area. The UK Research and Innovation's National Interdisciplinary Circular Economy Research programme is looking at how to transition to a more circular economy. Producers will need to move to more sustainable product design, and consumers, with support from the public and private sectors, will need to shift to more sustainable product choices and towards reusing, repairing, remanufacturing, and recycling products.

Policies and proposals

Agriculture, forestry, and other land use (AFOLU)

24. We have begun the Agricultural Transition Period and have moved away from the CAP. We are reducing and then stopping untargeted Direct Payments in England and moving to a system where public money rewards farmers and land managers for environmentally sustainable actions, including reducing emissions and expanding the carbon sequestration potential of our land. We will introduce three environmental land management schemes: the Sustainable Farming Incentive (SFI), Local Nature Recovery (LNR) and Landscape Recovery (LR). The SFI will be open to all farmers and will incentivise low carbon practices, for example, soil and nutrient management. LNR will fund actions that support local nature recovery and deliver local environmental priorities. The LR scheme will fund long-term land use change projects such as large-scale tree planting, and peatland restoration projects. Net zero will be a key priority across the delivery of our environmental land management schemes.

25. Take up of these schemes will be voluntary and will require a shift in the practices of landowners and farmers. We are working to ensure the schemes encourage participation, including through appropriate payment rates, in line with the Payment Principles.[82] Participants will still be able to benefit from private sector funding, for delivering additional benefits. Advice and guidance will also be provided to support participants to adopt new practices. Tests and trials for the schemes began in 2020. The scheme will be rolled out in full by 2024.[83] Government has committed to maintain current levels of spending on the sector in England, based on 2019 levels, until 2024/5, amounting to an average of £2.4 billion a year.

26. We are also supporting the acceleration of private investment in nature through initiatives such as the Natural Environment Investment Readiness Fund. These will test new models and build pipelines of investable nature projects by providing technical assistance and capacity building support to create opportunities for private investment. Projects will capture the value of the carbon and other benefits provided by natural assets such as woodlands, peatlands wetlands and river catchments. They will create multi-functional landscapes that deliver diverse benefits, providing a return on investment and improving our understanding of how to attract private investment.

27. We will boost the existing £640 million Nature for Climate Fund with a further £124 million of new money, ensuring total spend of more than £750 million by 2025 on peat restoration, woodland creation and management. This will enable more opportunities for farmers and landowners to support net zero through land use change.

Agriculture

28. Government will support a range of measures to decarbonise the agriculture sector specifically, including by providing further funding to support farmers to take up low carbon practices and technologies. We will introduce a targeted set of financial incentives to improve animal health and welfare and reduce emissions from animals, including action to identify and eliminate bovine viral diarrhoea, with pilots starting in late 2022 or early 2023. The Farming Investment Fund will provide further grants to farmers, enabling them to invest in equipment, technology and infrastructure that will improve their profitability and benefit the environment. The scheme will be launched in 2021. From 2022, Government will also provide grants for new slurry stores, equipment, and other interventions. The primary goal will be delivering reductions in nitrate and ammonia pollutants from slurry, a key cause of pollution on farms, but the grants will also reduce methane emissions and protect and restore habitats.

29. We will increase investment in industry-led research and development into productivity challenges, delivering net zero and testing new technologies and methods. The Farming Innovation Programme will open for applications in October 2021 with further competitions planned for 2022 and beyond. These will bring together interested farmers, scientists, and researchers to tackle productivity and environmental challenges. We will invest in supporting knowledge exchange so more farmers and growers have access to the latest findings from cutting-edge research that they can apply on their farms.

30. We will encourage and support increased agroforestry (trees and agriculture coexisting on the same land) through our environmental land management schemes from the early 2020s, enabling agricultural land to sequester emissions while delivering other environmental benefits, such as air quality and biodiversity, and providing alternative income streams for farmers from trees.

31. Government is working, and will continue to work, in partnership with the sector to develop a new outcome-focused approach to regulation and enforcement which supports net zero. For example, ruminant livestock are the leading cause of farm emissions, but feed additives with methane inhibiting properties have the potential to reduce emissions, especially from housed cattle. Whilst this is an emerging technology, government is actively investigating the promising role these products may have in delivering emissions savings in the mid-term, including by assessing whether regulation could ensure maximised take up of such products.

32. We will also consider how best to reduce and better target the use of manufactured fertiliser, including exploring the potential of regulation in this area. In addition, we are considering whether we need new legislative powers to improve soil management and nutrient management. We will consider the recommendations of the Nutrient Management Expert Group, due to report in spring 2022, on the optimal policy approaches to minimise emissions from fertiliser use.

33. The Government's upcoming Food Strategy will support the delivery of net zero, nature recovery, and biodiversity commitments and will help to create a food system that incentivises farmers to produce high quality, high welfare food in the most sustainable way. Government is exploring options to reduce carbon emissions from food production, support innovation in the food sector, incentivise land use change to sequester more carbon, and preserve natural resources.

34. Government is also committed to exploring the monitoring, reporting, and verification of emissions in the agriculture sector. This will enable us to understand where the greatest decarbonisation opportunities could be across the sector, considering all options. We will continue to review potential carbon pricing strategies for land use sectors, including the potential role for voluntary or compliance carbon markets to support cost effective decarbonisation for the sector.

Peat

35. The *England Peat Action Plan* (EPAP) sets out the government's long-term vision for managing, protecting, and restoring peatlands so that they provide a wide range of benefits to wildlife, people and the planet.

36. Tackling the drivers of peatland degradation is essential. The EPAP commits to ending the horticultural use of peat in the amateur sector by the end of this parliament and a consultation will be launched on potential legislative measures (e.g. a sales ban) in 2021. Legislation to end managed burning on protected blanket bog that is 40 cm deep or more, unless covered by a license, has already been laid, protecting 40% of England's blanket bog, and government is committed to reviewing the economic and environmental case for extending protections.

37. At least 35,000 ha of peatlands in England will be restored, by 2025, via the Nature for Climate Fund. From 2024, public funding for peatland restoration will be available in England through the new environmental land management schemes. To further support peatland restoration, government is implementing a range of policies that will mobilise private investment. The Natural Environment Investment Readiness Fund has been launched and a package of reforms to the Peatland Code, including expanding it to cover more peatland types, will be implemented in 2022. We will aim to restore approximately 280,000 ha of peatland in England by 2050.

38. Degraded lowland peat is responsible for 86% of England's peatland emissions. Full restoration may not always be desirable, due to the lowlands' agricultural value and interactions with landscape scale water level management regimes. Where it is not possible to restore peatlands, we will support new responsible management measures for lowland peatlands.The Lowland Agriculture Peat Taskforce will provide recommendations in summer 2022 on how to improve the condition of lowland farmed peatlands, both to reduce emissions and support continued profitable agriculture. From 2024, our Local Nature Recovery scheme will provide a key funding stream for wetter modes of farming, including paludiculture. To prevent delay, our Farming Innovation Programme will be open to supporting applications for R&D in paludiculture from the 20 October 2021, with more competitions to follow in 2022 and beyond.

Forestry and woodlands

39. We will treble woodland creation rates by the end of this Parliament, reflecting England's contribution to meeting the UK's overall target of increasing planting rates to 30,000 hectares per year by the end of this Parliament, and maintain new planting at least at this level from 2025 onwards. We will explore a long-term statutory tree target in England within the public consultation on Environment Bill targets. We intent to spend over £500 million of the Nature for Climate Fund on funding woodland creation and management in England until 2025, beyond which the new environmental land management schemes will provide the main source of public funding. Whilst this rate of planting will lead to a relatively small emission savings in the short-medium term, it will play an increasingly important role as time goes on, while also providing other environmental benefits.

40. Private finance for tree planting and management is being generated via the Woodland Carbon Code with the support of government's Woodland Carbon Guarantee. Government has also launched a new England Woodland Creation Offer to fund woodland creation in England and will establish new Woodland Creation Partnerships in key areas, bringing together government, NGOs, and the private sector to develop bespoke offers to encourage woodland creation.

41. The government will review guidance on the tax treatment of trees and woodlands, to provide greater clarity to landowners on how new and existing trees on their land affect tax liabilities. Further, government will regulate to improve protections for existing woodlands and increase the number of woodlands under active management, improving resilience to natural hazards.

42. Felled trees store carbon within them and timber has the lowest embodied carbon of any mainstream building materials. Guided by market analysis, fire safety and structural considerations, key opportunities for the safe growth of timber use will be in low-rise buildings using traditional and certain modern methods of construction, and in a wide range of commercial and non-residential settings. We will promote the safe use of timber in construction through several measures, including by:

- Providing financial support to develop innovative timber products through the Forestry Innovation Fund;
- Working with key construction stakeholders, including the Green Construction Board, Construction Leadership Council, Home Builders Federation, and Federation of Master Builders to develop a policy roadmap on use of timber;
- Driving an increase in the use of certain modern methods of construction, some forms of which can encourage use of sustainable materials such as timber;
- Working with Homes England and delivery partners to explore ways to increase timber use in the delivery of housing programmes;
- Increasing public demand for sustainably sourced timber through procurement policies; and
- Encouraging research into barriers to uptake of timber, including looking at timber strength grades and the fire resistance of engineered timber structures.

Biomass

43. Government will publish a *Biomass Strategy* in 2022 which we will set out the results of a review of the amount of sustainable biomass available to the UK (including domestically grown perennial energy crops and short-rotation forestry), and how this resource could be best utilised across the economy to help achieve net zero. The strategy will set out the role which Bioenergy with Carbon Capture & Storage (BECCS) can play in reducing carbon emissions and how the technology could be deployed. It will also consider where and how we can improve our existing biomass sustainability standards (already some of the world's most stringent) and examine the relationship between biomass, including how it is used, and our wider environmental targets, including air quality.

Resources, waste and F-gases

Resources and waste

44. The Government's Resources and Waste Strategy (RWS) set out the overall ambition and direction of travel for the waste sector. It made a commitment to increase municipal recycling rates to 65% and to ensure that no more than 10% of municipal waste is landfilled by 2035. Biodegradable waste sent to landfill today, however, slowly breaks down anaerobically, emitting methane for many years afterwards. Faster action will mean greater emissions savings. We will therefore explore policies to work towards the near elimination of biodegradable municipal waste to landfill by 2028. To support this commitment, we are bringing forward £295 million of capital funding which will allow local authorities in England to prepare to implement free separate food waste collections for all households from 2025.

45. To work towards these goals, we are delivering the reforms announced in the RWS. Consistent collections of household and business waste will be introduced via the Environment Bill. The powers will allow us to require local authorities to separately collect a core set of materials for recycling, including paper and card, glass, metal, plastic, food waste and household garden waste. This will divert significant volumes of biodegradable waste from landfill and provide a high volume of emissions savings. A deposit return scheme for drinks containers and extended producer responsibility for packaging, placing the net costs of disposing of packaging on producers, will also be introduced. These two measures will increase the volume of materials being recycled and decrease our consumption of virgin materials, thereby reducing the amount of waste sent to landfill and reducing emissions from other sectors.

46. Complementing these measures, the introduction of the plastic packaging tax from April 2022 will encourage greater use of recycled plastic in plastic packaging, instead of new (virgin) plastic. The tax will be charged at £200 per tonne and be paid by manufacturers and importers of plastic packaging that contains less than 30% recycled plastic. It is estimated that this will lead to an increase in the use of recycled plastic by 40% in 2022-23, equal to carbon savings of nearly 200,000 tonnes of CO2 emissions. The government will also review aspects of the Landfill Tax in England and Northern Ireland in due course, as announced in Spring 2021. This will ensure the tax continues to support the government's ambitious environmental objectives.

47. Government is committed to moving to a more circular economy. This means keeping built assets, products, and materials in use for longer, including through repair and reuse, and making greater use of secondary materials, thus reducing waste arising. Recycling and material substitution, especially of carbon intensive materials such as steel, aluminium, and cement, are also an important part of our approach. The draft *Waste Prevention Programme for England (WPP)* (recently consulted on) sets out the overall approach to improving resource efficiency across key sectors and announced government's intention to consult on introducing extended producer responsibility in other areas, including textiles. The *Industrial Decarbonisation Strategy*, meanwhile, outlines our high-level ambition for resource efficiency measures across industry. At least one legislative target in the area of resource efficiency and waste reduction will be set under the Environment Bill. For further information on our plans for resource efficient manufacturing see the *Industry* chapter.

48. Government is also committed to eliminating food waste to landfill and delivering the UN Sustainable Development Goal 12.3 to halve food waste by 2030. The Environment Bill will require all local authorities in England to separately collect household food waste, preventing it from being sent to landfill. This will create carbon savings and support the shift to a circular economy, as food waste is instead turned into biogas and digestate (a soil improver) through anaerobic digestion. In addition, government will continue to work with Waste and Resources Action Programme (WRAP) and industry, and to support the Courtauld 2030 voluntary agreement with food and drink businesses, the Food Waste Reduction Roadmap, and the Target Measure Act approach, as well as campaigns in the public and private sector to reduce food waste, including the annual Food Waste Action Week.

49. Wastewater emissions will decrease due to improved treatment processes and expected data improvements. Water company research and investment into reducing process emissions from wastewater treatment plants will result in reductions in municipal process emissions via alternative treatment processes such as anaerobic treatment, membrane activated biofilm reactors, alternative ammonia removal processes and nature-based solutions. Improvements in the way companies, and government, report on industrial emissions, and the way they are calculated, are also likely to result in reductions to the values on record.

F-gases

50. Government will continue to impose the requirements of the F-gas Regulation, which covers England, Wales and Scotland. The regulation requires a range of measures to reduce emissions, including controls on gas placed on the market, product bans, leak checks and mandatory certification for handlers of F-gases. These actions will help us to meet the Kigali Amendment target of reducing HFC consumption by 85% by 2036, as well as the F-gas Regulation's target of a 79% reduction by 2030.

51. A review of the F-gas Regulation has commenced and is due to complete no later than 2022. This will be used to assess whether we can go further than the current requirements and international commitments, including by looking at what additional reductions in F-gas use can be made to help the UK meet net zero by 2050.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government and Northern Ireland Executive

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action to reduce emissions across the Natural Resources, Waste and F-Gases sectors, and across the UK.

Wales

In November 2020, the Welsh Government published its National Peatland Action Programme to target peatland bodies most in need of restoration, with the aim of delivering 600-800 ha of restoration per year.[84] It will also safeguard those in good and recovering condition. Activity will be delivered by Natural Resources Wales and partners across a range of land uses on both private and public land.

When the Senedd first sat in 1999, Wales recycled less than 5% of its municipal waste. In 2020, Wales highest ever recycling rate of over 65% put it third in the world, with 403,000 tonnes of CO_2 avoided in 2019/20.

This success is due to a truly collective effort by local authorities, communities and households, while the Welsh Government has set targets and funded infrastructure. Food waste is collected from every household and recycling centres are evolving into modern eco-parks where businesses and enterprises capture the value in materials and keep resources in use.

Scotland

The Scottish Government has set ambitious targets to restore 250,000 ha of peatland by 2030 and for 18,000 ha of new woodlands to be created annually by 2024/25, with woodland cover increased from around 19% to 21% of the total area of Scotland by 2032. Scottish Forestry and Forestry and Land Scotland will work with investors, carbon buyers, landowners, and market intermediaries to increase private investment in new woodlands to increase the woodland carbon market by at least 50% by 2025.

I n its recent Programme for Government, the Scottish Government allocated an additional £150 million for forestry and woodland creation: Scottish Forestry will use £100 million of this to support new tree planting; and Forestry and Land Scotland will use £30 million to expand Scotland's national forests and land, and £20 million to invest in modernising nursery facilities to increase tree production.

A new Scottish Agriculture Bill will be brought forward in 2023 to replace the EU Common Agricultural Policy. Co-development and co-design with rural partners will be central to the development of future support structures and delivery. The Agriculture Reform Implementation Oversight Board (ARIOB) will be asked to incorporate recommendations from farmer-led groups, into the work implementing policy reform. These groups were established to develop proposals to cut emissions across agriculture, support sustainable and high quality food production, and design a new support system. A preliminary package of funded measures will be agreed COP26, and the ARIOB will also consider responses to the public consultation launched in August on the same themes.

Northern Ireland

The Forests for our Future Programme aims to plant 18 million trees by 2030 to create 9,000 ha of new woodland. The programme will improve the resilience of Northern Ireland's forests and woodlands and increase their contribution to a sustainable, healthy environment; increase the contribution of forests and woodlands to Northern Ireland's sustainable and inclusive economic growth; and increase the use of Northern Ireland's forest resources to enable more people to improve their health, wellbeing, and life chances.

Legislative provisions to help to limit emissions from F-gases (which have a high greenhouse warming potential) and ozone depleting substances have also been brought into operation in Northern Ireland.

3vii. Greenhouse Gas Removals

Balancing residual emissions to achieve net zero

Our Key Commitments

- Set the ambition of deploying at least 5 $MtCO_2$/year of engineered removals by 2030, in line with CCC[85] and National Infrastructure Commission assessments.[86]
- Deliver £100 million innovation funding for Direct Air Carbon Capture and Storage (DACCS) and other GGRs.
- Develop markets and incentives for investment in greenhouse gas removal methods, by consulting on our preferred business models to incentivise early investment in GGRs, in 2022.
- Working in partnership with the devolved administrations, we will aim to launch a call for evidence in the coming months exploring the role of the UK ETS as a potential long-term market for GGRs, as part of our upcoming consultation on the UK ETS.
- Explore options for regulatory oversight to provide robust monitoring, reporting and verification (MRV) of GGRs, following the recommendations of the BEIS-led MRV Task & Finish Group involving experts from industry and academia.
- Seek an amendment to the Climate Change Act to enable engineered removals to contribute to UK carbon budgets.

Progress to date

1. The primary method of achieving net zero is to take ambitious decarbonisation measures across society. However, we must also acknowledge that sectors such as industry, agriculture and aviation will be difficult to decarbonise completely by 2050. Greenhouse gas removals (GGR) are therefore essential to compensate for the residual emissions arising from the most difficult activities to reduce or eliminate from within polluting sectors. This approach is supported by the Climate Change Committee,[87] the Energy Systems Catapult,[88] the National Infrastructure Commission and the National Grid ESO (the GB electricity system operator).[89]

2. GGR is the name given to a group of methods that actively remove greenhouse gases, predominantly CO_2, from the atmosphere, also commonly referred to as Carbon Dioxide Removal (CDR) methods and Negative Emission Technologies (NETs). The range of GGR approaches fall broadly into two categories:

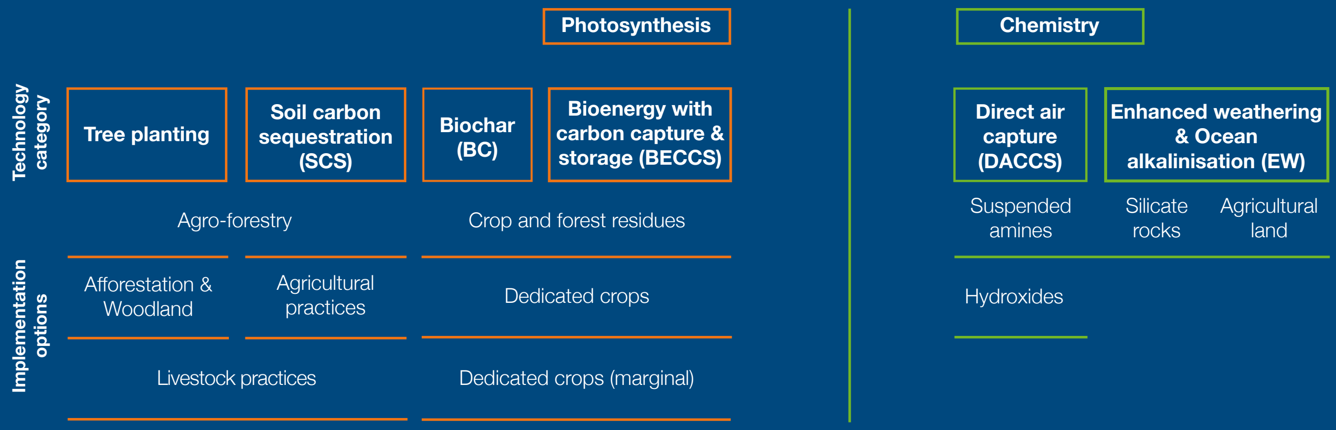
- Nature-based approaches: such as afforestation, and soil carbon sequestration.
- Engineering-based approaches: such as Direct Air Carbon Capture and Storage (DACCS), Bioenergy with Carbon Capture and Storage (BECCS), wood in construction, biochar, and enhanced weathering (EW).

3. Following the sector classification adopted by the CCC and in this Strategy, this chapter focuses on engineered removals. Nature-based solutions, such as afforestation, are discussed in the *Natural Resources, Waste and F-gases* chapter.

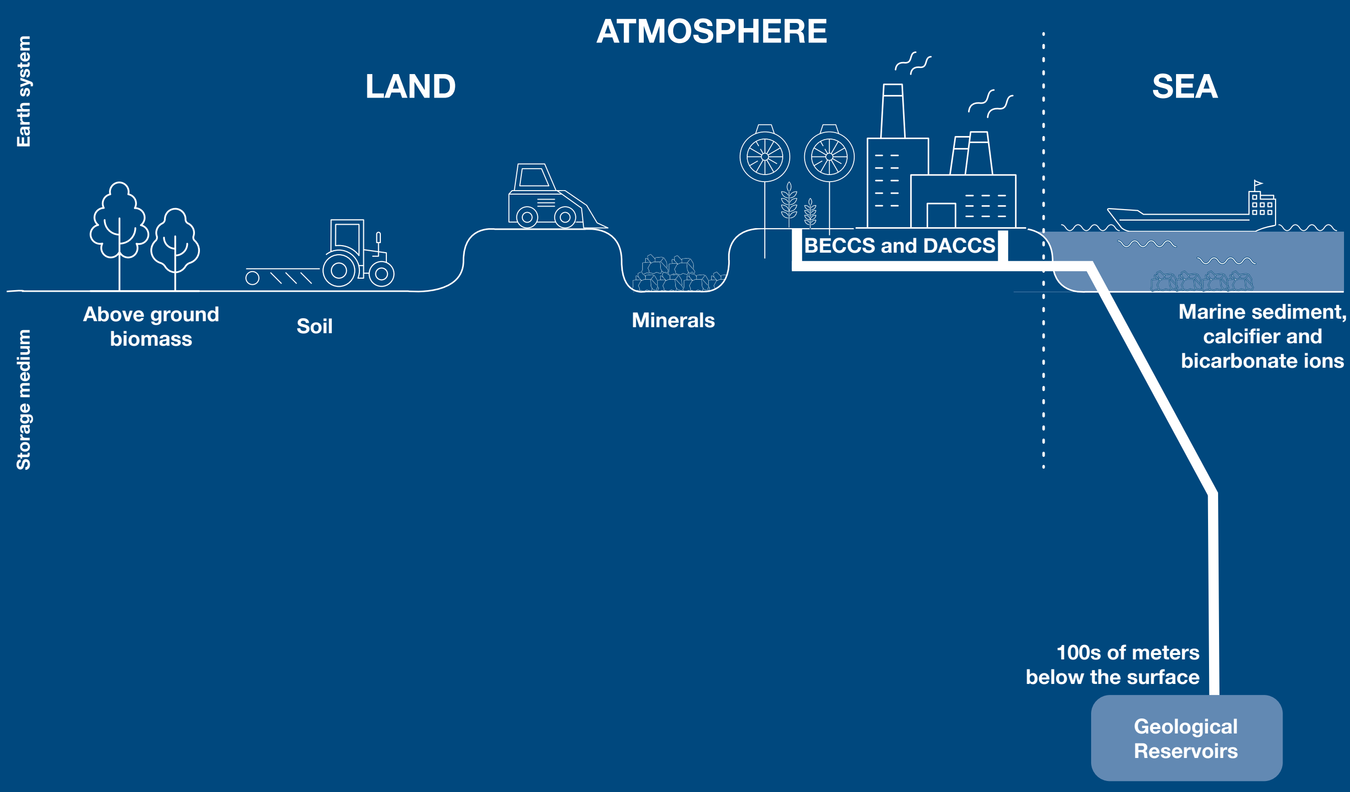
4. The 2017 *Clean Growth Strategy* was the first time the UK government formally addressed the need to deploy GGR methods. Since then, we have:

- Committed up to £100 million funding to research and develop nascent GGR;
- Published a call for evidence on GGR in December 2020; and
- Commissioned 4 studies to further our evidence base on the potential for GGR deployment in the UK and understanding of possible policy incentives.

Figure 25: Non-exhaustive illustration of the current portfolio of GGRs.[90]



	Photosynthesis				Chemistry		
Technology category	Tree planting	Soil carbon sequestration (SCS)	Biochar (BC)	Bioenergy with carbon capture & storage (BECCS)	Direct air capture (DACCS)	Enhanced weathering & Ocean alkalinisation (EW)	
Implementation options	Agro-forestry		Crop and forest residues		Suspended amines	Silicate rocks	Agricultural land
	Afforestation & Woodland	Agricultural practices	Dedicated crops		Hydroxides		
	Livestock practices		Dedicated crops (marginal)				



5. In December 2020, BEIS and HM Treasury jointly launched a Call for Evidence on GGRs, which invited views on the role of GGRs in reaching net zero and potential mechanisms which government could consider to enable their deployment. A Summary of Responses to the Call for Evidence has been published alongside this Strategy.

Net zero transition and opportunities for the sector

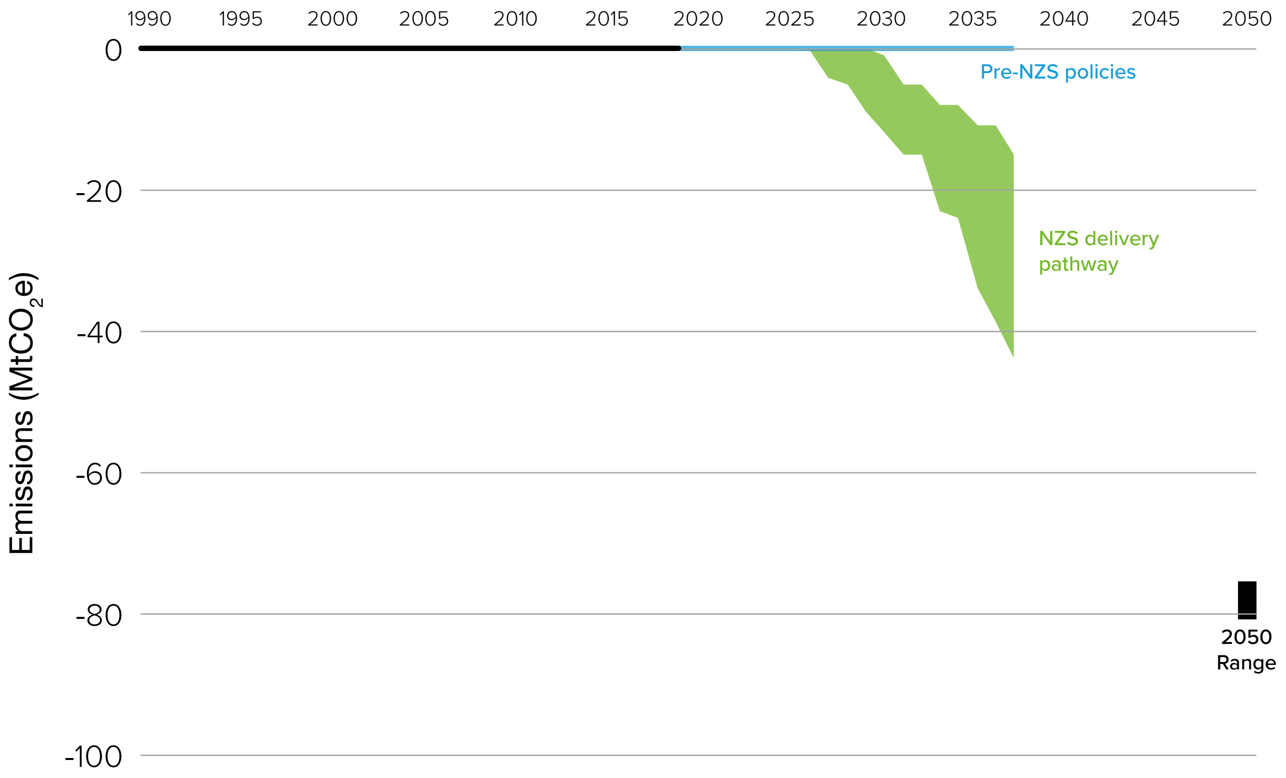
Our 2050 vision and how we get there

6. We are clear that the purpose of greenhouse gas removals is to balance the residual emissions from sectors that are unlikely to achieve full decarbonisation by 2050, whilst not substituting for ambitious mitigation to achieve net zero. GGRs must not be pursued as a substitute for decisive action across the economy to reduce emissions, often referred to as mitigation deterrence.[91]

7. There is also a need to ensure that GGRs result in a permanent net reduction in atmospheric carbon. This is a complex task which, at least in the near-term, may require case-by-case scrutiny of the carbon intensity of GGR supply chains and long-term indirect emissions of GGR projects. Developing a robust approach to the Monitoring, Reporting and Verification (MRV) of negative emissions is essential to the deployment of GGRs at scale. Future markets in which negative emissions are traded, whether voluntary or otherwise, will require careful regulation to ensure that capital is being invested into permanent, verifiable carbon removal.

8. Evidence around scale-up potential of engineered removal solutions in the UK is rapidly evolving, alongside innovation in the sector. This evidence[92,93] suggests that the next decade will be critical and several GGR solutions, such as Direct Air Capture, will have to be developed or scaled-up significantly during the late 2020s and early 2030s to contribute effectively to later carbon budgets and our net zero target, as well as to build our evidence and experience in the sector.

Figure 28: Indicative greenhouse gas removal (negative) emissions pathway to 2037



Source: BEIS analysis

9. Both nature-based and engineered removal methods will be necessary. For engineered removals, a portfolio approach, supporting innovation, demonstration, and commercialisation of a wide range of removal solutions in the 2020s, is needed to ensure GGRs can contribute effectively to meet our NDC and CB6 targets. The government's current suite of innovation programmes for DACCS and other GGRs will help ensure we continually target efficiency improvements, cost reductions and novel GGR technologies to inform our approach over the coming decades.

10. Based on the current evidence base and projects in the pipeline, our analysis indicates that engineered removals would be expected to deploy from 0 $MtCO_2$ today to at least 5 $MtCO_2$ by 2030 and to around 23 $MtCO_2$ by 2035, with higher and lower deployment possible depending on sector-specific and wider economy developments.

11. By 2030 we envisage significant deployment of mature BECCS technologies and commercial scale deployment of DACCS. BECCS technologies will include retrofit applications in the power and industry sectors. BECCS applications in the power sector could be deployed by the late 2020s, and potentially achieve ambitious contributions to our NDC target by 2030. Engineered removals are likely to be located within or near industrial clusters, benefitting from access to CO_2 transport and storage infrastructure, essential to support delivery of net-negative emissions.

12. By the early 2030s the portfolio of GGRs deployed at scale will expand as technologies mature and demand from end-use sectors increases. Beyond the contribution of power BECCS to the electricity grid, production of hydrogen, biogas/biomethane fuels with BECCS could also support the decarbonisation of transport, industry and potentially power and heat in buildings. Industry may also benefit from BECCS applications in sectors such as cement. When applicable in these areas, BECCS can represent a cleaner form of energy production than fossil fuel counterparts, whilst also bringing the additional benefit of negative emissions. The early 2030s could also see progress in deployment of DACCS technologies, thanks to efforts in demonstration and piloting during the 2020s through the support of our Direct Air Capture and other GGRs innovation competition.

13. By 2050, deployment of engineered removals at large scale, between 75 and 81 $MtCO_2$ per year, will be needed to help compensate residual emissions. This is expected to be equivalent to around 45-80% of total emissions captured across the UK economy and will see predominantly the scale up of DACCS and BECCS with gasification technologies.

Greenhouse gas removals in the context of the wider net zero system

There will be several complex interdependencies between GGR methods and the wider net zero system. Progress towards decarbonisation in other sectors will affect the extent to which GGR deployment will be required to hit our emissions targets. Conversely, GGRs have resource requirements that will impact other sectors. For example, deployment of engineered GGRs in the early years will likely be constrained by the availability of CO_2 transport and storage injection capacity and any development of GGR business models will need to consider interactions with Industrial Carbon Capture and hydrogen business models, along with wider carbon pricing policy. We have committed to consider how the UK Emissions Trading Scheme could be expanded in future to provide a long-term support mechanism for GGRs.

Biomass availability and supply

Biomass policy is highly interdependent with GGR deployment. Sustainable biomass is a unique renewable organic material, and the future availability of sustainable biomass directly influences the scale GGRs such as BECCS and biochar can deploy to. Constraints on demand for perennial energy crops and solid recovered fuels, related mostly to technological and financial challenges, will need to be overcome via research and innovation to see significant increase in the take up of these biomass feedstocks. The upcoming Biomass Strategy (due to publish in 2022) will review the amount of sustainable biomass available to the UK and set out a framework for how this resource can be best utilised across the economy to help achieve our net zero target. The upcoming biomass policy statement gives an early indication of this framework, setting out the principles and policy aims for biomass up to 2050.

The Strategy will also assess the UK's current sustainability standards, to see where and how we can improve them even further. Any future BECCS project would be required to meet stringent sustainability requirements for the production and use of biomass, as will be set out in the Biomass Strategy.

Using our land effectively

Land use change will be required to accommodate GGRs, either directly through nature based GGRs such as afforestation or indirectly from increased production of woody biomass, such as perennial energy crops or short rotation forestry, to use for BECCS or other opportunities in the wider bioeconomy.

What is best grown, where, in what quantity, and for what purpose, determines the feasibility of a GGR through land-use change. Feasibility therefore must consider, amongst others: alternative land use, feasible technological options for production, the net impact on GHG emissions, interactions with competing land demands for other strategic government objectives such as food security, nature conservation and housing, as well as social implications such as integration of GGRs into existing farm practice and environmental co-benefits/risks.

Further research is required into best practice for establishing GGRs in a productive and biodiverse landscape, and what levers may be required to establish such measures on land that is largely privately owned. Research projects through the UKRI SPF on GGRs and NERC GGR Research Programme will start to address these evidence gaps. GGR deployment will require alignment with HMGs schemes to reward environmental land management for example: Sustainable Farming Incentive (SFI), Local Nature Recovery (LNR) and Landscape Recovery Schemes. We will also need to consider interactions with private sector demands, such as through the domestic voluntary carbon market.

Uncertain impacts from climate change such as impacts to national stocks of high-grade farmland also demands consideration of what is both feasible now and on the way to 2050. Differences in spatial and temporal scales between removal technologies, such longer pay-back times for afforestation as opposed to short rotation forestry, create opportunities to maximise carbon removals to 2050 through a mix of land based GGRs.

Managing environmental risks and benefits

There are significant opportunities for maximising environmental co-benefits through nature based GGRs. For example, integrating perennial energy crops (e.g., short rotation coppice (SRC)) into existing farm systems can increase the abundance and diversity of flora and fauna at a field scale, though these benefits depend on factors such as historic cropping patterns and spatial distribution. At a landscape scale, afforestation can deliver co-benefits through natural flood management and urban cooling. However, benefits depend on sustainable forest management and choosing the right location and species of tree in the ecosystem.

We must ensure that GGR technologies do not create new environmental risks. For instance, feedstock production for BECCS, biochar and wood in construction have potentially significant land requirements which if mismanaged could pose risks to biodiversity. The deployment of BECCS could also potentially impact local air quality and we must ensure that regulation and abatement on emissions other than CO_2 develop to reflect this. It is also necessary to ensure resilience to the impact future climate change might have on the feasibility to deliver GGRs and wider environment objectives.

CO_2 Transport and Storage networks

By the early 2030s, CO_2 transport and storage infrastructure availability could potentially constrain GGR deployment, as the significant overall expansion of CCUS projects creates competition for access to the network.

Seizing new opportunities

14. The UK is well placed to take a leading role in GGR policy development and deployment. We have world-leading academic and industry expertise in relevant sectors, as well as a rapidly developing carbon capture usage and storage (CCUS) sector and access to large volumes of quality geological CO_2 storage. Enabling GGR deployment will not only help us hit net zero but can support the UK's ability to export skills and expertise to other nations with comparable ambitions for the sector.

15. To achieve the level of negative emissions indicated by our central delivery pathway to 2037 and keep us on track to deliver net zero, we will need additional public and private investment of around £20 billion. Scaling up the GGR sector will also regenerate communities and open up new employment opportunities right around the UK.

16. It will be crucial to ensure that future GGR policy maximises the economic and regional development opportunities of developing the low carbon economy in our industrial heartlands. Economic benefits include creating new, highly skilled jobs in our industrial heartlands and safeguarding those existing in adjacent sectors with the potential to be adversely affected by the transition to net zero, as well as supply chains.

Policies & proposals

17. Government has a clear role to play in responsibly deploying GGRs, and is committing to an ambition of deploying at least 5 $MtCO_2$/year of engineered removals by 2030. To achieve this, we are taking ambitious steps to enable commercial demonstration and deployment of engineered GGRs such as Direct Air Capture. We are addressing their financial and regulatory barriers, whilst also working to build the evidence base and address continued uncertainty around how GGRs can most effectively and sustainably be deployed and verified. Our role will change over time, as GGRs become more established, and the sector matures.

Addressing financial barriers and attracting investment

18. One of the fundamental barriers to GGR deployment is the lack of an established market or customer demand for engineered removals. GGR technologies are associated with high capital and operational costs, making private investment unattractive in the absence of a stable revenue stream for the provision of negative emissions.

19. The government's vision is to establish a liquid market for carbon removals, in which polluters have a strong policy or financial incentive to invest in GGRs to compensate for their remaining emissions. The UK Emissions Trading Scheme (ETS) is a possible market-based solution for stimulating investment by GGRs – moving us towards a single, integrated compliance market for carbon, with negative emissions supporting liquidity as the ETS allowance cap falls over time.

20. GGR credits could function within an ETS market through, for instance, allowing polluting sectors to meet their obligations through the procurement of negative emissions alongside conventional abatement options. In the *Energy White Paper*, the government committed to exploring how the UK ETS could incentivise the deployment of GGR technologies. We aim to work with our Devolved Administration colleagues to launch a call for evidence in the coming months on the role the UK ETS could have as a potential long-term market for engineered or nature-based GGRs. This may explore possible eligibility criteria for participation in the UK ETS, different types of GGR market design, and timings for when GGRs could be added to the market.

21. We recognise that a market for GGRs will take time to establish and a phased approach is likely to be necessary. In the short-term, there may be a role for government in providing bespoke support for initial projects to de-risk investment decisions and provide revenue certainty for technology developers. Yet we also recognise the potential for early support instruments to integrate with market-based approaches, such as combining contract mechanisms with inclusion of GGRs in the UK ETS.

22. To advance our ambition to stimulate the GGRs sector, we will consult on business models for engineered GGRs in Spring 2022. This will set out details of our preferred mechanisms to incentivise early investment and enable commercial demonstration of a range of GGR technologies from the mid-to-late 2020s. The consultation will consider how GGR incentives interact with policies and business models currently under development for CCUS, hydrogen production, sustainable aviation fuels and other relevant sectors, along with wider carbon pricing policy. It will also consider how near-term policy incentives can most effectively leverage private investment and enable a transition towards a market-led framework as the sector matures.

23. Our proposals will be informed by a study currently being conducted for BEIS by Element Energy, as well as a recent study on commercial frameworks for first-of-a-kind Power BECCS projects which is published alongside this document.

24. Whilst seeking to capitalise on the economic benefits of GGR development in the UK, we are also mindful of potential disruption to existing markets and the effects on consumers and businesses. The cost of support for GGRs is likely to be shared between the public and private sector. We will seek to develop an appropriate balance of risk allocation over the short, medium, and long term. Potential policy frameworks to enable developing GGR solutions will require careful consideration to guard against unintended effects. We will ensure that support for GGRs does not distort the development and commercialisation of decarbonisation technologies in other sectors.

Innovation

25. The majority of GGR techniques are at a pre-commercial stage and require innovation and demonstration support to be ready for commercial deployment. To address this GGR technologies were included as one of ten innovation priority areas announced in the *Ten Point Plan* for a green industrial revolution.[94] Together with UKRI, we are investing £100 million in the research, development, and demonstration of greenhouse gas removals across multiple programmes. This includes the DAC and other GGR innovation competition which will support the construction of pilot plants for a range of promising technologies to help them achieve commercial realisation.[95] The programme's pilot projects could remove between 100 and 1,000 tonnes of CO_2e per year in 2025 and have the potential to scale up to millions of tonnes by the 2030s.

26. Through the government's Strategic Priorities Fund, UK Research and Innovation (UKRI) will invest £31.5 million in five land based GGR demonstrator projects and a central hub. The hub will lead on coordination across the programme, as well as conducting cross-cutting research on the environmental, economic, social, ethical and governance implications of GGR approaches.

27. The Biomass Feedstocks Innovation Programme aims to increase the production of sustainable domestic biomass by funding innovative ideas that barriers production. The sustainable, increased supply of biomass for bioenergy conversion is a critical factor for the success of BECCS.

28. We are also publishing the outputs of two BEIS commissioned research projects designed to further our understanding and evidence base on GGR methods and their deployment. An updated assessment of greenhouse gas removal methods and their potential deployment in the UK provides a comprehensive and up-to-date assessment of lifecycle costs, TRL and deployment potential to 2050.

Monitoring, reporting and verification of GGRs

29. Once atmospheric carbon has been captured, the length of time it remains captured becomes crucial in verifying the effectiveness of a GGR process. This applies to both nature based and engineered solutions and is often referred to as the 'permanence' or 'durability' of GGRs. Establishing robust Monitoring, Reporting and Verification (MRV) protocols is highly complex, particularly for some nature-based solutions.

30. In 2021, we established a GGR MRV Task and Finish Group, comprised of experts across government, industry, academia, and regulatory services. The role of the group was to provide advice and guidance on the development of a MRV policy approach for GGRs. A recommendation made by the group is the need for an independent audit function to be responsible for a monitoring, reporting and verification regime. This would ensure that the amount and permanence of removals are quantified, robustly and transparently, which will be essential to developing and supporting a market for GGRs.

31. Alongside this document we have published a report summarising the work of the group, including proposed principles to guide our MRV approach, initial suggestions for how MRV protocols could operate, and the future work required to advance the development of an MRV policy for negative emissions. The government will carefully consider the Group's advice as we take forward future work in this area.

32. Accounting for emissions associated with international supply chains presents a challenge for GGR carbon accounting, and we will engage with our international counterparts to ensure best practice is achieved. Accounting for possible re-emissions, e.g., of CO_2 captured internationally but stored in the UK may be a particular challenge. We commit to collaborating with international partners to ensure alignment on any future MRV framework.

Legal and regulatory

33. Currently the Climate Change Act 2008 only recognises removals from Land Use, Land Use Change and Forestry (LULUCF) as counting towards our carbon budgets, a definition which does not allow engineered removals and some nature-based solutions to contribute. We propose to bring forward legislative amendments to address this.

34. An MRV regime will be required to ensure that the amount and permanence of removals are quantified, robustly and transparently, with tolerable uncertainty. We will explore options for establishing a regulatory function to provide this oversight, taking into consideration the advice of the MRV Task and Finish Group.

Working together across the UK

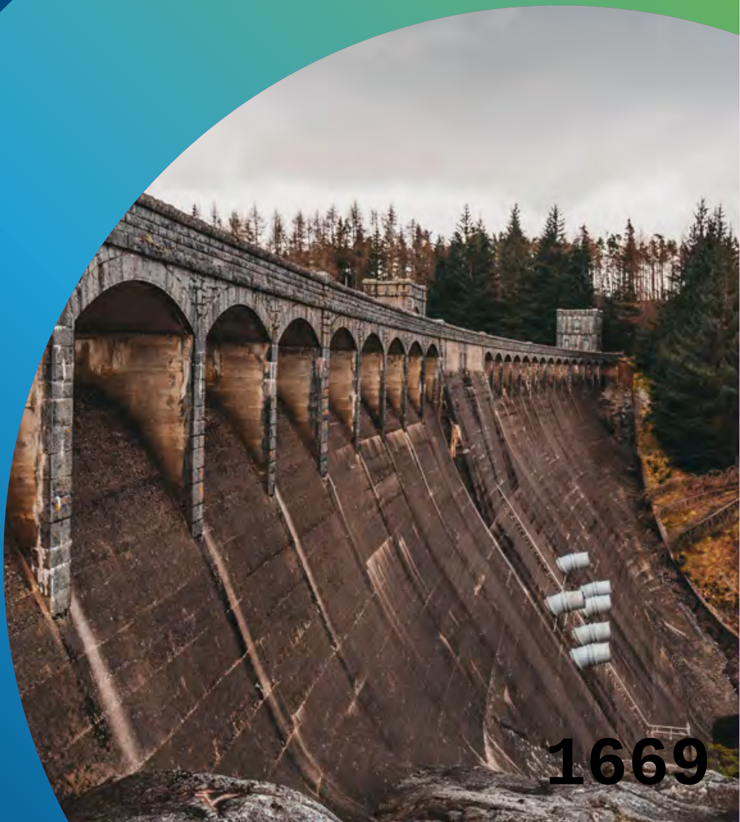
Example of policy action by Scottish Government

UK Government is working across all levels of government and with Devolved Administrations to ensure consistent action on Greenhouse Gas Removals, and across the UK.

Scotland

Storegga and Carbon Engineering have announced a partnership to develop commercial Direct Air Capture (DAC) projects in the UK, potentially contributing to the removal of millions of tonnes of CO_2 each year. One location being considered for their first proposed plant will sequester up to 1 mtpa, connected via pipeline to the Acorn Carbon Capture and Storage project at St Fergus. The proposed DAC facility would deliver permanent CO_2 removal by capturing CO_2 from the air then safely and permanently storing it deep below the seabed in an offshore geological storage site. The offshore Acorn CO_2 storage site is aiming to be operational by the mid-2020s and the first DAC project could be operational within two years of the store opening.

The Scottish Government's Climate Change Plan committed to a detailed feasibility study of opportunities for developing negative emission technologies (NETs) in Scotland. This will identify specific sites and applications of NETs, including developing work to support policy on Direct Air Capture and its role in our future energy system. The launch of a £180 million Emerging Energy Technologies Fund to support Hydrogen, CCS, and NETs projects has also been announced.



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Supporting the Transition across the Economy

Chapter 4

4i. Innovation for net zero

Harnessing UK strengths in R&D to reach net zero

Our Key Commitments

- Increase government **investment in R&D to £22 billion;** increase total R&D investment to 2.4% of GDP by 2027.
- Publish the **UK's first Net Zero Research & Innovation Framework** to set out the key research and innovation challenges for the next 5-10 years; and a future update to demonstrate how the government is delivering against these.
- **Deliver a Government programme of innovation to enable decarbonisation –** funding of at least £1.5bn during next spending review period expanding a portfolio of cross government net zero innovation to fund BEIS-led programmes on power, buildings and industry; DfT-led programmes across transport; and DEFRA led programmes on natural resources, waste and F-gases, to target priorities aligned with the Net Zero Research & Innovation Framework. This spending includes new programmes set out in this Strategy such as £60m Heat Pump Ready programme.
- Take a **leadership role in Mission Innovation 2.0,** a global initiative working to accelerate clean energy innovation.[1]

The challenge

1. Innovation is central to our approach to delivering net zero. It will require a step change in the rate of new technologies and processes being developed and deployed into the market and being adopted by businesses and consumers. Continued investment in cutting-edge research, development, and demonstration, will be integral to achieving this transformation and to the UK leading the world in areas of existing and potential competitive advantage. This investment will also support businesses to grow and solutions to be delivered at scale. Research, development, and innovation are needed to allow government, industry and business to make decisions about what new technologies and systems are promising. To respond, government must enable the efficient scaling of technologies, systems, and business models to pull them through to commercialisation for 2050 - and beyond.

Our goal

2. Our goal is for the UK to be a global leader in the technologies, processes, services, and business models needed to decarbonise our economies, protect our environment, and adapt to a changing climate. We will support our world class innovators, entrepreneurs, and financial institutions to develop and deploy the key technologies of the future. This will need to take place alongside other cross-cutting policies, regulatory changes, and commitments.

3. By supporting innovation, we could unlock the potential for 300,000 jobs in exports and domestic industry through new commercial opportunities across low carbon sectors.

4. In the Prime Minister's *Ten Point Plan for a Green Industrial Revolution,*[2] we restated our commitment to raise total private and public R&D investment to 2.4% of GDP by 2027 – enabling the next phase of green innovation to help bring down the cost of the net zero transition, nurture the development of better products and business models, and understand consumer choices. We have started delivering on this with funding announced for programmes across the portfolio including renewables, energy storage and flexibility, and hydrogen.[3] This is contributing to levelling up across all regions of the UK whilst helping us to achieve our net zero target.

The role of innovation

5. Innovation can significantly reduce costs of the technologies, processes, and systems needed to reach net zero. This goes beyond just developing technologies. It also means exploring new business models, approaches to financing, the regulatory environment and how consumers respond. Taking a whole systems approach to innovation will be integral to maintaining and developing the UK's global leadership in areas where we have, or can develop, an international comparative advantage or unique capability. We must harness the UK's international reputation to attract inward investment and anchor existing and emerging supply chains in the UK. International collaboration will also be critical to ensure that clean technologies become cheaper and more readily available.

6. Innovation is a process which occurs within an ecosystem of interacting actors, technologies, and institutions. This requires technologies, systems or processes to progress through multiple phases of development – from basic research, through to commercialisation and diffusion. However, innovation does not flow neatly in one direction from one phase to the next; it is unpredictable and serendipitous, involving constant cycles of learning, testing, refining, and discovery. At each phase of the innovation process there are different market failures and barriers, requiring distinct interventions. In the early stages, there are often minimal incentives for private actors to invest in innovation and direct funding policies can help 'push' technologies towards demonstration and early commercialisation. In the later stages, the importance of attracting private finance grows. Market incentive policies support the development of markets and leverage private finance to 'pull' technologies towards deployment and diffusion.

7. The Prime Minister's *Ten Point Plan for a Green Industrial Revolution*, our *Plan for Growth* and our new *Innovation Strategy* bring together ambitious policies and significant public investment to achieve net zero, whilst seeking to mobilise substantial private investment. These commitments will position the UK to take advantage of export opportunities in global markets presented by these low carbon technologies and services.

Case study: Glass Futures with Encirc pilot project

Through government's 2016-21 Energy Innovation Programme, BEIS funded Encirc (a glass container manufacturer) and Glass Futures (an industry research and technology organisation) to lead a trial project based in Derrylin, Northern Ireland to help determine the most effective approach to using low carbon fuels in manufacturing in the glass sector.

This revolutionary project has proven that new bottles can be made from 100% recycled glass by using energy only from burning low carbon biofuels. It is thought that this world-first initiative will set a global standard and make way for an industry-wide reduction in carbon emissions in the glass sector.

When made from waste organic materials, biofuels are a renewable and much more sustainable fuel source than those traditionally used by the glass sector and can reduce the carbon footprint of each bottle by up to 90%. By using up to 100% recycled glass to create new bottles, the trial has further minimised the lifetime impact of these new products.

Supporting innovation for net zero

8. Achieving net zero will require profound changes to the UK economy. It will mean increasing our low carbon electricity supply, making the transition to low carbon buildings, decarbonising transport, building a hydrogen economy, decarbonising industry, rolling-out carbon capture and storage, transforming the way land and marine spaces are used, improving agricultural management, adopting better waste management, and deploying technologies to remove greenhouse gases from the atmosphere. This should include innovation to mitigate any environmental impacts from new technologies on our pathway to net zero.

9. In each of these sectors, known technologies, business models, services and approaches will need to be demonstrated and then deployed at scale, while novel technologies need R&D support now to determine whether they can be affordable and viable options in the longer-term. Underpinning this will be research to understand consumer acceptability and behaviour, and to create economic incentives will also be required for lasting change.

10. We're publishing the *Net Zero Research & Innovation Framework* which sets out the critical net zero research and innovation challenges across the UK that require development over the next 5-10 years, and presents timelines of short, medium, and longer-term priorities. The framework will help to align current and future government funding around agreed priorities and to crowd-in effort and investment from the private sector and research communities by providing a clear signal on our areas of focus.

Government R&D Support

11. Government investment in research drives progress on our goals, from the physics underpinning battery technology to the mathematics underlying climate modelling. In November 2020, we committed to increasing investment in core UK Research and Innovation (UKRI) and National Academy funded research by more than £1 billion by the April 2024 (the 2023/24 Financial Year). UKRI investment in research, innovation, and skills creates the conditions for the UK to address the complex and interrelated challenges of achieving net zero by 2050.

12. Beyond early-stage research, investment in new technologies is essential for bringing them closer to commercialisation. We will expand our cross government portfolio of net zero innovation support, delivering at least £1.5 billion during the next spending review period. This will accelerate the commercialisation of low carbon technologies, systems, and business models across the economy.

13. The Transport Decarbonisation Plan committed to implementing a range of innovation programmes to support the decarbonisation of transport, with successful projects for zero emission road freight trials and hydrogen transport pilots recently announced. Building on the success of our £20 million zero emission road freight trials, we will expand these to trial three zero emission HGVs technologies at scale on UK roads to determine their operational benefits, as well as their infrastructure needs. The accompanying *Jet Zero: our strategy for net zero aviation* proposes a suite of policies to reduce aviation emissions, including accelerating the development of sustainable aviation fuels and supporting the development of zero emission flight. The *Agricultural Transition Plan* set out the commitment to boost innovation and help farmers and growers increase productivity, sustainability, and resilience to a changing climate. Given the importance of R&D to deliver emissions savings across the natural resources, waste and F-gases sectors, we are also committing to spend £75 million on net zero related R&D in these sectors over the next three years.

14. We will prioritise innovations where there is a strong case for UK Government investment, while leveraging additional funding from industry. It will also support the UK in maintaining its leadership in the development of technologies such as nuclear reactors and fusion energy,[4] which are expected to complement renewable sources in the future. With high levels of innovation alongside ambitious policy support in technologies, the UK's low carbon sectors with the largest potential could unlock £60 billion of GVA in the UK.[5]

15. The Industrial Strategy Challenge Fund (ISCF),[6] delivered by UKRI and its partners, drives UK growth and productivity by directing innovation across sectors and disciplines behind government's strategic priorities. ISCF has to date allocated £824 million to eight challenges aligned to the 2017 Industrial Strategy Clean Growth Grand Challenge. Examples include the Transforming Food Production Challenge; the Faraday Battery Challenge; the Driving the Electric Revolution Challenge.

16. The government's *Innovation Strategy* sets out our plans for a refreshed Innovation Missions programme to build on UK leadership in mission-driven innovation and bring government together with industry, civil society, and academia to respond directly to major challenges confronting the UK. As referenced in the *International* chapter, Missions can play an important role in stimulating and leveraging innovation for tackling complex problems while simultaneously promoting growth and improved business outcomes and restoring the UK's place as a science superpower.

17. It is a strategic focus of our *National Space Strategy* to utilise space technology in the fight against climate change. Satellites provide an extraordinary insight into our climate and environment and enable us to understand and monitor how climate change is impacting the Earth. We will strive to remain at the forefront of Earth Observation (EO) technology and know-how. This supports our ambition to be a global science and technology superpower and to lead the world in tackling climate change and biodiversity loss.

18. It is essential that we track cross-government activity and ensure that innovation funding is strategically aligned to deliver the government's net zero ambition. This will be supported by the Net Zero Innovation Board (NZIB), chaired by the UK Government's Chief Scientific Advisor.

19. Alongside our policies that specifically support our net zero objectives, there will be continued significant public investment in R&D to support all sectors. This includes the creation of a new institution – the Advanced Research and Invention Agency (ARIA) – to fund high-risk, high-reward research. ARIA's leadership will have full scope to determine the areas in which it will invest.

Case study: Hy4Heat Programme and Hydrogen Fuelled Appliances

The Hy4Heat programme was launched by BEIS in 2017 to explore the use of hydrogen gas for heating by seeking to demonstrate technical feasibility and safety. It aims to define quality and technical standards, and to develop domestic and commercial hydrogen appliances. The programme, with up to £25 million funded by BEIS, is supporting the innovation journey of a range of domestic hydrogen appliances and meters including world-first hydrogen-ready boilers, cookers, and fires.

These hydrogen appliances and meters are being installed at a hydrogen home facility, developed in partnership with Northern Gas Networks (NGN) and Cadent. This will enable industry and members of the public to see how these appliances work in a home setting. These properties will be the first UK houses to demonstrate the use of hydrogen appliances in a real-world setting.

Policy and regulatory frameworks

20. As set out in the *Ten Point Plan* and *Energy White Paper*, we will continue to develop a policy environment and regulatory framework which incentivises further deployment of new technologies, services, and business models. The UK's Electricity Market Reform is an example of how government can drive significant cost reductions in low carbon technology. Furthermore, while supporting the deployment of offshore wind through the Contracts for Difference scheme, costs have reduced by >50% in the last decade. This provides a clear example of policy 'pull' whereby open competition worked to drive cost reductions through deployment and innovation. As noted throughout the strategy, government will work with industry, businesses and consumers to consider the removal of regulatory barriers which may be hindering our transition to net zero.

Encouraging private sector investment

21. To deliver net zero, it is essential that public investment catalyses significant flows of private investment into innovative companies and activities. This means creating the right conditions for all businesses to innovate and giving them the confidence to do so. The right conditions will often involve de-risking capital in the forms of grants (allowing freedom to innovate) and concessionary capital (allowing businesses to commercialise and scale their operations). Providing the private sector with clarity on government R&D priorities can also help to build the confidence to invest in innovative companies and activities. As outlined, our *Net Zero Research & Innovation Framework* sets out a structure for this and a future update will demonstrate how the government is delivering against this Framework.

22. In *Build Back Better: our plan for growth*, and the *Innovation Strategy*, we set out our aim to unlock the potential of the £2.2 trillion held in UK pension schemes by addressing barriers to long-term investment. The government has established the Productive Finance Working Group, which published its roadmap for increasing productive finance investment in September 2021,[7] and is progressing policy development through several Department for Work and Pensions consultations. These workstreams explore ways to make it easier for schemes to invest in alternative assets, including equity investment in innovative firms; creating the conditions for capital to flow into the UK's most promising firms will help ensure that finance is available for the innovation required to meet our net zero goals and improve outcomes for UK savers. Government will continue to engage closely with pension funds and the investment industry to understand the scope for industry-led initiatives that take advantage of innovation investment opportunities.

23. We will also provide the right conditions to attract private investment in R&D and innovation, including through tax and regulatory frameworks as well as policy signals from government. At Spring Budget 2021, the Government announced a review of R&D tax reliefs with the publication of a wide-ranging consultation. The review will ensure that the reliefs are up-to-date, competitive and well-targeted.

Case study: Energy Entrepreneur's Fund (EEF)

Since 2012, the UK government's Energy Entrepreneurs Fund (EEF) has awarded £72 million worth of grants, supported 156 projects, and leveraged more than £500 million in private investment – a figure that is still growing. The EEF supplies innovation grants for SMEs and start-up companies to back the development and demonstration of disruptive technologies whilst also supporting our decarbonisation targets.

Axis Energy Projects (AEP) was funded with over £200,000 with £40,000 of match-funding from the private sector. AEP tested floating offshore wind (FOW) technology in Edinburgh, Scotland simulating how FOW can be resistant to 100-year storm events in water depths of 65 – 100 metres. The project has increased technology readiness levels from 3 (research) to 6/7 (deployment). The programme has had several achievements including supporting the displacement of over 21 million kilograms of CO_2 per year and it will also help to lower the Levelised Cost of Energy (LCOE) with a 30% reduction in comparison to other FOW designs and comparable offshore fixed installations. AEP's research and testing has also reduced the operating costs including low-cost deployment and reduced dependency on specialist vessels. A new company has been formed – Axis Energy TLB Ltd. – which will enable the commercialisation of the technology, having secured trademarks and patents around the world. A recent report from the Offshore Renewable Energy Catapult (OREC) predicts that the UK FOW industry could support up to 17,000 jobs by 2050 and generate a gross value added (GVA) of £33.6 billion.

Wider support

24. Non-financial support in the form of engagement with businesses is also key to the development and deployment of new technologies, systems, policies and business models to achieve net zero. This includes, for example, support provided through UKRI, its Knowledge Transfer Network, and other bodies like the Catapult network and Intellectual Property Office. It also includes UKRI's digital platform pilot programme, which will be used to bring net zero businesses together with investors for deal flow and to make information on companies more accessible to investors. The *Innovation Strategy* set out how we will build on this important support and provide advice, networking opportunities, skills development, and testing facilities. This includes a new online Innovation hub from Innovate UK, which will make it easier for businesses to navigate the government's funding offer, and expansion of the Innovate EDGE service which helps firms to enhance their investment readiness. More detail on our approach to green jobs and skills is set out in the *Green jobs, skills, and industries* chapter.

25. The *Innovation Strategy* also set out our ambition for government departments to procure more innovative solutions. Departments will produce clear policy problem statements that describe the priority outcomes that they want to solve or achieve. Alongside this, every major project[8] should publish an outcome statement. Both measures will improve demand-signalling from departments, allowing them to procure innovation to accelerate the UK's transition to net zero. This will help us to leverage public procurement as a tool that drives greener and more resilient outcomes across public services.

International collaboration and leadership

26. Building on our approach domestically, we are committed to continued active membership of Mission Innovation as the primary forum to strengthen international cooperation on clean energy innovation which is essential for our long-term climate and energy goals. An ambitious second phase of Mission Innovation is a priority for government. We will provide global leadership and commit to co-leading missions to build a renewable-powered future and deliver low cost, low carbon hydrogen.

27. Elsewhere, UK participation in Horizon Europe, the world's largest collaborative research programme worth around €95 billion over the next decade, will help us reach our net zero goals. With a minimum of 35% of funding earmarked for climate change projects, this collaboration with other world leaders in net zero research will drive further progress.

28. Further detail on government's plans for international collaboration and leadership, including Mission Innovation, can be found in the *International leadership and collaboration* chapter of the strategy.

Case study: Horizon 2020

- **Secure, Clean and Efficient Societal Challenge -** Between 2014 and 2020, around €5.9 billion was allocated through Horizon 2020, to support non-nuclear research through the Secure, Clean and Efficient Energy Societal Challenge. This aimed to support transition to a sustainable and competitive system focused on efficiency, low carbon technologies and smart cities.
- **Nova Innovation -** Nova is an Edinburgh-based tidal energy device and project developer based in Edinburgh and Shetland. Nova was awarded a total of €32.9 million in funding from Horizon 2020, including €20 million funding from Societal Challenge for Secure, Clean and Efficient Energy for their projects investigating tidal energy. The project allowed Nova to access infrastructure that is not available in the UK, for example testing facilities in the Netherlands, and provided networking opportunities that led to Nova working with major multinational companies to create bespoke components.

4ii. Green Investment

Leading the world in green finance

Our Key Commitments

- Use the UK Infrastructure Bank (UKIB) to crowd in private finance, support more than £40 billion of investment, and pull through low carbon technologies and sectors to maturity and scale.
- Continue to issue green gilts following the success of the UK's debut sovereign green bond in September 2021, which aims to raise a minimum of £15 billion this financial year. Issue a National Savings & Investment Green Retail Savings Product.
- Support the British Business Bank's new objective to incorporate net zero and wider environmental, social and governance strategy across all activity, as well as the updated FCA and Bank of England's remit reflecting the importance of environmental sustainability and the transition towards net zero.
- Introducing new Sustainability Disclosures Requirements through *Greening Finance: A Roadmap to Sustainable Investing*, including through:
  - Becoming the first G20 country to make disclosures aligned to the Taskforce for Climate-Related Financial Disclosures (TCFD) mandatory across the UK economy.
  - Developing a UK Green Taxonomy and creating the Green Technical Advisory Group to advise on greenwashing and how to implement the taxonomy in a UK context.
- We published our roadmap setting out our approach to sustainability disclosures ahead of COP26. This includes a commitment to publish a second iteration of the *Green Finance Strategy* for the UK which will outline the pathway to net zero for finance in the UK.
- We will work with external partners and data providers to better track private investment into the net zero economy going forward.

The challenge

1. Both public and private investment will be crucial for any path to net zero. While we expect most investment to come from the private sector, market failures mean the private sector alone will not deliver emissions reductions and innovation at the pace required.

2. Our 2019 *Green Finance Strategy* demonstrated how the strategic use of public funds, long-term policy frameworks, and signalling can leverage private investment into the technologies and infrastructure that will be needed to deliver net zero. Each technology and sector will present its own challenges, and long-term government support for a large pipeline of projects will be needed.

Our goal

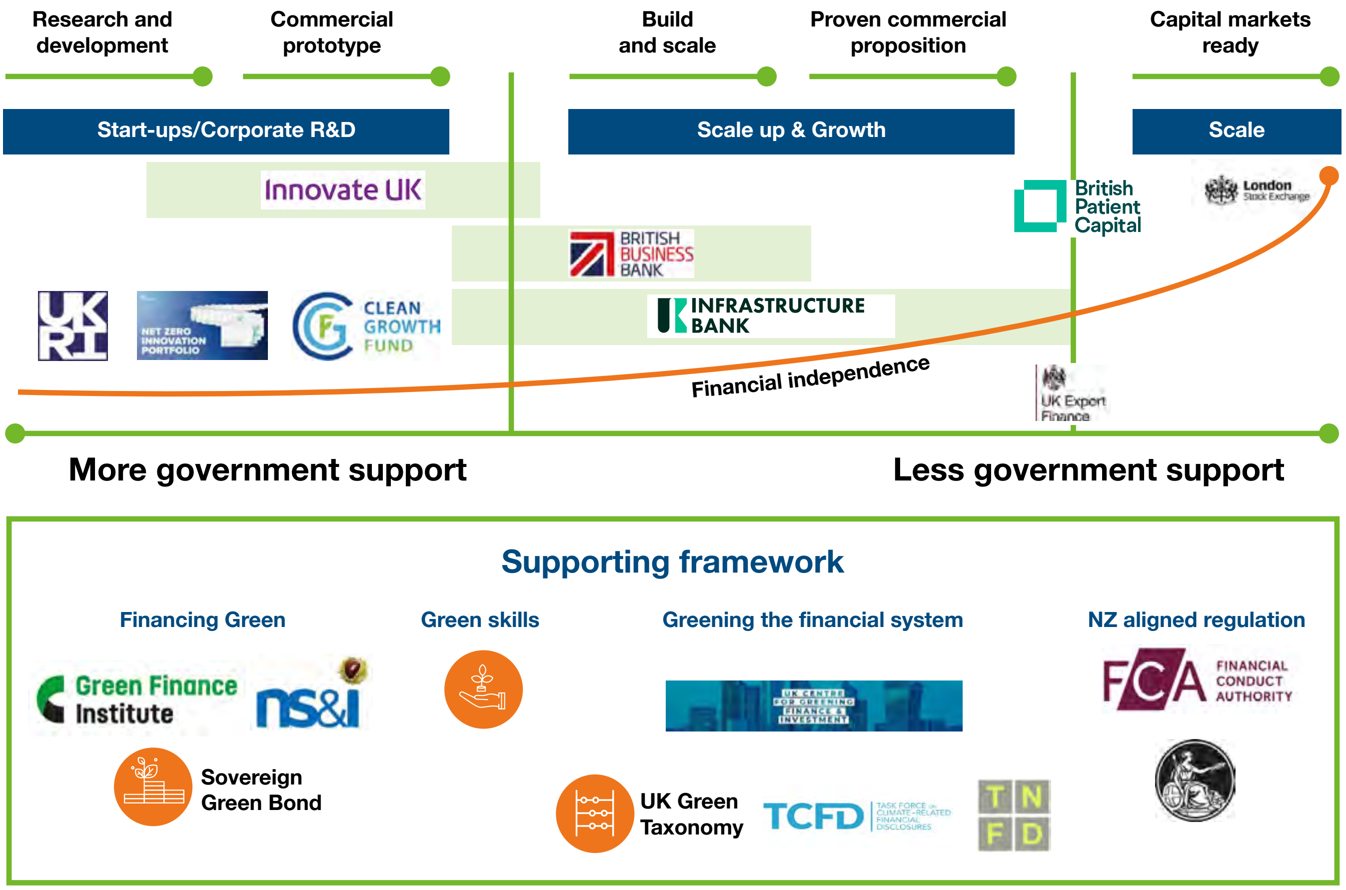
3. We will work with the private sector to deliver a world-leading net zero financial system, ready to seize the opportunities of net zero. Climate-related financial risk will be embedded into our regulatory frameworks to help guide capital flows to green investments.

4. We estimate that additional capital investment must grow from present levels to an average of £50-60bn per year through the late 2020s and 2030s. Most of this investment will come from the private sector, providing new opportunities for businesses and investors.

5. This will mean supporting the full funding cycle, from emerging technologies through to infrastructure and project finance, to deliver the economic transition. Each green technology and infrastructure will require different types of financial support depending on its maturity, as shown in figure 28. We must engage all types of capital, from early-stage grant and angel investment through to institutional finance like pension fund investors.

6. The UK is a world leading financial hub, with access to global capital pools, outstanding professional services, and a robust legal and regulatory framework. As such, the UK financial services industry is poised to enable private capital to flow into our net zero investment needs.

Figure 27 - Public Finance Interventions across the different stages of commercialisation[9]



7. Public funds will be used strategically to support new technologies, as well as emerging sectors, as they move from the innovation stage through to commercialisation and deployment. Early-stage R&D is supported by various government grants. Later-stage organisations can reach commercialisation and benefit from investment through the Clean Growth Venture Capital (VC) Fund or support from the British Business Bank (BBB). These stages of support are essential for scaling the necessary technologies and supporting the growth of businesses aligned to meeting our net zero ambitions.

8. Providing the suitable conditions for regulatory and early-stage innovation is a significant part of our Net Zero Strategy, but we must also mobilise the wider financial sector to meet the upfront investment challenge. This means stimulating new ways of providing information to markets on green investment and exposure to climate related financial risk, and providing the investment conditions to mobilise private capital into a portfolio of net zero financing.

9. We are driving more disclosure and transparency in the markets on climate risks and opportunities through the introduction of Sustainability Disclosure Requirements, as outlined in *Greening Finance: A Roadmap to Sustainable Investing*. These bring together and streamline UK sustainability reporting requirements, including reporting aligned with the Taskforce for Climate-Related Financial Disclosures (TCFD) recommendations and UK Green Taxonomy disclosures.

10. Targeted public intervention via the British Business Bank (BBB), UK Export Finance and the UK Infrastructure Bank (UKIB) will pull through investment from the private sector. For instance, British Patient Capital, a commercial subsidiary of the BBB, is contributing to the transition to net zero through its existing investment strategy: 9% of its underlying investment portfolio is in clean growth, sustainability, and mobility companies.

11. This builds on the growing voluntary commitments from financial institutions to a net zero transition that are already pivoting financial flows towards net zero in the run-up to COP26.[10] For example, the Glasgow Financial Alliance for Net Zero (GFANZ), which was launched as part of the COP26 Presidency, brings together many of the world's biggest banks, asset owners, asset managers, insurers and service providers that are credibly committed to achieving net zero emissions. Using the UN's Race to Zero as the entry criteria, the gold standard for net zero commitments, GFANZ has raised, deepened, and broadened the global financial sector's net zero ambitions. GFANZ has launched as ambitious body of technical work to support net zero aligned investment and accelerate the transition to a net zero financial system and global economy.

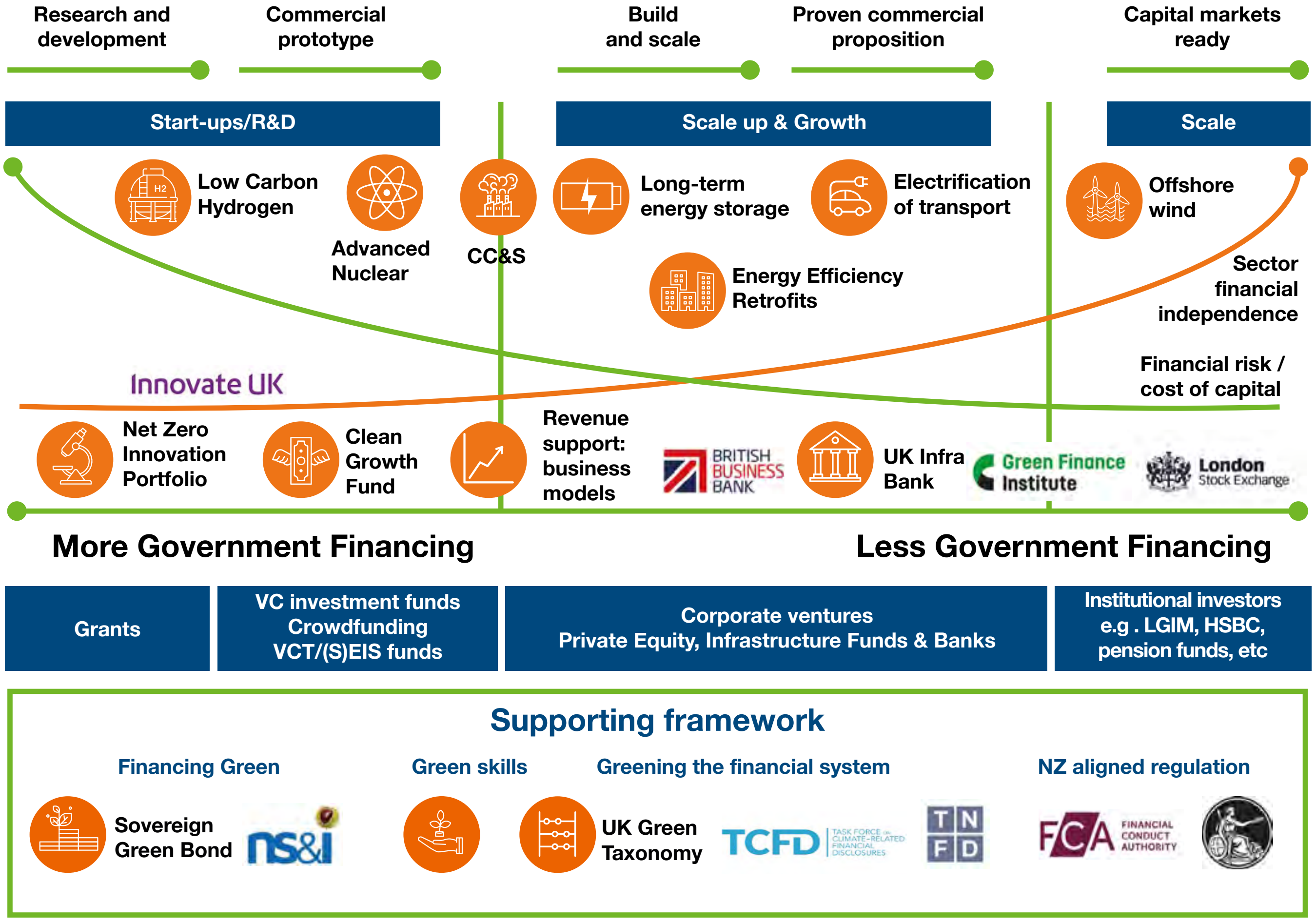
12. We will publish an update to the *Green Finance Strategy* in 2022 which will include a net zero transition pathway for the UK financial sector. This will set out how this crucial sector will transition to net zero as a whole.

Financing green

13. The scale of the net zero challenge and persistent market failures mean that public sector intervention is needed to shape and accelerate the flow of private capital. The right policy signals can act as a catalyst for private sector investment, as shown by by £90 billion of new investment in renewable energy since 2012, in part facilitated by the Electricity Market Reforms (EMR).[11] By bringing down the cost of capital through strong policy frameworks, we will reduce the financing costs of reaching net zero, delivering a better deal for the taxpayer.

14. The pathways set out in this strategy demonstrate that, whilst each sector requires its own policy framework, there are cross-cutting interventions required to support the transition to net zero. We will replicate the success of offshore wind and take actions to secure access to finance across the economy, ensuring that all sectors are able to access private investment going forward. For example, the Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS) scheme (see paragraph 19), will unlock private sector capital for industrial carbon capture and hydrogen production projects by providing long-term certainty to investors, de-risking revenue streams in these sectors.

Figure 28 - Low carbon sectors commercial maturity and associated capital requirements[12]



15. Through the net zero innovation portfolio, funding is provided for low carbon technology innovation. As these technologies, and sectors, commercialise, they can benefit from further investment readiness support to help them access repayable private finance. For example, the Natural Environment Investment Readiness Fund (NEIRF),[13] launched by Defra and the Environment Agency in 2021, will build the portfolio of potential investments for net zero investors in nature.

16. Some of these technologies may also avail of venture capital to allow them to scale rapidly. Government has shown its support for this necessary innovation underpinning its clean growth objectives with a £20 million cornerstone investment in the venture capital Clean Growth Fund[14]. This Fund aims to accelerate the deployment of innovative clean technologies that reduce greenhouse gas emissions, alongside catalysing the UK clean growth venture capital market and leveraging private sector funding into early-stage clean tech start-ups. For example, the fund led a £4.7 million investment round into Piclo (the independent energy trading marketplace) with co-investment from Mott MacDonald Ventures.

17. The BBB is a government-owned economic development bank with a mission to drive sustainable growth and prosperity across the UK, and to enable the transition to a net zero economy, by improving access to finance for smaller businesses. UK Government has worked with the BBB on their new mission and objective to support the UK's transition to a net zero economy and incorporate environmental, social and governance issues across of its activities. The new net zero objective will support firms looking to move towards net zero, helping the UK reduce its energy consumption and mitigate the impacts of climate change.

18. Going beyond SME finance to larger scale infrastructure finance, there are significant pools of private finance ready to deploy into UK projects but there can be a mismatch between market appetite and the risk profile of projects. Infrastructure investment is vulnerable to market failure, as it is often complex, large, novel and long-term. Launched in June 2021, the new UK Infrastructure Bank can play a pivotal role in this space, crowding in private sector investment in important areas and helping to kick start new sectors. Across the Bank's full mandate (also covering regional growth), it has £12 billion of equity and debt capital and will be able to deploy £10 billion of government guarantees. We expect the Bank to use this to crowd in private investment as a cornerstone investor or guarantor to enable more than £40 billion of investment in the areas most prone to market failure, and to help deliver its dual policy focus of tackling climate change and supporting regional and local economic growth. Furthermore, the Bank will play a pivotal role in catalysing the role of local government in the transition, by financing strategic infrastructure projects led by local authorities, and providing advice and expertise in order to strengthen the pipeline of investable projects.

19. Industries will need to be supported in their transition away from high carbon emitting operations. For example, the IDHRS scheme will provide a revenue mechanism to enable deployment of industrial carbon capture and hydrogen production. UK Export Finance (UKEF)'s Transition Export Development Guarantees (TEDG), launched in 2020, will ensure that businesses, including those in the supply chain, are supported at all stages of their transition journey. This product can be used by a company for working capital, capital expenditure or R&D needs, provided they have a credible transition plan. The first TEDG was announced in August with UKEF providing an 80% guarantee on the £430 million commercial loan to Wood Plc. This support from UKEF will help Wood to continue to capitalise on opportunities linked to clean energy, hydrogen and decarbonisation. Furthermore, this instrument will support the export of low carbon technology from the UK as evidenced by this guarantee which will support Wood to take advantage of green trade opportunities.

20. The UK financial system is also taking a global leadership role transition financing and sustainable finance more widely. An example of transition finance leadership is the London Stock Exchange Group (LSEG) which was the first exchange globally to launch a dedicated Transition Bond Segment. This distinct transition label is the application of globally recognised standards, enhancing visibility and providing assurance to issuers and investors. We have seen the financial sector in the UK take the lead in net zero transition (for example, through the Glasgow Financial Alliance for Net Zero[15]) as well as leading financial innovation (such as Green Home Finance Innovation fund).

21. The Chancellor, in his Mansion House speech[16] in July 2021, set out how the government will ensure that the financial system in the UK plays a major role in the delivery of the UK's net zero target and ambition for a 'nature positive' future. This will build on the investment principles outlined in the 25 Year Environment Plan including 'do no significant harm' to the environment with investment, and implement a series of programmes aimed at building the portfolio of investable assets across the UK. This will involve providing grant programmes like the Natural Environment Investment Readiness Fund (NEIRF) to help nature-based projects become investment ready, but also providing capital through public-private impact funds such as the Big Nature Impact Fund to leverage in private finance. In addition to investing in climate and environmental solutions, government is also committed to ensuring sufficient private capital is available for investment into adaptation and resilience measures.

22. Furthermore, the government is supporting the development of a Taskforce on Nature-Related Financial Disclosures (TNFD). This will provide a framework for corporate and financial institutions to report and act on evolving nature-related risks to support a shift in global financial flows away from nature-negative outcomes and toward nature-positive outcomes. This market-led, global initiative will build, consult on, and test, its framework over the next 2 years and will be designed to complement the TCFD by building on its 4-pillar approach and drawing on its lessons learnt.

23. These interventions are important to driving the desired 'nature-positive' future. As set out in the Prime Minister's *Ten Point Plan*, we hope that the UK will also become a leader in high-quality voluntary carbon markets (VCMs). For these private markets to scale successfully in support of net zero, their integrity and use as an addition (rather than alternative) to rapid decarbonisation will be critical. The government is closely following the important work of various sector-led initiatives including: the Taskforce for Scaling Voluntary Carbon Markets (TSVCM); the Voluntary Carbon Markets Integrity Initiative UK VCM Forum; and, the Financing UK Nature Recovery coalition.

24. The UK Government issued its inaugural green gilt on 21 September 2021. This was a landmark transaction for sterling markets and the UK. At £10 billion, it was the largest sovereign green bond issuance to date and attracted the largest ever order book for a sovereign green bond. The inaugural green gilt also achieved the largest "greenium" for any debut sovereign green bond to date, demonstrating good value for money for the taxpayer (a "greenium" refers to more favourable pricing achieved by the issuer of a green bond compared to that for a hypothetical, equivalent conventional bond). The UK will then be following up with a second issuance in mid-to-late October, as the UK looks to build out a green yield curve. This followed the successful publication of the UK Government Green Financing Framework on 30 June 2021, which outlines how proceeds raised from the green gilts will help tackle climate change, biodiversity loss and other environmental challenges.

25. NS&I will issue its retail Green Savings Bonds later in 2021. These bonds will be the first standalone retail product to be tied to a sovereign's green bond framework and will allow all UK savers to contribute to the fight against climate change and the government's other environmental objectives. It gives UK savers the opportunity to take part in this collective effort to tackle climate change by contributing to public spending on green, whilst increasing awareness in the government's green initiatives. This series of wholesale and retail green financing issuances demonstrate the UK's commitment to sustainable finance ahead of COP 26 in November.

26. We are also committed to tracking finance flows, to complement how we measure carbon. Hence, we will be working with external partners and data providers to better track private investment into the net zero economy going forward. This will enable the UK to robustly, and regularly, assess the alignment of the UK's financial flows with net zero.

27. The UK launched the Green Finance Education Charter in our 2019 *Green Finance Strategy*,[17] reflecting the need for UK and global financial services industries to develop the capabilities of their workforce in green finance principles and practice. Since then, twelve leading professional bodies representing over 1 million finance professionals have signed up to the Charter, hosted by the Green Finance Institute. To further build UK capacity, capability and climate leadership, we will look to expand Charter membership to universities and others, and work with the Institute for Apprenticeships and Technical Education (IfATE). We will also seek to internationalise the Charter by encouraging similar development overseas.

Case study: The Green Finance Institute model

The Green Finance Institute (GFI) was established in 2019 with funding from HMG and the City of London Corporation, though it operates independently of government and is commercially focused.

Sitting at the nexus between the public and private sectors, the GFI provides critical guidance to government and the financial sector and delivers programmes which mobilise investment and lending towards real economy outcomes. Through the application of the GFI's rigorously designed financing solutions, they have already identified and co-designed effective interventions that have deployed capital towards a net zero, carbon resilient economy.

The GFI primarily operates by convening and leading coalitions of global experts that focus on different sectors and seek to identify scalable financial solutions that accelerate sector-specific transitions to a low carbon future.

There are several coalitions and initiatives that the GFI now operate:

- The Coalition for the Energy Efficiency of Buildings (CEEB) is the GFI's flagship programme, set up in 2019 to develop the market for financing a net-zero climate-resilient built environment. Today, the CEEB has over 300 members and accounts for 70% of the UK mortgage market. This work is now expanding into Europe.
- In September 2020, the CEEB launched the Green Home Finance Principles, in collaboration with the Loan Markets Association, to embed transparency and consistency into the green home finance market. Today, the Principles have supported 11 financial institutions with combined mortgage balances of +£480 billion to launch, or commit to launch, green lending products that minimise the risk of greenwashing.
- The Coalition for the Decarbonisation of Road Transport (CRDT) was established in May 2021 to unlock financial barriers to the decarbonisation of road transport and enabling infrastructure.
- The GFI played a key role in the Dasgupta Review and is also working on a series of potentially transformative funding mechanisms to support the UK's 25-year Environment Plan alongside Defra and the Environment Agency.
- The GFI was appointed Chair and convener of the Green Technical Advisory Group (GTAG), tasked with providing independent expert advice to government on how to implement a taxonomy in the UK.
- The GFI is also hosting the Executive Secretariat for the Taskforce on Nature-related Disclosures and launching an initiative this November to unlock the barriers to channel private finance towards nature in the UK.
- In partnership with the City of London Corporation, the GFI will host a Green Horizon Summit at COP26, which will focus on mobilising capital in the transition to net zero.

Greening finance

28. Financing the technologies required for our transition to net zero is only part of the solution. The transition represents both a risk and an opportunity for the real economy and the financial system that supports it. It is therefore vital that climate-related financial risks and impacts are factored into investment decisions and reflected in the cost of finance for different technologies and companies. To achieve this, we will harness the international reputation of the UK's leading financial sector to encourage private investment to support low carbon innovation and manage climate-related financial risk.

29. As the Chancellor outlined in his Mansion House speech,[18] the government intends to introduce economy-wide Sustainability Disclosure Requirements covering the whole economy. This will include requirements to report on businesses and investment products impact on the climate and environment, as well as the risks and opportunities these impacts pose to business. Our approach is detailed in *Greening Finance: A Roadmap to Sustainable Investing*.

30. The UK has already established itself as a world leader on green finance regulation, becoming the first G20 country to make disclosures aligned with the Task Force on Climate-related Financial Disclosures (TCFD) recommendations fully mandatory across the economy by 2025. As part of the roadmap to delivery, BEIS consulted earlier in the year on mandatory climate-related financial disclosures by publicly quoted companies, large private companies and the largest Limited Liability Partnerships (LLPs) from the 6th April 2022. Following widespread support for the proposals, we will shortly be setting out regulations to bring this into force, including a requirement for scenario analysis - a powerful tool to support companies in their assessment of climate-related risks and opportunities.

31. Alongside measures to implement mandatory disclosures aligned with the TCFD recommendations for companies and LLPs:

- The Financial Conduct Authority has already introduced a listing rule for premium listed companies which commenced on 1 January 2021. This requires companies to include a statement in their annual financial report which sets out whether their disclosures are consistent with the recommendations of the TCFD, and to explain why if they have not done so.
- Government introduced regulations, in force from 1 October 2021, to require pension schemes with £5 billion or more in assets to report line with the TCFD's recommendations. By October 2022, over 80% of members of occupational pension schemes – and more than 70% of assets under management – will be in schemes reporting in line with the TCFD recommendations.

32. Our stated objective is to increase the quantity and quality of climate-related financial disclosures in a proportionate manner. This is to ensure market participants have better information to adequately understand climate-related financial risks and opportunities to support the transition to net zero.

33. In November 2020, the Chancellor announced that the government is implementing a UK Green Taxonomy. This will clearly set out the criteria which specific economic activities must meet to be considered environmentally sustainable. The first two Technical Screening Criteria (TSC) on climate change mitigation and adaptation will be made by the end of 2022. To support the development of the TSCs, we have since announced the appointment of a Green Technical Advisory Group (GTAG) in June 2021. Made up a of range of financial and business stakeholders, taxonomy and data experts, and subject matter experts, and chaired by the Green Finance Institute, this will provide independent, non-binding advice to the government on developing and implementing a Green Taxonomy in the UK context. For example, we have established an Energy Working Group as part of the GTAG to provide advice on key technologies such as hydrogen and carbon capture and storage. Taken together, these enhanced Sustainability Disclosure Requirements will support companies to communicate clear and credible low carbon transition plans needed by investors.

34. Key to delivering enhanced disclosure on climate change is the availability of data financial institutions can use. The UK Centre for Greening Finance and Investment (CGFI) is a national centre established to accelerate the adoption and use of climate and environmental data and analytics by financial institutions internationally. CGFI will equip financial institutions with the tools and capacity required to effectively allocate capital to meet net zero ambitions and ensure global UK leadership in green finance and green finance data and analytics.

Case study: Providing a net zero-aligned regulatory environment

In March 2021, the Chancellor outlined his recommendation to regulators that they should "have regard to the government's commitment to achieve a net zero economy by 2050". There has already been significant work by the Bank of England and the Financial Conduct Authority.

The Bank of England

The Bank's approach to climate change is to play a leading role, through its policies and operations, in ensuring the financial system, the macroeconomy, and the Bank of England itself, are resilient to the risks from climate change and supportive of the transition to a net zero emissions economy.

Recent actions to deliver this include:

- In April 2019, the Bank published a comprehensive set of supervisory expectations for how banks and insurers should enhance their approaches to managing the financial risks from climate change. This was followed up in July 2020 with a Dear CEO letter, which included additional guidance and set a deadline for firms to embed fully these expectations by the end of 2021.
- In June 2021 the Bank launched its Climate Biennial Exploratory Scenario (CBES) exercise to assess the resilience of individual banks, insurers, and the wider UK financial system to three different climate scenarios. These scenarios are based on those published by the international central banks and supervisors Network for Greening the Financial System (NGFS), of which the Bank is a founding member and where it chairs the workstream developing the NGFS climate scenarios.
- In November 2020, the UK joint regulator and government TCFD Taskforce, of which the Bank is a member, published an interim report and roadmap for mandatory TCFD-aligned disclosure requirements across the economy by 2025.
- The Bank has also sought to lead by example and in 2021 became the first central bank to publish a climate-related financial disclosure which included analysis of financial asset portfolios held for monetary policy purposes. The Bank also committed to reduce the emissions from its physical operations to net-zero by 2050 at the latest.

The Financial Conduct Authority (FCA)

The FCA's work on climate change and sustainable finance aims to make sure market participants can manage the risks, impacts and opportunities from moving to a more sustainable economy and can capture opportunities from the net zero transition. Key developments in 2021 include:

- Introducing a TCFD-aligned Listing Rule for premium-listed commercial companies, and consulting on new proposals to extend the application of the rule to issuers of standard listed equity shares, and to implement new disclosure rules for asset managers, life insurers, and FCA-regulated pension providers with a focus on the information needs of clients and customers;
- Co-chairing work on climate-related and sustainability disclosures at the International Organisation of Securities Commissions and the Financial Stability Board;

- Issuing a supervisory letter to the chairs of Authorised Fund Managers, including a set of guiding principles to help clarify the FCA's expectations for the design, delivery and disclosure of retail responsible and sustainable funds – both as applications are submitted for authorisation and on an ongoing basis;
- Launching a comprehensive innovation work programme on sustainability, including the announcement that the next cohort of the Digital Sandbox Pilot will focus on sustainability and climate change; the FCA has begun work with the City of London Corporation and industry to support the development of solutions to ESG data and disclosures issues via a digital testing environment, and is aiming for this environment to go live in Q1 2022; and,
- Alongside the other financial regulators, publishing an inaugural Climate Adaptation Report (CAR) setting out the actions the FCA and financial services industry are taking to adapt to the challenges of climate change; the CAR will include a chapter on net zero which will explore net zero commitments, targets, tools and challenges.

4iii. Green Jobs, Skills, and Industries

Creating the skilled workforce to deliver net zero and putting UK supply chains at the forefront of global markets

Our Key Commitments

- Publish sector and supply chain development plans for key low carbon sectors and work with business to encourage investment in green skills and industries in the UK.
- Publish a UK Critical Minerals strategy, setting out our approach to securing technology-critical minerals and metals.
- Support the development of a skilled, competitive supply chain for key green industries in the UK.
- Reform the skills system so that training providers, employers and learners are incentivised and equipped to play their part in delivering the transition to net zero – including by legislating for skills required for jobs that support action on climate change and other environmental goals to be considered in the development of new local skills improvement plans.
- Deliver a Lifetime Skills Guarantee and grow key post-16 training programmes (such as apprenticeships, Skills Bootcamps and T levels) in line with the needs of employers in the green economy, helping individuals get the training they need for a job in the green economy, either at the start of their careers or when retraining or upskilling once already in the workforce.
- Introduce a sustainability and climate change strategy for education and children's services which will include a focus on equipping children and young people with the knowledge and skills they need to contribute to the green economy.

The Challenge

1. The national and global shift towards net zero provides a once in a generation opportunity to level up the country, create new green jobs, and put the UK at the forefront of growing global markets in green technologies. Delivering on this promise, whilst meeting our ambitious climate and environmental targets, will be in a large part dependent on having a sufficiently skilled workforce and robust, competitive supply chains in the UK.

2. Recent developments have thrown into sharp relief the inherent vulnerabilities associated with complex global supply chains and shocks to the global economic system. The transition to net zero will change the nature of the UK's critical supply chains. Our aim is to help ensure that supply chains critical for the transition to net zero are secure, ensuring that we have access to the materials, minerals, and chemicals that our growing green economy will need. Our approach is that there is no "one size fits all" model for building resilience in individual supply chains: often a combination of levers may be the best solution to address a vulnerability.

3. We will need tens of thousands of engineers to build and maintain new offshore wind farms off the coasts of northern England and Scotland, construct nuclear power stations in the South of England, and manufacture electric vehicles in the Midlands; skilled builders and trades people to retrofit homes and buildings across the country; and conservation and biodiversity professionals to deliver nature-based solutions to climate change.

4. Alongside a broader shift to digitisation and automation, we can expect the transition to net zero to be one of the dominant labour market trends in the next 30 years: approximately 6.3 million jobs in the UK, about one in five, are likely to be affected by the transition to a green economy, with workers experiencing either an increase or decrease in the demand for their skills.[19]

Our Goals

5. The government's ambition is to:

- Support up to 440,000 jobs across net zero industries in 2030, contributing towards a broader pivot to a greener economy which could support 2 million jobs in green sectors or by greening existing sectors by:
  - Working with business to grow green industries, supply chains and skills in the UK, and ensure our resilience to international changes in supply chains; and,
  - Using our net zero policy and funding to promote the growth of green skills and the green economy.
- Enable workers, industries, and places to transition to a net zero economy by 2050, and support industry to develop the skilled workforce to deliver a green industrial revolution by:
  - **Reforming the skills system** to make it more responsive to the needs of employers, so that training providers, employers, and workers are incentivised and equipped to support the transition to net zero;
  - **Ramping up support for workers in the high carbon economy to transition to green jobs**;
  - **Working with business to ensure people from all backgrounds can access the opportunities in the green economy**, including through career advice; and,
  - **Providing children and young people with the high-quality education and training they need to work in a future green career**, through improving teacher training and development in STEM and other key subjects, and expanding post-16 training programmes in line with the needs of the green economy.

The Green Jobs Taskforce

To better understand how the UK could grasp opportunities of the Green Industrial Revolution, the Department of Business, Energy and Industrial Strategy and the Department of Education launched the Green Jobs Taskforce in November 2020. The Taskforce provided an independent assessment of the potential skills and labour market impacts of the net zero transition, including how we can ensure green jobs are open to all and support workers to transition to the green economy.

The independent Taskforce, which included representatives from industry, trade unions, the skills sector and community organisations, took a broad view of green jobs, as “employment in an activity that directly contributes to, or indirectly supports, the achievement of the UK’s net zero emissions target and other environmental goals, such as nature restoration and mitigation against climate risks.” Its report, published in July 2021, included 15 recommendations for government, industry and the skills sector, which focused on three themes across the “life cycle” of green jobs: driving investment in net zero to support good quality green jobs in the UK; building pathways into good green careers; and supporting workers in the high carbon economy to transition.

The ideas generated through the Taskforce and its engagement with industry have informed the development of this Strategy.

Working with business to grow green UK industries and resilient supply chains

6. The investment needed for the transition to net zero will primarily be delivered by the private sector. As such, our first priority is to provide businesses, investors, workers, and skills providers with policy certainty to unlock investment, ensuring we support green industries to develop in the UK.

7. In line with *Build Back Better: Our Plan for Growth*, we are taking action across a range of low carbon industries with the greatest economic potential and competitive strength. In doing so, we will support the growth of UK supply chains and create new opportunities for UK businesses and level up the country. We are acting to build green industries such as offshore wind in North East England and in Scotland, carbon capture and hydrogen production in our industrial heartlands, electric vehicles manufacture in the midlands and Northeast of England, and the restoration and protection of nature in rural areas.

8. We also recognise that the starting position when building resilience in critical supply chains should be to take a market-first approach. The UK prospers under an open economy and openness itself confers resilience. We will leverage the UK's competitive strengths across the supply chain, while deploying those levers available to the Government – including UK Export Finance and the new Office for Investment – to ensure that we exploit our strengths, while supporting those areas that could be vulnerable to global shocks.

Case studies: Driving investment into green supply chains in the UK

The Prime Minister's *Ten Point Plan*, and our subsequent sectoral strategies, put in place a range of funding and policy initiatives to enable green industries and supply chains to develop in the UK, supporting our ambition to deliver on green jobs:

Building the Offshore Wind Supply Chain

Announced as part of the *Ten Point Plan*, the UK's offshore wind manufacturing industry has already seen almost £1.5 billion of investment unlocked by the £160 million Offshore Wind Manufacturing Investment Support scheme, which aims to further develop the UK's offshore wind capabilities. The investments have seen a significant boost over the summer with up to 3,600 jobs supported across the Humber region. This continues to lay the groundwork to deliver 40 GW of energy from offshore wind by 2030 and for UK businesses and workers to take full advantage of the booming offshore market in the UK and internationally, support up to 60,000 jobs in the industry and its supply chain, and help eliminate the UK's contribution to carbon emissions by 2050.[20]

We are preparing for the next wave of deployment around the UK, with world leading 1 GW deployment targets for innovative floating offshore wind turbines. The government has set up a floating offshore wind demonstration programme to support development of state-of-the-art technologies and products in the floating offshore wind industry.

Net Zero Hydrogen Fund

Government has set an ambition to deploy 5 GWs of low carbon hydrogen production capacity in the UK by 2030, supported by a package of measures including the Net Zero Hydrogen Fund (NZHF). The NZHF will kickstart the hydrogen economy in the early 2020s by supporting projects with upfront costs, stimulating private sector investment, and developing the pipeline of projects needed to deliver hydrogen production at scale by 2030.

Transforming automotive manufacturing

The UK is already capitalising on opportunities from the global shift to electric vehicles, as demonstrated by recent investments made by Stellantis in Ellesmere Port, and Nissan and Envision AESC in Sunderland. Allocating a further £350 million of our up to £1 billion Automotive Transformation Fund (ATF) to support the electrification of UK vehicles and their supply chains. This will help ensure the UK maximises the benefits from the transition to a zero emission vehicle future and support tens of thousands of high-quality green jobs across the UK. Government and industry have also jointly committed around £1 billion through the Advanced Propulsion Centre for collaborative research and development in the next generation of low carbon vehicle technologies. A further £318 million of government funding has been provided to put the UK at the forefront of the design, development, and manufacturing of electric batteries through the Faraday Battery Challenge and nearly £80 million to Driving the Electric Revolution to accelerate growth in the supply chain for power electronics, machines and drives.

Driving investment and jobs in the natural environment

Government’s Green Recovery Challenge Fund is supporting over 150 projects across England that are tackling climate change, restoring nature, and supporting 2,500 green jobs. The Nature for Climate Fund is also contributing to net zero and creating and supporting green jobs by funding new woodland creation and peatland restoration. In addition, the £9 million Natural Environment Investment Readiness Fund is stimulating a pipeline of nature projects that can attract private sector investment.

9. We are working in partnership with our world-class sectors to enable them to take part in the transition, for example through the *North Sea Transition Deal*, which committed to focusing on supporting the transformation of the oil and gas supply chain to service the low carbon energy sector. Building on this, we have established the Energy Supply Chain Taskforce (UKESC) as a joint enterprise between industry and government to guide policy making and maximise the jobs and business opportunities from the transition in the UK. The UKESC cover all energy sectors and regions of the UK and, building on work already underway, it will map the energy project pipeline and identify higher value segments of the supply chain to prioritise in the UK.

10. The *Integrated Review Security, Defence, Development and Foreign Policy* committed to 'a resilient UK able to withstand and proactively tackle the challenges of today and the future', including a specific focus on supply chain resilience, committing to 'using all our economic tools and our independent trade policy to create economic growth that is distributed more equitably across the UK and to diversify our supply chains in critical goods'. Similarly, the *Plan for Growth* outlines the importance of international markets to ensuring diverse supply sources for the goods and services we need, improving the resilience of our supply chains and benefitting prosperity.

11. The development of resilient, efficient, and competitive supply chains will be a collaborative strategic endeavour. To support this, in May 2021 we published the *CCUS Supply Chain Roadmap*, which sets out how government and industry can work together to harness a strong UK supply chain, and we have committed to publish a hydrogen sector development action plan in 2022, which will outline how the government will support companies to secure supply chain opportunities, skills and jobs in the sector. We will build on this by working with industry to publish further sector and supply chain development plans for those low carbon sectors where the UK has the potential to capture an economic advantage. This will include ensuring we are resilient to international changes in supply caused by external shocks, including climate-related disruption, spikes in global demand, rising commodity costs, or artificial constraints on supply. For example, we will need to ensure we have access to a diverse range of sources of chemicals, given they feed into 95% of our manufacturing base. As we move forward, where possible, government will provide more visibility around planned deployment cycles to increase the opportunity for suppliers to invest in long-term production, infrastructure, and training.

Deep Dive - Critical Minerals, Supply Chains and Net Zero

The transition to Net Zero means new supply chains are becoming critical to the UK's energy production. Critical minerals are metals and non-metals that are vital for a defined economic activity and for the well-being of the country, yet whose supply may be at risk owing to geological distribution, lack of substitutes and/or other factors. Such minerals provide materials essential for components in many of today's rapidly growing clean energy technologies – from off-shore wind turbines to electric vehicles. The World Bank suggests that the production of minerals such as graphite, lithium and cobalt, could increase by nearly 500% by 2050 to meet the growing demand.[21]

The government is committed to working with industry and with international partners to safeguard these supply chains and our future economic resilience. We are actively supporting the adoption of transparent, ethical and responsible mining practices, reflecting environmental, social and governance (ESG) considerations, and are participating in the development of global standards through the British Standards Institution.

We will establish an Expert Committee on Critical Minerals to provide independent advice to government on the scope and content of a critical minerals strategy and will publish an updated list of these minerals to guide investment decisions. We will establish a Critical Minerals Intelligence Centre to provide robust, dynamic analysis on stocks and flows to guide our decision-making.

Going forward, the government will publish a UK Critical Minerals strategy in 2022, setting out our approach to securing the technology-critical minerals and metals aimed at:

- Ensuring the UK has a reliable supply of critical minerals and metals;
- Establishing an enabling environment for growing the sector in the UK;
- Showing leadership through working bilaterally and multilaterally to support work on international standards to extend and strengthen the circular economy in technology-critical minerals;
- Ensuring our work to build critical mineral supply chain resilience supports our international development priorities;
- Using our R&D resource to build a better understanding of markets and prices to help mitigate the impact of supply shocks and demand spikes, and to enable better foresight and early intervention; and,
- Work with UK industry (including SMEs) to consider how private and public sectors can better share risks to promote investment and drive innovation at all levels.

We will support the engagement of the UK's mining sector in new and existing markets, facilitating investment and collaboration in extraction and processing opportunities. We will also champion free and open global trade including through Free Trade Agreements to support this ambition and will explore use of Freeports to support opportunities for the UK to develop as a critical minerals processing hub supplying Europe and beyond.

Supporting workers, industries, and places to transition and develop the skills needed to deliver net zero

12. There are urgent and emerging skills challenges across the green economy which we will need to address over the short and long term if we are to meet our ambitions for a Green Industrial Revolution. We aim to quadruple our offshore wind capacity to 40 GW, with the growth in this sector supporting up to 60,000 jobs in 2030.[22] In the construction and heating sectors, up to 230,000 skilled trades people could be required in 2030 to deliver the retrofitting of houses[23] and to meet our ambition of installing 600,000 heat pumps a year by 2028, we will need to rapidly increase the number of qualified installers from around 3,000 to 35,000 within the next 7 years.[24] As the automotive manufacturing sector transforms to producing electric vehicles, as many as 50,000 workers in the UK's automotive manufacturing sector could need reskilling by 2025.[25] In forestry and its supporting sectors, industry estimates point to projected labour demand of approximately 2,000 jobs over the next five years.[26]

13. As well as specialists in these sectors, employers will also need workers with wider cross-cutting skills to deliver net zero, including digital and data skills, project management, communications and change management. [27] There will also be increased need to work in a multidisciplinary way due to the way work will change in some sectors such as whole house retrofitting will need knowledge of multiple technologies.[28]

14. The impact of the transition on the labour market will not be evenly spread across the UK, reflecting the geographical distribution of where existing industries will need to adapt and others new ones will flourish.[29] However, there are opportunities for workers in transitioning sectors, such as oil and gas, to utilise their specialist skills in key important green sectors, sectors such as hydrogen and CCUS with these two sectors expected to grow from the middle part of this decade.

Working with industry and key partners to support good green jobs and skills

15. Industry and government will need to take action to ensure the UK has the skilled workforce to deliver net zero and that workers, industries and places are supported on the transition. This will be particularly important given the pace and scale of the change, and the specific challenges faced by smaller companies in some sectors and supply chains. To drive this forward we have announced a cross-cutting delivery group to include representatives from industry, the skills sector and other key stakeholders to support the development and delivery of the Government’s plans for green jobs and skills. We will set out further details of the membership and mandate of the cross-cutting delivery group later this year.

16. To support this work, and monitor our progress, it is vital that we continue to develop the evidence on how net zero will impact jobs and skills. The Office for National Statistics will seek to refine our understanding and measurement of the green economy as the UK transitions to net zero, including looking at such issues as quality of work and diversity within the green economy.

17. Join up between local bodies, employers and local communities will be key to ensuring an effective transition. Building on the measures set out in the *Local Climate Action* chapter, and our skills system reforms, we will assess how local areas are working to support workers and communities with the net zero transition across England.

18. We want to see continuous improvement in the quality of jobs in the UK, both in the creation of new high-quality jobs which support Government priorities such as net zero, and through in-work progression. We will continue to drive this agenda forward through the Employment Bill, which will support our ambition to make the UK the best place in the world to work and grow a business, and the cross-cutting delivery group will consider how government and industry can work together to ensure green jobs are good jobs.

19. While skills policy is a devolved matter, the Government also welcomes close engagement with the devolved administrations, Mayoral Combined Authorities and the Greater London Authority, on this agenda, to ensure everyone across the UK has access to green skills and jobs.

Working together across the UK

Examples of policy action by the Scottish Government, Welsh Government and Northern Ireland Executive

Northern Ireland Executive

The forthcoming *Green Growth Strategy*, will be a multi-decade strategy to balance climate, environment and the economy. It means a move from a high to a low greenhouse gas emissions economy to improve people's quality of life through green jobs and a clean environment.

Innovation is key to the disruptive transition required. '10X Economy' sets out the vision for the 2020s as a decade of innovation bringing opportunity and growth. The focus on innovation is reinforced in the Energy Policy Options paper also strongly advocating innovation. New skills will be critical to allow innovation to flourish into delivery. The Skills Strategy consultation recognises that a transformational change in skills is required to take advantage of Northern Ireland's scale, yet addressing the challenges in the skills sector.

To take one example, the decarbonisation of gas infrastructure will involve the development of new supply chains for production of biomethane from anaerobic digestion plants and development of hydrogen production technologies, which will support green jobs and new skills in these sectors.

Scotland

The Scottish Government has set out a package of measures to create good, green jobs, reskill those that need it and provide a career platform for the next generation. It includes:

- a £100 million Green Jobs Fund to help businesses create new, green jobs. Related funding will make focused investments in machinery and equipment and research and development in five priority sectors: energy transition; transport; manufacturing; construction; agriculture and land use;
- a £25 million National Transition Training Fund with a focus on:
  - The provision of green skills;
  - A Young Person's Guarantee for 16-24 year olds;
  - The use of public procurement to build low carbon supply chains.

The Climate Emergency Skills Action Plan (CESAP) sets out a clear direction for the change of Scotland's skills system, and signals the role that businesses, communities and individuals across Scotland will play in achieving this.

The CESAP focuses on immediate action as well as the longer-term systemic change that needs to take place by 2045. It is being driven by senior representatives of central and local government and its agencies, skills providers, industry and independent experts, and is chaired by Professor Dave Reay of Edinburgh University.

The Scottish Government's Green Jobs Workforce Academy was launched in August 2021. The Academy will make it easier for people from a wide range of backgrounds to launch a green career, and to access appropriate training. The Academy will support delivery of a skills guarantee for workers in carbon-intensive sectors.

Wales

Since its launch in 2010 the £30+ million BEACON, a collaboration led by Aberystwyth University, working with Bangor and Swansea Universities and the University of South Wales, has built up a strong skill base in the bio business sector by providing collaborative R&D support for Welsh businesses[30]. BEACON has worked successfully with hundreds of companies, enabling them to develop and trial ideas on an industrial scale, and to get their products and services closer to market. Products include bio plastics, food additives, building materials and fuel.

Reforming the skills system

20. We are driving forward reforms to put employers at the heart of the skills system and ensure colleges are responsive to the needs of local economies. As demand for green skills continue to grow across the UK, employers in the green economy must prioritise investment in the retraining and upskilling of their workforce, and actively take the opportunity to engage with education providers to shape local provision.

21. Central to our strategic reforms are the plans set out in the Skills for Jobs White Paper, which will enable local employers to set out their green skills needs to drive provision in local colleges. The programme is made up of two parts: local skills improvement plans and the Development Fund.

22. First, the Trailblazers for local skills improvement plans, led by employer representative bodies will identify and articulate unmet and future local skills needs and work with further education providers to adapt their technical training offer so that it becomes more responsive to employers' needs. Through the Skills and Post-16 Education Bill, we are legislating to put the employer leadership of these plans on a statutory footing and ensure they have regard to skills needed to help deliver on our net zero target, adaptation to climate change, and other environmental goals.

23. Second, our £65 million Development Fund pilots in 2021-2022 will support work to identify employers' skills needs, design provision to respond, and build the capacity of local further education providers to deliver. Where local areas identify a skills need, for example increasing the number of trained retrofitters, providers could use this funding to purchase equipment, train their staff, bring in industry expertise to provide training, or deliver new provision. The majority of the 18 pilots announced in July 2021 include a project focused on green skills, covering areas including decarbonisation, renewable energy, and electric vehicles.

24. Alongside this. we want people to get the advanced technical and higher technical skills they need to get good jobs. Colleges' place at the centre of their local communities and economies means that they are key to unlocking opportunities across the country and to building back better. We are, therefore, reforming the adult skills funding and accountability system for further education colleges and other training providers in a way that will help improve our skills provision. We are consulting on a range of proposals to make sure colleges are better supported to focus on helping their students into good jobs; reduce the complexity of funding so that colleges can focus on their core role of education and training; and define clearer roles and responsibilities for the key players in the system. This means that, for the first time, we will be able to reflect the value that relevant courses deliver to the taxpayer in the funding rate colleges receive for putting on courses. This will encourage providers to put on courses in subjects where there is strong demand from employers. We will hold colleges to account for delivering good outcomes, and are consulting on proposals to introduce new Accountability Agreements setting out national priorities against which we expect colleges to deliver, for example enabling students to access opportunities in the green economy.

25. Supporting the transition through the skills system will require teachers in the further education sector to have a strong understanding of sustainability. To deliver this, we have worked with employers to develop a refreshed apprenticeship standard for further education teaching (Level 5 Learning and Skills Teacher), which came into effect in September 2021. For the first time, all further education teachers training via an apprenticeship will be required to integrate sustainability into their teaching, including through modelling sustainable practices and promoting sustainable development principles in relation to their subject specialism. Early estimates from the Trailblazer Group suggest around 1,500 teachers each year could train using this apprenticeship standard. This standard will soon be incorporated into all future further education teaching qualifications, so that all teachers across all subject areas will be able to embed and promote sustainability in their teaching.

Ramping up support for workers in high carbon sectors to transition to green jobs

26. Over 80% of the workforce of 2030 is already in work today[31], as such meeting our ambitious targets for climate action in the next decade, and reaching net zero by 2050, will require government and industry to work together to ensure workers in high-carbon sectors can retrain and upskill as they move into jobs in the green economy. Much of this will take place in industry (see the case study below) and we will support this through our targeted programmes for industries and workers.

Case study: Industry action on reskilling for the transition

Centrica

Centrica have announced plans to hire 3,500 Smart Energy Apprentices by 2030, with the first 1,000 apprentices recruited by the end of 2022. Apprentices joining Centrica receive technical skills training and knowledge for the job at the company's academies in Dartford, Hamilton, Leicester, and Thatcham. Many have taken up the opportunity to upskill at Centrica to become domestic electrical installers, with skills in Electric Vehicle charging point installation, or to achieve gas boiler service and repair capability.

Upskilling training for domestic electrical installers lasts 20 weeks and is offered after Smart Energy Engineers have finished their apprenticeship. The gas boiler service and repair programme also takes place after completing the Smart Energy Apprenticeships, and is split over two years. Every year, Centrica's academies train and assess 5,000 engineers to keep all British Gas engineers compliant with their specific roles' regulatory and industry requirements.

27. In key sectors, we will ramp up our support to develop UK supply chains and enable workers to access green jobs. This will include working with industry on a Heat Network Skills Programme to increase the capacity and capability of the UK supply chain to support the sector to reach its growth potential. Our Public Sector Low Carbon Skills Fund will enable public sector organisations to acquire expert skills in order to unlock decarbonisation projects. Alongside this, we will work with industry to support training and new routes of entry to help boost heat pump installer numbers and other areas of skills shortage to support the decarbonisation of buildings. We will also support the development of new green skills for hydrogen, CCUS and industrial decarbonisation to ensure the UK workforce is ready to deploy low carbon technologies. Our funding for the Aberdeen Energy Transition Zone will position the region as an exemplar for low carbon development, supporting the transition of existing oil and gas skills to renewable energy sectors. We also will continue to support the forestry sector to improve its training and career services.

28. Through the Lifetime Skills Guarantee, we are supporting workers to gain the skills they need to transition to the green economy, including through targeted support for retraining. As part of this, through the National Skills Fund (NSF) investment we are delivering Skills Bootcamps, which are short, flexible courses covering digital, technical and green skills. Green Skills Bootcamps are available in areas such as housing retrofit, solar, nuclear energy and vehicle electrification. Overall, we expect there will be approximately 16,000 Skills Bootcamp places available across the country in financial year 2021-22. We will undertake robust evaluation of this exciting training model to explore potential future plans. In addition, our Free Courses for Jobs offer has, since April 2021, been supporting adults that do not have a qualification at Level 3[32] or higher to access over 400 Level 3 courses for free. The offer currently includes qualifications linked to green sectors such as Agriculture, Building and Construction, Engineering, Environmental Conservation, Horticulture and Forestry and Science. An estimated 11 million adults over the age of 24 in England are eligible for the Free Courses for Jobs offer. We will continue working closely with employers to understand where the offer could be extended further to enable more adults to access qualifications to give them skills needed for the net zero transition.

29. This will be underpinned by the Lifelong Loan Entitlement (LLE) from 2025, which will provide individuals with a loan entitlement equivalent to up to four years of post-18 education to use over their lifetime. As part of the pathway towards the LLE, we will trial short course provision at Levels 4-6 to support in-work adults to upskill and retrain, enabling learners to flexibly build towards a full qualification in subjects crucial for net zero including STEM and digital innovation.

30. Through the NSF we are also delivering an Emerging Skills Project in electrification and battery technology, which commenced in June 2021.Alongside this, our NSF funded In-Work Skills Pilot, launched in September 2021, will seek to respond to immediate skills shortages required for net zero, stimulate demand for short course provision at levels 4-5 across STEM sectors, and boost worker's career and progression opportunities in key green sectors, such as electrification in the auto industry and low carbon engineering.

31. Given the pace and the scale of the transformation, we are considering how government can work more closely with sectors in the future to support them in the green transition, and identifying where we can adapt and enhance our support for people at risk of redundancy to support a transition to green jobs. This builds upon our existing work coach interventions and targeted provision including Sector-based Work Academy Programmes (SWAPs), traineeships, apprenticeships and other skills provision which are ensuring jobseekers can develop the right skills to move into green jobs.

Working with business to support people from all backgrounds to have a green career

32. We support the Green Jobs Taskforce's recommendation that industry should prioritise ensuring that people from all backgrounds can work in green jobs, building on existing good practice and capitalising on the unique opportunity of young people's interest in climate change and the environment. A more diverse workforce will aid the transition by expanding the talent pool, encouraging new ways of thinking, enhancing innovation, and boosting profitability and productivity across the economy.[33]

33. To drive this important work forward we will continue to encourage industry to ensure there is equal opportunity for all to work in the green economy, building on our support for industry initiatives such as the POWERful Women campaign and commitment under the 'Equal by 30 Campaign' to close the pay gap, improve female representation in senior roles and opportunity for women in the global clean energy sector by 2030. Through the cross-cutting delivery group we will explore what actions can be taken across industry to improve diversity in the green economy, including improving data collection and transparency.

34. Alongside this, we will continue to work with green employers to raise awareness of the opportunities in the green economy through an integrated careers information, advice and guidance offer through schools, colleges, universities, and employers to raise awareness of different career pathways in low carbon sectors.

35. To further break down perceived barriers to working in the energy sector, boost diversity and increase STEM skills, our Build Back Better campaigns will seek to inspire people from all walks of life to work in the green economy, and raise awareness of green education, training, and careers.

36. The UK's joint presidency of COP26 brings a unique opportunity to showcase green careers to a new generation of children and young people. We are capitalising on this by working with industry to launch the Faces of The Energy Transition campaign to showcase the inspiring people, projects and organisations working to achieve the clean energy transition, and supporting green careers events at COP26 in Glasgow.

Building a foundation for future green careers

37. Schools and colleges will play a vital role delivering high-quality education and training to equip young people with the knowledge and skills required for the green economy. This will help to grow the pipeline of skilled workers needed to help deliver the net zero transition.

38. The science, geography and citizenship programmes in the National Curriculum at both primary (KS1-2) and secondary (KS3-4) cover key content which supports knowledge and understanding of sustainability and climate change. An environmental science A Level was introduced in 2017. Equipping students with secure knowledge and skills in STEM and other key subjects will be critical in supporting them to progress to skilled jobs in the green economy. We are, therefore, supporting teachers to deliver high-quality teaching in these subjects by creating a world-class teacher development system that builds from initial teacher training through to early career support, specialisation and onto school leadership. Our vision is that a golden thread of training, support and professional development - informed by high-quality evidence - will run through each phase of a teacher's career. We are also funding several initiatives to support subject-specific professional development in STEM subjects across all key stages. We are working with Oak National Academy to give teachers access to high-quality curriculum resources to support their teaching, including in subjects that cover sustainability and climate change. We are also working with industry, through programmes such as Tomorrow's Engineers Code, to showcase the diversity of roles and people that make up the STEM sector, encouraging more young people from different backgrounds to choose a career in the sector.

39. We will build on this by bringing forward a strategy which will set out how our children's services, education and skills systems will support the UK to meet its net zero target, become more resilient to climate change and improve biodiversity. This will include a focus on ensuring excellence in education for a changing world, which will prepare children and young people with the knowledge and skills they need to contribute to the green economy.

40. At post-16 level, we will continue to build on our apprenticeship reforms, set out in the *Skills for Jobs White Paper*, to align the majority of post-16 technical education and training with employer-led standards by 2030. A strengthened system of employer-led standards, underpinning apprenticeships, T-levels and new higher technical qualifications will ensure employers, including in low carbon sectors, have a central role in designing and developing qualifications and training.

41. To ensure this system reflects the needs of the green economy, the Institute for Apprenticeships and Technical Education (IfATE) has convened a Green Apprenticeships Advisory Panel (GAAP) to work with employers to align apprenticeships to net zero objectives. Work is underway to map existing apprenticeship standards against green occupations and identify opportunities to create new standards in areas including retrofit, agri-tech and renewable energy and the GAAP has endorsed existing apprenticeships which support green career pathways. We have already seen positive engagement in the energy sector with over 1,000 apprenticeship starts in Wind Turbine Maintenance and Operations Engineering Technician standards in 2019/20. The GAAP will build on this list into 2022, in line with the *Ten Point Plan* and the findings of the Green Jobs Taskforce. The work of the GAAP will also support other key post-16 programmes that are underpinned by the same standards as apprenticeships (such as T levels and higher technical qualifications) to align with the needs of the green economy.

42. In 2021, we introduced the first occupational traineeships, in collaboration with sector bodies, to provide a clear, planned transition to an apprenticeship at Level 2-3 for young people aged 16-24. Going forward, we will consider the potential to develop and introduce other occupational traineeships, including in priority and green sectors to ensure that young people secure the jobs of the future.

43. We are continuing to roll out T Levels that support green careers, providing high quality technical qualifications as an alternative to A Levels which are underpinned by the same employer-led approach as apprenticeships. The building services engineering for construction T Level, launched in September 2021, will cover housing retrofit and heat pump installation. From September 2022, new T Levels will be available in Engineering, Manufacturing, Processing and Control, with

Agriculture, Land Management and Production available by September 2023. IfATE is exploring the suitability of potential future T Levels and occupational specialisms, focusing on areas to support green skills.

44. IfATE has introduced an approval process for Higher Technical Qualifications (HTQs) at Levels 4 and 5. HTQs will be rolled out for teaching from September 2022, covering eleven occupational routes - including qualifications in digital, construction and engineering – coming on stream up to 2025. Future roll-out will continue supporting the development of skills for the transition to net zero as a key government priority. The goal is to grow the number of learners undertaking high-quality level 4 and 5 qualifications to meet skills needs at this level. Earlier this year, we launched an £18 million higher technical education provider growth fund to allow investment in new equipment that will support providers to expand technical studies, and boost local employer links. Our growth fund is supporting 15 universities and 87 FE colleges to teach HTQs from next year.

45. Finally, our network of Institutes of Technology (IoTs) across England are utilising their state-of-the-art facilities to offer training in green skills. This includes the East London IoT which offers training in green and zero carbon energy production, and the Greater Birmingham and Solihull IoT which focuses on sustainable engineering. The network is supporting increased participation from under-represented groups, including women, helping to grow the pipeline of individuals with STEM skills needed for green jobs. We are investing £120 million in the second wave of IoTs, to be up and running by 2022.

Next steps

46. The policies set out in this chapter represent a first step in addressing the challenges identified by the Green Jobs Taskforce. We will progress further work through the cross-cutting delivery group, maintaining the momentum generated by the Taskforce to drive action across the green skills agenda. Working alongside industry, we will continue to build the evidence on the skills gaps which could hamper the net zero transition if left unaddressed, assess how far existing interventions are on course to address those skills gaps, and where appropriate identify further opportunities to flex key skills programmes to support green sectors and occupations.

4iv. Embedding Net Zero in Government

Climate considerations underpinning policy across Government

Our Key Commitments

- Require the government to reflect environmental issues in national policy making through consideration of five environmental principles.
- Ensure that decisions taken on government spending are informed by their impact on meeting net zero.
- New measures to reduce emissions from Government's £292 billion procurement spending – and ensure suppliers have plans for achieving net zero on major qualifying public contracts.
- Continue to fund the Public Sector Decarbonisation Scheme at £475 million per year to drive ambitious emissions reductions in schools, hospitals, and other public buildings, whilst taking further action on skills, reporting, and targets.
- Publish an annual progress update against a set of key indicators for achieving our climate goals.
- Expand climate change training to ensure the Civil Service has the skills and people it needs to deliver net zero.

The challenge

1. Net zero is a complex and transformative undertaking for the UK. The way the government operates must rise to meet this challenge. This means reducing the public sector's own carbon footprint – but also changing how we are organised and how we take decisions. Building on our recent historic progress, we are now going further to ensure the whole government meets the challenge of net zero.

Our goal

2. Since setting the net zero target, a huge effort has taken place across government to ensure we are set up in the right way to deliver on our climate ambitions. We have gone further than ever before to put the climate at the heart of our decision-making. This includes:

- Establishing two Cabinet Committees dedicated to climate change;
- Announcing as part of the Integrated Review of Security, Defence, Development and Foreign Policy that tackling climate change and biodiversity loss will be the Government's number one international priority;
- Using the Environment Bill to require the government to reflect environmental considerations in national policy making through consideration of five environmental principles;
- Taking new approaches to embed net zero in spending decisions;
- Establishing the No.10 Delivery Unit to ensure the government maintains a sharp focus on delivering the country's key priorities. One of the four priorities for this Unit is the delivery of net zero; and,
- Setting out in collaboration with key net zero delivery departments, a high level strategy for delivering on the UK's net zero commitments through the BEIS Outcome Delivery Plan 2021-2022. This plan identified key programmes critical to delivery and set out an evaluation plan to monitor and assess progress.

3. These efforts put climate change at the heart of our decision-making and have led to the ambitious announcements set out in recent years: the Prime Minister's *Ten Point Plan for a Green Industrial Revolution*, dedicated strategies for key sectors of the economy, and this Net Zero Strategy; and set us up to deliver on those commitments.

4. Our goal is to go even further to embed net zero across government activity. This will mean that government takes net zero into account when taking decisions, public sector buildings will emit less carbon, our procurement decisions will lead to greener supply chains, and civil servants across government will have the skills they need to deliver this mission.

5. To do this we must understand the interactions between climate change and other UK priorities. The measures set out in this chapter are crucial for ensuring that the UK takes a whole system approach to tackling climate change:

- Multiple forums – including Cabinet Committees – that bring together different perspectives on net zero and its interaction with other priorities;
- Delivering climate skills and training across the Civil Service – not just to civil servants working directly on climate issues;
- Close working relationships with local government and the Devolved Administrations; and,
- Embedding net zero in a wider range of decision-making levers.

Net zero in government decision-making

6. In the last two years the Government has made commitments to strengthen governance around net zero. Two Cabinet committees were established in 2020 to rationalise climate governance and put net zero at the heart of government decision-making. This is driven by the Prime Minister, who chairs the Climate Action Strategy Committee (CAS). This Committee considers matters relating to the delivery of the UK's domestic and international climate strategy. In addition, the Climate Action Implementation Committee (CAI) which is chaired by the COP President Designate. It considers the delivery of COP 26, net zero and building the UK's resilience to climate impacts. These committees' ability to scrutinise progress and take whole system decisions will be strengthened by the new measures described in this chapter.

7. These committees are supported by well-established and robust governance at official level. This includes a cross-government Director General group that was established in 2019 to ensure a whole-of-government approach to climate policy, with oversight at the most senior levels. Chaired by the BEIS Director General for Net Zero and International, this group brings together officials from across government, creating a whole system perspective, to support the delivery of significant climate announcements, including those contained in this Strategy.

Consistency of approach across the UK

8. To reach net zero we must take a UK-wide approach. The UK Government and the Devolved Administrations are committed to working together to deliver coordinated policy action to meet respective emissions reduction targets across the UK. Combined, Scotland, Wales and Northern Ireland produced 22% of UK emissions in 2019,[34] and accounted for 16% of the UK's population, 13% of economic activity[35] and nearly half of the UK's land area (46%).[36] Powers and policies to deliver ambitious emissions reductions in the Devolved Administrations Scotland, Wales and Northern Ireland are partly reserved to the UK Government and partly devolved.

9. The UK Government and the Devolved Administrations have established governance arrangements to ensure a joined-up and collaborative approach to climate change. At the bimonthly Net Zero, Energy and Climate Change Inter-Ministerial Group, UK Government ministers meet with Devolved Administration counterparts to discuss emerging policies that will contribute to delivery of net zero targets across the UK, such as delivering a UK-wide Emissions Trading Scheme, and the level of the sixth carbon budget which was set in law in June 2021. The Group is supported by the official-level Net Zero Nations Board on alternate months.

Embedding net zero in government decisions

10. Climate change is a major issue for all governments in the 21st century. Our mission to reduce emissions, seize economic opportunities, and adapt to extreme weather events will affect many more of the decisions that the Government takes than it would have done in previous decades. To that end, it is essential that we put in place new levers to ensure that all the Government's decisions adequately take climate change into account. This Strategy sets out key measures we will take to ensure a climate-focus on key future decisions made by the government.

11. We are using the Environment Bill to require the government to reflect environmental issues such as climate change in national policy-making through consideration of five environmental principles:

- The integration principle is the principle which states that policy-makers should look for opportunities to embed environmental protection in other fields of policy that have impacts on the environment.
- The prevention principle means that government policy should aim to prevent, reduce or mitigate harm.
- The rectification at source principle means that if damage to the environment cannot be prevented it should be tackled at its origin.
- The polluter pays principle is the principle that those who cause pollution or damage to the environment should be responsible for mitigation or compensation.
- The precautionary principle states that where there are threats of serious or irreversible environmental damage, a lack of scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

12. The duty to consider these principles should be applied in the early stages of policy development and considered throughout. In doing so, the extent to which a policy will contribute to climate change should be considered alongside other impacts of the policy on the environment. Net zero will therefore be facilitated by the principles where they are applied to relevant decisions.

13. The integration principle will create a prompt for policy makers to embed environmental protection in policy making, triggering consideration of the government's priorities for environmental protection (such as net zero) and whether these priorities can be supported through the new policy. The polluter pays and prevention principles could also help to contribute to net zero targets, through encouraging policies that reduce carbon emissions and prevent adverse impacts on climate where possible. These principles will ensure the environment is at the heart of policymaking across government.

14. Ensuring spending decisions contribute to net zero is a major priority for HM Treasury. The Green Book already mandates the consideration of climate and environmental impacts in spending. It has been updated so that policies must be developed and assessed against how well they deliver on the Government's long-term policy aims such as net zero.

15. Spending reviews are critical moments for the Government to look strategically at the country's priorities and make spending decisions based on these. At Spending Review 2020 (SR20), guidance required departments to state the greenhouse gas emissions of bids, and their impact on meeting Carbon Budgets and net zero. Allocations to departments were informed by this information, and £12 billion was committed to green measures. We have reviewed the learning from this exercise to further embed climate change in spending decisions in the next spending review and in the long term.

16. In September 2021, the Government published updated guidance on how impacts on greenhouse gas emissions should be measured in policy decisions. As a result, departments must place a significantly higher value on emissions in determining policy, as the values now fully reflect the UK's increased ambitions on climate. This complements wider considerations on natural capital impacts in policy decisions – and represents a significant step forward in incorporating environmental impacts into policy development.

17. As set out in the *Green Investment* chapter, we have also taken steps to ensure net zero is embedded in government funding and regulation of the financial system. Arm's-length bodies, such as the British Business Bank, have adopted net zero as a core objective. This will expand the flow of finance to those innovative firms that will help us reduce our energy consumption and mitigate the impacts of climate change.

18. This builds on important announcements in the 2021 Budget, particularly the new UK Infrastructure Bank that will use its £22 billion of financial capacity to crowd-in private investment to support economic growth, accelerate our progress to net zero, and help level up the UK. One of the Bank's objectives is to help the UK transition to net zero emissions by 2050.

19. We will make sure that the reformed planning system supports our efforts to combat climate change and help bring greenhouse gas emissions to net zero by 2050. For example, as part of our programme of planning reform we intend to review the National Planning Policy Framework to make sure it contributes to climate change mitigation and adaptation as fully as possible.

Supporting UK businesses

20. We are considering net zero through our support to business too across government activity. Innovate UK is the UK's Innovation Agency, it drives productivity and economic growth by supporting UK businesses to commercialise new ideas and address the big societal challenges facing the UK today.

21. As the UK moves to a net zero economy, Innovate UK is supporting businesses to exploit new ideas, develop supply chains, and thrive in growing global markets. Last year Innovate UK committed to spend £276 million with UK businesses to tackle net zero.

Net zero in the work of regulators

22. Many of the UK's regulators will play a role in facilitating delivery of the infrastructure, technologies and activities that will deliver the net zero transition. Several examples are set out in the sector focused chapters in this strategy. The government is also considering whether and how the functions of those regulators most important to the transition can be strengthened.

23. For example, to provide strategic guidance to Ofgem on the government's energy policy, the *Energy White Paper* committed the government to consulting on an energy sector strategy and policy statement (SPS) for Ofgem during 2021. The SPS will set out the strategic priorities and policy outcomes of the government's energy policy, with net zero as the driving theme. This will impose a legal obligation on Ofgem to have regard to the strategic priorities and policy outcomes when exercising its regulatory functions. To provide clear legal accountability, Ofgem will be required to report on how it intends to implement the SPS at the outset, and then report annually on its performance and its plans for the coming year.

24. The Competition and Markets Authority (CMA) is reviewing how the UK can better use the tools available under competition and consumer law to achieve net zero and our sustainability goals. The CMA will provide this advice in early 2022. This follows recent CMA work on misleading environmental claims, its market study into electric vehicles and its publication of information to businesses on sustainability agreements.

25. The National Infrastructure Strategy committed to taking a long-term approach to investment for the benefit of both investors and consumers, responding to the findings of the National Infrastructure Commission's report on the future of economic regulation in key infrastructure. The government also committed to publishing an overarching policy paper in 2021. The policy paper will set out next steps on key issues including: the consideration of duties in the round to ensure they reflect new challenges such as achieving net zero, promoting coherence, and supporting a transparent strategic framework; and the exploring of the merits of a cross-sector-strategic Policy Statement to provide clarity on government's overarching strategic vision for the regulated sectors.

26. In addition, the Government has recently consulted on proposals for reforming the UK's regulatory framework. When the consultation response is published, it will include the Government's decisions on how regulators can be encouraged to consider themes such as competition, innovation and net zero in their regulatory activities. For example, the consultation sought views on whether regulators might be granted more flexibility by government to choose how they intervene in their sectors, to allow more agile, smarter regulation. The Government would like to see a consistent approach taken across the various regulated sectors and will set out more thinking on this in due course.

Demonstrating progress towards net zero

Increasing transparency of progress

27. Every year the government comprehensively reports the UK's historic emissions since 1990 and publishes projections of future emissions.[37] The UK's 'Energy and Emissions Projections' is a world-leading approach to projecting the UK's annual emissions, by sector, according to United Nations Framework Convention on Climate Change guidelines.

28. We are now going further to clearly demonstrate the tangible milestones that the UK will have to reach to achieve net zero, and to communicate and invite scrutiny on this progress to the public.

29. It is critical for public and industry confidence that the UK has a clear plan for achieving net zero – and that we are transparent about how this plan progresses and changes over time. The *Journey to Net Zero* chapter of this Strategy report set out a delivery pathway: an indicative trajectory of emissions reductions based on potential in each sector of the economy, which keeps us on track to meet the sixth carbon budget ending in 2037. Sector chapters set out policies and proposals in line with this indicative pathway to ensure we are on track for net zero. While it is impossible to predict every path to net zero, this pathway sets out the decisive action we know is needed and acts as the best plan we have to measure progress against.

30. We are therefore committing to provide a public update every year on progress in the previous year against the delivery pathway to net zero set out in this Strategy. This will include:

- An update on progress against the targets and ambitions set out in this Strategy (see Table A), building on this list over time to incorporate additional Government targets and wider non-Government indicators of progress;
- Commentary on contextual changes that might affect the exact pathway to meeting decarbonisation commitments; and,
- A summary of key areas of progress made against this pathway the policies and proposals in this strategy.

The following targets and ambitions will form part of the Government's annual update on progress towards net zero:

Power	By 2035 all our electricity will come from low carbon sources subject to security of supply. 40GW of offshore wind by 2030, including 1GW floating wind.
Industry	Ambition to deliver 6 $MtCO_2$ per year of industrial CCUS by 2030, and 9 $MtCO_2$ by 2035.
Fuel supply and hydrogen	5GW of low carbon hydrogen production capacity by 2030. Achieve a final decision on whether to enable blending up to 20% hydrogen by volume into the Great Britain gas network by 2023, subject to successful completion of safety trials. The offshore oil and gas sector to have an absolute reduction in production emissions of 10% by 2025, 25% by 2027, and 50% by 2030 on the pathway to net zero by 2050.[38]
Heat and buildings	Aim to reduce direct emissions from public sector buildings by 75% by 2037 compared to 2017. Achieve a minimum market capacity of 600,000 heat pumps per year by 2028. As many homes to reach EPC Band C as possible by 2035, where practical, cost effective, and affordable. As many fuel poor homes as reasonably practicable to Band C by 2030.

Transport	Double cycling from 2013 to 2025.[39] Increase walking activity by 2025.[40] Deliver 4,000 new zero emission buses and the infrastructure needed to support them. 25% of the government car fleet ultra low emission by December 2022 and 100% of the government car and van fleet zero emission by 2027. 100% of new cars and vans sold are zero emission by 2035. 100% of new HGV sold are zero emission. 100% of new buses/coaches sold are zero emission. Maximise GHG savings from low carbon fuel use in transport by increasing the Renewable Transport Fuel Obligation main obligation from 9.6% in 2021 to 14.6% in 2032.
Natural resources, waste, and F-gases	Restore at least 35,000 ha of peatlands in England by 2025 and approximately 280,000 hectares of peat in England by 2050. Increase tree planting rates from 13,660 hectares across the UK in 2020 to 30,000 hectares each year by the end of this Parliament. Deliver the UN Sustainable Development Goal 12.3 to halve food waste by 2030. Explore policies to work towards the near elimination of biodegradable municipal waste to landfill by 2028. Meet the Kigali Amendment target of reducing HFC consumption by 85% by 2036, as well as the F-gas Regulation's target of a 79% reduction by 2030.
Greenhouse gas removals	At least 5 $MtCO_2$/yr of engineered removals by 2030.

31. We will publish an updated Net Zero Strategy when we set the next Carbon Budget.

Strengthening delivery oversight of net zero projects and programmes

32. Significant recent steps have been taken to oversee the delivery of key projects and programmes that will contribute to net zero. This year, the Prime Minister established the No. 10 Delivery Unit to ensure the government maintains a sharp focus on delivering the country's key priorities. One of the four priorities for this Unit is the delivery of net zero. BEIS in parallel has developed a new model for monitoring net zero delivery and reporting on programme and project-level risks – ensuring decision makers get early visibility of common issues and inter-dependencies across all programmes delivering net zero. This will enable them to make informed, timely decisions to enable us to stay on track to meeting net zero.

33. This complements work led by the Infrastructure and Projects Authority (IPA). The IPA is the government's centre of expertise for infrastructure and major projects, supporting the successful delivery of all types of major projects. The IPA sits at the heart of government, reporting to the Cabinet Office and HM Treasury. The Project Outcome Profile Tool launched in July 2021, ensures that projects and programmes are clearly linked to government priorities (such as net zero) from the outset and support their delivery. Its assurance toolkit has recently been updated to include key tests and key questions on the environment, climate adaptation, and net zero, in the Government's gateway process. Through the IPA's *Transforming Infrastructure Performance: Roadmap to 2030*, it is driving the use of whole life carbon reporting to reduce embodied carbon in the built environment.

Government leading by example

Decarbonising the public sector

34. Government and the wider public sector will lead by example during the transition to net zero. As well as ensuring that net zero is reflected in our structures and practices, we will continue to take ambitious action to reduce public sector emissions, showing leadership to the wider economy, and making a direct contribution to reaching net zero.

35. Direct emissions from public sector buildings account for around 2% of total UK emissions, and the public sector has reduced its emissions by around 40% since 1990.[41]

36. We intend to act in three areas to ensure we are on track to achieve net zero: investment, transparency, and capacity and capability, and in doing so will aim to reduce direct emissions from public sector buildings by 75% against a 2017 baseline, by the end of Carbon Budget 6.

Investment

37. Reducing direct emissions from public sector buildings requires investment in measures to reduce fossil fuel use, including the installation of low carbon heating and complementary energy efficiency improvements, and the installation of low carbon electricity systems such as rooftop solar PV. The Public Sector Decarbonisation Scheme is providing over £1 billion in grants over 2020/21 and 2021/22 for public sector bodies to fund heat decarbonisation and energy efficiency measures.

38. Building on the success of the Public Sector Decarbonisation Scheme, we will continue and extend the scheme to ensure that public sector bodies have access to finance to continue decarbonising their estates , investing a further £1425 million over 2022/23 to 2024/25.

High standards with transparency

39. Public sector organisations should be taking steps to achieve net zero now should report their progress so they can be held accountable and as publicly funded organisations. Government departments and their arm's length bodies already set and report against targets to reduce their greenhouse gas emissions in Greening Government Commitments. The updated Greening Government Commitments framework for 2021-25 will ensure the public estate continues to reduce its environmental footprint, align with commitments in our 25 Year Environment Plan and be consistent with a trajectory to achieving net zero greenhouse gas emissions by 2050.

40. All public sector bodies should now be monitoring their energy use and have targets to reduce emissions, particularly, to reduce the direct emissions for which they are responsible. To ensure we are on track to reach net zero, emissions from the public sector should be reported and monitored on a consistent and coherent basis. We will provide guidance to make clear the government's expectations in this regard.

41. We will also legislate to enable us to require the reporting of public sector emissions on a consistent and coherent basis if this is not done on a voluntary basis, and, if insufficient progress is made on reducing emissions in the public sector, to require that all public sector organisations are working toward and reporting against a legally-binding target to reduce their greenhouse gas emissions.

Capacity and capability

42. Reducing emissions requires specialist skills and expertise, as well as funding. Action at an unprecedented scale is required to reduce emissions from public sector estates in line with net zero, and organisations need the right skills and structures to deliver on this. We will continue to work with partners across government and the wider public sector to understand these needs, and provide the support needed to address them.

Delivering net zero through public procurement

43. The Government is determined to leverage public procurement to help achieve net zero. We will use our buying power to drive decarbonisation and to create the policy tools and training to enable public procurers to grasp this opportunity.

44. Clearly establishing the strategic importance of net zero at project design stage, as described above, will mean that it is easier to draw through this ‘golden thread’ when reaching procurement stage. The government has recently announced three distinct new policies that can all help public procurers fully embed net zero into their work. These all kick in at different stages of the commercial cycle, complementing each other in terms of their scope and their reach.

45. *The National Procurement Policy Statement* (NPPS), published in June 2021, sets out clear principles that contracting authorities should be following organisationally. Tackling climate change and achieving net zero is one of the key considerations established – this should then be woven through individual procurements (for qualifying procurements).

46. The Procurement Policy Note on *Taking account of carbon reduction plans in the procurement of major government contracts* comes into effect from Autumn 2021. This will impact over £50 billion of procurement spend. For qualifying contracts, it requires suppliers who are bidding on central government contracts (over £5 million p/a in value) to commit to achieving net zero by 2050 and to detail their organisation’s UK greenhouse gas emissions via the publication of a Carbon Reduction Plan. Failure to do so may mean exclusion at supplier selection stage. Government will continue to take action to reduce emissions, and this policy is an important step in ensuring our supply chain is sharing this ambition and taking similar steps to reduce their emissions.

47. The Social Value Model requires government to expressly evaluate environmental, social and economic benefits, with these factors comprising a minimum of 10% of the evaluation score for qualifying procurements.[42]

48. Throughout the development of these policy measures, government has been working with departments, suppliers and industry bodies to raise awareness of how environmental considerations can be brought into the commercial process, and to build capability in understanding and assessing suppliers’ commitments. Several thousand buyers across government have completed Social Value training to develop the skills required to embed environmental policy outcomes and improve the sustainability of government contracts. We will continue to support the adoption and implementation of environmental policy measures to deliver the best commercial and environmental impact for the UK.

49. These measures provide a platform for even stronger action. We have embarked upon a programme of major domestic procurement reform. This will enable us to use flexibilities provided by our departure from the EU to give even greater consideration to environmental factors in our decision making. One specific example is the proposal to break the subject matter of contract link so that a company's wider environmental proposals for the project can be factored into procurement decisions.

50. Domestically we also want to make it easier for procurers to balance carbon against cost. We want to underpin our net zero target and COP26 ambitions by developing tools to help us decarbonise the government's supply chains and stimulate innovation and growth in the UK's green economy. This work also takes into account the Climate Change Committee's (CCC) call for credible, quantifiable pathways for sectoral decarbonisation. We will also explore the possibility of establishing a new single unit for all sustainable procurement policy within government to strengthen performance, coordination, and oversight.

51. Our ambition is necessarily high – we are changing the expectations on ourselves when it comes to utilising £292 billion of annual procurement spend. In doing so we are also sending a clear signal to the market: data on carbon impact, and immediate ambition to reduce it, will be increasingly important in how we choose to do business with you.

Showing leadership on domestic and international standards

52. The BSI, in its role as the UK's national standards body, works across the sectors and topics that will be critical in achieving net zero, including greenhouse gas management, energy transition, biodiversity and sustainable finance. This work is helping the UK to take a global leadership role in net zero and influence change on a global scale. To this effect BSI and the International Organization Standardization have developed the London Declaration – a commitment to actively consider climate change in the development and revision of all international standards and to facilitate the involvement of civil society and those most vulnerable to climate change.

53. Through BSI's international reach, the UK will be able to help stakeholders reach consensus in international climate change standards and lead change globally in support of net zero.

Ensuring the right skills and talent in government

54. The government has established the Government Skills and Curriculum Unit (GSCU) to oversee the delivery of better training, knowledge and networks that the over 440,000 people working in the Civil Service will need today and in the future.

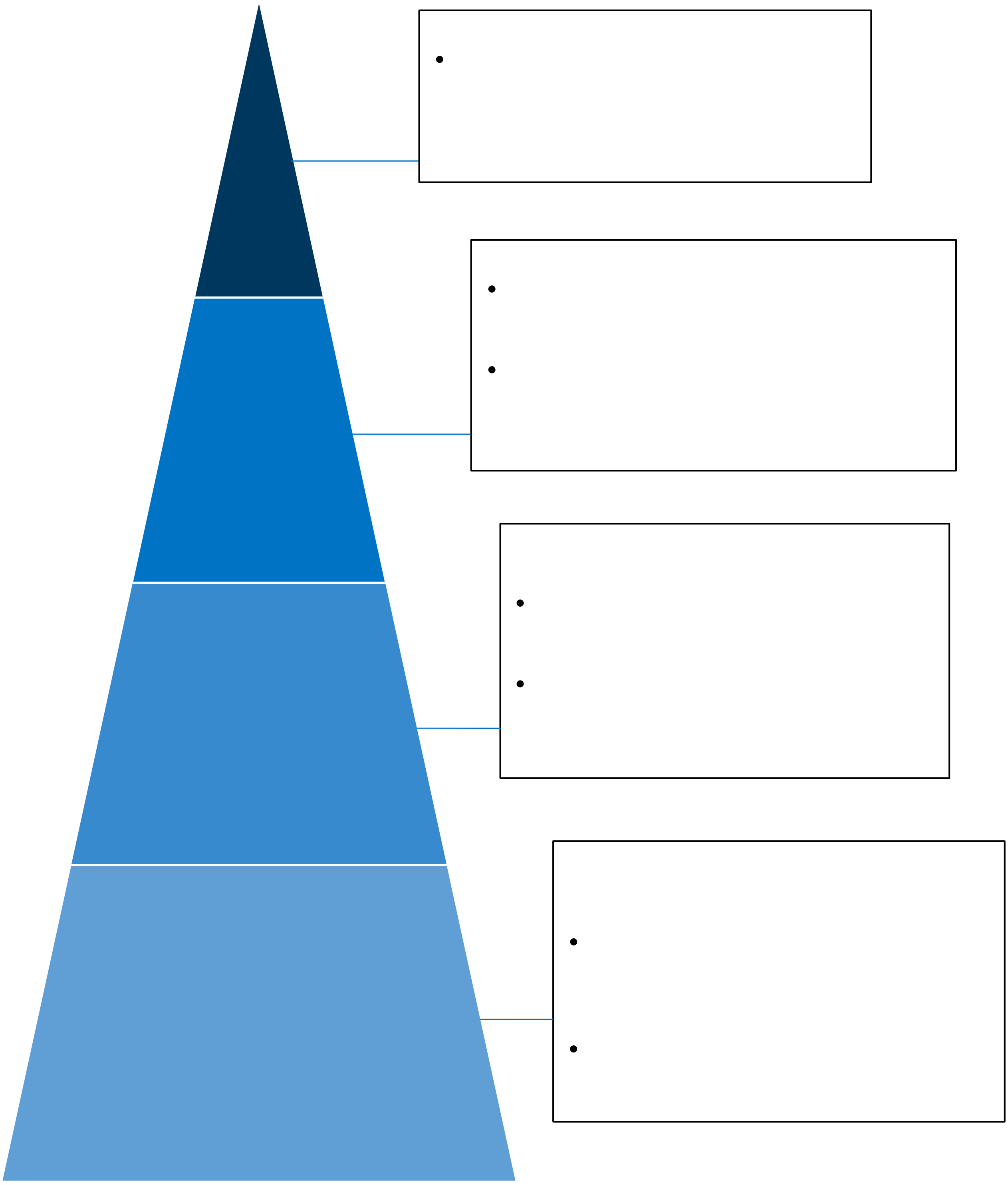
55. Net zero will continue to be a priority for the government until 2050 and beyond. To that end, BEIS and GCSU are reviewing the skills, training and networks that civil servants need to lead the UK's future efforts to decarbonise (see infographic below).

56. We are expanding the curriculum for civil servants to include specific training on climate change. We are also establishing climate specific training within the Civil Service Fast Stream curriculum.

57. We have also embedded climate considerations in the Policy Profession Standards, the competency framework that supports professional development for all civil servants developing policy. For the first time, this makes explicit that good policymaking requires an awareness of the potential for all policy areas to contribute or undermine our climate goals.

58. We are establishing a new climate focus within the Civil Service Fast Stream Generalist Scheme, which will focus on providing relevant skills and opportunities to some of the future leaders of the Civil Service.

Ambition for climate capabilities across Government



4v. Local Climate Action

Supporting decarbonisation and regeneration in our local areas and communities

Key Commitments

- Set clearer expectations on how central and local government interact in the delivery of net zero.
- Build on existing engagement with local actors by establishing a Local Net Zero Forum to bring together national and local government senior officials on a regular basis to discuss policy and delivery options on net zero.
- Continue the Local Net Zero Programme to support all local areas with their capability and capacity to meet net zero. This includes provisions to:
  - Continue the Local Net Zero Hubs (previously known as the local energy hubs) to support all areas of England to reach net zero, including those lacking capacity and capability, or those facing unique challenges.
  - Promote best practice and support local authorities to develop net zero projects that can attract commercial investment.
  - Increase knowledge sharing to demonstrate and share successful net zero system solutions.

The challenge

1. Devolved and local government play an essential role in meeting national net zero ambitions. Across the UK many places have already made great strides towards our net zero future, having set their own targets and strategies for meeting local net zero goals. Taking a place-based approach to net zero is also vital to ensuring that the opportunities from the transition support the government's levelling up agenda.

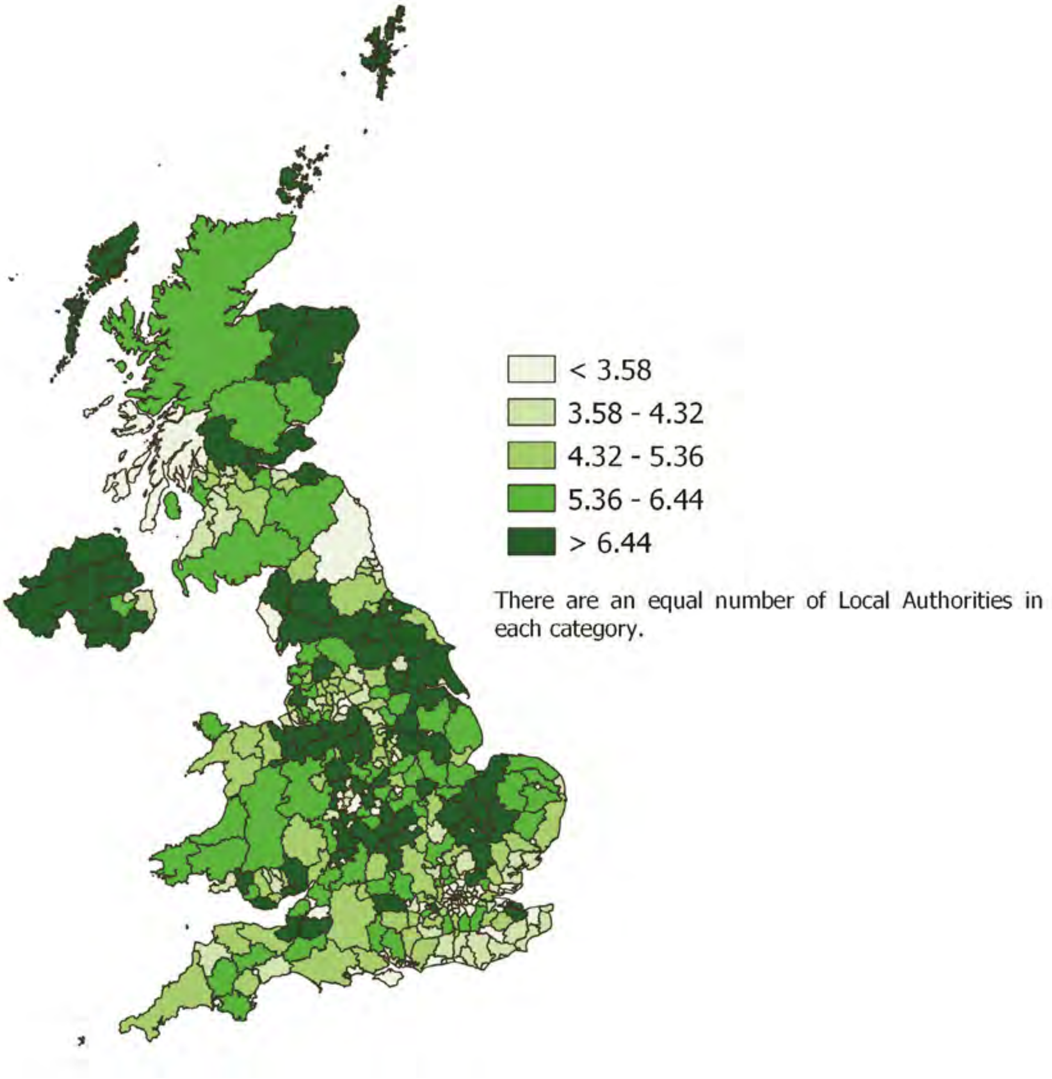
2. The combination of devolved, local, and regional authorities' legal powers, assets, access to targeted funding, local knowledge, and relationships with stakeholders enables them to drive local progress towards net zero. Not only does local government drive action directly, but it also plays a key role in communicating with, and inspiring action by, local businesses, communities, and civil society. Of all UK emissions, 82% are within the scope of influence of local authorities.[43]

3. Local leaders are well placed to engage with all parts of their communities and to understand local policy, political, social, and economic nuances relevant to climate action. The government currently works with the Core Cities Group, for instance, which undertakes a range of activities to promote climate change adaptation, raise awareness and foster leadership in cities. Local government decides how best to serve communities and is best placed to integrate activity on the ground so that action on climate change also delivers wider benefits – for fuel poor households, for the local economy, for the environment and biodiversity, as well as the provision of green jobs and skills.

4. Despite the excellent work already underway, we understand that there remain significant barriers to maximising place-based delivery on net zero. We know that some places are moving faster than others and that places and communities will face different challenges when meeting net zero commitments and adapting to climate change.

5. There are significant regional variations in the level of emissions (see Figure 29 below) and some of the hardest hit local economies that face multiple development and growth challenges are proportionally home to a greater number of lower skilled workers. Many of these areas are also where high-carbon industries are located.

Figure 29: Net emissions of carbon dioxide per capita by Local Authority (tonnes CO_2e per capita) in 2019



Source: ONS

6. We also recognise that certain types of communities, such as rural and coastal communities, face significant and unique challenges. For example, the increased age of rural housing makes it both more difficult and expensive to introduce energy efficiency measures and rural communities also have greater reliance on cars. Similarly coastal communities face significant challenges as they may be vulnerable to more frequent flooding, rises in sea level, and accelerated coastal erosion which will have the potential to affect public services and infrastructure. However different types of localities may also have opportunities available to them that do not exist everywhere. For instance, coastal communities may be able to utilise tidal energy or industrial scale water source heat pumps, and rural areas may have access to sustainable biomass.

7. There are currently no net zero statutory targets on local authorities or communities in the UK, and we do not believe that a new general statutory requirement is needed. This is because of the existing level of local commitment with the sector, and because it is difficult to create a uniform requirement that reflects the diversity of barriers and opportunities local places experience. However, we do understand that there is a real need to ensure local leaders across the board are supported by enhancing the capacity and capability of local areas to deliver net zero, coordinating engagement with local authorities, and clarifying expectations at a national level to accelerate local progress towards net zero.

8. Central and local government will need to work closely together to deliver net zero and our interim carbon budgets. Government analysis suggests that over 30% of the emissions reductions needed across all sectors to deliver on our Carbon Budget 6 target, as set out in this strategy, rely on local authority involvement to some degree.[44]

Our goal

9. The government will continue to set UK-wide priorities for meeting carbon budgets and for assessing how each sector will help meet those budgets. Local government has a key role in integrating delivery at a local and regional level to deliver more cost-effective routes to net zero and derive local co-benefits that embed climate action in the heart of local places and services. By taking this approach, we can achieve even more for net zero and for the economy locally and nationally; we recognise that a one-size-fits-all approach will not work. We want to build strong partnership working between central, devolved, and local government, increase the co-ordination and better support all levels of government to utilise the influences available to them.

10. We want to continue to empower our local leaders to take the actions which will lead to the biggest gains in emissions reduction, including the potential opportunities in building back greener and meeting our ambitions to level up the country. While the COVID-19 pandemic has severely impacted our communities, it has also reshaped how we think about place, community, and our natural and built environment.

11. Community empowerment, engagement, and action can play a role in supporting the UK's transition to net zero and enable communities to access the benefits that it brings, from greener jobs to improved health. Communities are especially well placed to help raise awareness and engage people in adopting net zero behaviours. For example, community ownership of renewables and other assets, often in partnership with other organisations, can be an important driver of reducing local emissions. It can also enable people to learn more about climate change and build sustainable behaviours.

12. We will continue to provide support for public and private investment opportunities in local places that will enable the local delivery of emissions savings across the sectors. In the sector chapters we have shown the range of programmes from building retrofit, heating, electric vehicle charging and many others where funding will go to local government to deliver action in their communities.

Enabling local areas to deliver net zero

13. To support all local government in developing and delivering their net zero delivery plans, we need to act in three key areas:

a. **Setting clearer expectations** for local places, clarifying how the partnership with local government should work, and considering how action at national, regional, local, and community levels fits together to tackle the emission and climate risk challenges we face, and the wider benefits the transition brings.
b. **Providing resources** for local places to deliver stronger contributions to national net zero targets, across dedicated funding streams for net zero and non-ringfenced funding, noting the number of broader priorities on which local government needs to deliver.
c. **Building capacity and capability** at the local level to support ambition and share best practice, while also providing support in areas that may not have made as much progress to date.

14. To act effectively across these areas, and for local government to translate national goals into local action, we will build on our existing engagement to improve the way local and national government collaborate on net zero. The Department for Business, Energy and Industrial Strategy (BEIS) will take overall responsibility for improving coordination with local government and other local actors on the effective design and delivery of local net zero policies, as part of the Department's overall responsibility and wider leadership on delivering net zero. Other departments will continue to lead on their specific policy areas such as Department for Transport on the decarbonisation of transport. We intend to build on many of the existing ways of working together to provide more consistency and clarity over roles and responsibilities between national and local government.

15. We will do this by establishing a Local Net Zero Forum to ensure that there is direct input from local leaders. Chaired by BEIS, the Forum will be cross departmental and bring together national and local government senior officials on a regular basis to discuss policy and delivery options on net zero. The forum will build on our current engagement mechanisms through the representative bodies such as the Local Government Association (LGA), Association for Public Service Excellence (APSE), Core Cities and the Association of Directors of Environment, Economy, Planning & Transport (ADEPT). The creation of the Forum also draws on the recommendations for a policy framework put forward by member network UK100. The Forum will support the establishment of clearer delivery roles for local government and provide a single engagement route into HM Government in a coordinated and coherent way.

16. On adaptation, local actors will be supported through increased Environment Bill powers to take effective action, reduced financial burdens from waste management and stronger abilities to improve health and social outcomes for local citizens.

17. Achieving our aims requires national decision makers to have the right knowledge and awareness to understand the local impacts of decisions. BEIS will work with other departments and stakeholders to demonstrate successful net zero system solutions by creating a network of experience that amalgamates learning through case studies and non-spatial planning tools.

18. We have already developed a Carbon Literacy toolkit for the delivery of Carbon Literacy training for local authorities. This training has been made available to all local authority staff and aims to increase awareness and ability to reduce emissions across all the policies and programmes local government work on. BEIS has created a sector course and places like Manchester and Sheffield are among the early adopters who have trained staff and councillors.

Funding

19. Funding for local climate action comes from a combination of the Local Government Finance Settlement, other government grants and support schemes, borrowing, and private finance. Collectively, this means there is a range of funding available for local authorities to act on climate change. Some have chosen to explore community bonds and crowdfunding. A third of local authorities say their climate change plans will be cost-neutral by incorporating goals into existing service area strategies, drawing on the funding available for those services.

20. An important part of the funding landscape is the diverse range of grant funding schemes provided by HM Government to support local delivery. The recent National Audit Office (NAO) review into local government and net zero identified 22 dedicated grant schemes for net zero work from central to local government. We recognise that longer term and more co-ordinated funding streams can enhance innovation and investment, reduce bureaucracy, and encourage more efficient and integrated decision making. We will explore how we could simplify and consolidate funds which target net zero initiatives at the local level where this provides the best approach to tackling climate change. Building on the vision in the Prime Minister's *Ten Point Plan*, we also will work across departments to explore how we can give certainty to investment in longer-term programmes supported by regeneration initiatives.

21. In addition to the above, the UK Infrastructure Bank (UKIB) will lend to local authorities for strategic and high value projects and invest in projects alongside the private sector, crowding in private sector capital. It has twin objectives of helping to tackle climate change, particularly meeting the UK's net zero emissions targets and helping to support regional and local economic growth across the UK. The UKIB will offer loans to local authorities for high value and strategic projects of at least £5 million. To complement this investment activity, over time, the UKIB will develop an expert advisory service to help local authorities develop and finance projects. The UKIB will build partnerships across the UK including with government departments, government sponsored bodies, local authorities and relevant representative organisations to foster collaboration and drive value for money. As it engages with the market, the UKIB will continue to learn and adapt, which will ensure that its loans to local authorities are as effective as possible.

22. The UKIB is currently operating in an interim form, as it expands its capability and capacity. It will continue to refine the Local Authority Lending Function over the coming months.

23. The Department for Business, Energy and Industrial Strategy will continue to work with partners and the finance sector to develop new finance and business models to support local delivery. These business models will look to develop aggregated projects and portfolios of projects building up scale and spreading delivery risk more effectively for investors.

Sectoral priorities at a local level

24. We understand that for local areas to deliver net zero they will need specific support to plan and identify priorities across different sectors of the economy.

Local energy

25. Decarbonisation of our buildings, transport systems and energy system will require significant action at a regional and local level. Generation and storage are becoming increasingly decentralised, with solar and batteries being deployed in buildings, vehicles, and local communities. Heat and transport decarbonisation in particular needs to be delivered in a way that meets local needs and with the involvement of local decision makers. Decarbonisation will require strong co-ordination across electricity, heat, hydrogen, transport, and buildings. That means local actors can be strong drivers of change, enabling coordinated non-spatial planning and engagement with markets, and supporting cleaner, cheaper and more efficient energy whilst providing a significant contribution towards local economic strategy.

26. Better engagement and information sharing across organisations can enable better forward-planning and a more coordinated approach. BEIS has work underway with Ofgem to develop a better understanding of the opportunities and challenges presented by local area energy mapping and planning (LAEMP) and are considering the most appropriate policy options to take forward. This work could help to bring together key local stakeholders to explore the impact of decarbonisation choices across sectors and how different technology options may impact on local energy networks.

27. The Government has committed up to £102.5 million of funding through the Industrial Strategy Challenge Fund to Prospering from the Energy Revolution. This is an innovation programme which develops smart local energy systems to provide investable, scalable local business models and finance mechanisms using integrated approaches to deliver cleaner, cheaper energy services. The programme is supporting three places to demonstrate the use of this framework today and a further ten places to develop detailed plans and business cases to deliver whole place decarbonisation.

28. The programme is designed to work across a range of different areas including, big urban conglomerations, cities, towns, industrial regions, regeneration projects and rural communities. Each of these face different challenges and opportunities in reaching net zero and the programme seeks to identify the economic as well as the social and environmental benefits of delivering integrated Smart Local Energy Systems, not just for the place but also nationally.

29. The government also provides funding to deliver programmes that support decarbonisation through the Local Net Zero Programme (previously known as the Local Energy Programme), which is supporting Local Enterprise Partnerships (LEPs), local authorities, and communities in England to play a leading role in decarbonisation and clean growth. Almost £22 million has been invested in the Local Energy programme to date, including funding for the creation and continuing support of 5 Local Net Zero Hubs. The Hubs promote best practice and support local authorities to develop net zero projects that can attract commercial investment. The Hubs are currently supporting local authorities to develop projects with a potential capital value of over £2 billion and have identified further possible projects that take the potential capital value of the pipeline to over £3 billion.

Heat and buildings

30. Local Authorities have been, and will continue to be, key delivery partners when it comes to improving the housing and building stock across the country, especially through integrating activity on energy efficiency, heating and retrofit. This has been recognised in recent years through their delivery of Green Home Grants, Home Upgrade Grant, and heat networks. As demonstrated in previous chapters (*Heat and Buildings*), local delivery of these schemes has been integral in reducing carbon emissions and supporting local economies. For example, over 200 local authorities have taken part in phase 1 of the Green Home Grants Local Authority Delivery Scheme (LAD) which is focussed on low-income households in homes that most need energy efficiency upgrades. Phases 1 and 2 of the Local Authority Delivery schemes aim to support around 50,000 households who will benefit from energy efficiency upgrades, making it easier and cheaper to heat their homes. Government has also delivered the Public Sector Decarbonisation scheme which provides grants for public sector bodies to fund heat decarbonisation and energy efficiency measures. Under Phase 1 of the scheme, over £500 million was awarded to local authorities.

31. National planning policies already recognise the importance of sustainable development and make clear that reducing carbon emissions should be considered in planning and decision making. The National Model Design Code provides tools and guidance for local planning authorities to help ensure developments respond to the impacts of climate change, are energy efficient, embed circular economy principles, and reduce carbon emissions. The government is considering how the planning system can further support our commitment to reaching net zero. We will make sure that the reformed planning system supports our efforts to combat climate change and help bring greenhouse gas emissions to net zero by 2050. For example, as part of our programme of planning reform we intend to review the National Planning Policy Framework to make sure it contributes to climate change mitigation and adaptation as fully as possible.

Local transport

32. To decarbonise the transport sector, in July, the government published its *Transport Decarbonisation Plan,* which sets out the commitments and the actions needed to decarbonise the entire UK transport system. One of the six strategic priorities of the plan is developing solutions that consider the needs of different locations, highlighting the importance of tackling emissions at a local level to ensure that every place in the UK has its own net zero transport network by 2050, serving the unique needs of its communities.

33. To support this, we will reform the way local transport infrastructure is funded to drive decarbonisation at a local level, engaging local areas about their investment priorities in the round, and making quantifiable carbon reductions a fundamental part of local transport planning. Later this year we will also publish a Local Authority Toolkit to help local authorities reduce emissions from transport. It will provide local authorities with guidance and information to help them build business cases, develop innovative policies, secure funding, and deliver measures on the ground.

Local green infrastructure and the environment

34. Government will launch a new National Framework of Green Infrastructure Standards in 2022. This will support local areas and regions to deliver well-designed green infrastructure where it is most needed to deliver multiple benefits. These networks of green and blue spaces and other natural features, including trees, provide an opportunity to benefit local economies and bring about long-term improvements in people's health and wellbeing. At the same time, it can help us to mitigate and adapt to climate change, through capturing and storing carbon, shading and cooling, and reducing flooding.

35. The Environment Bill is also creating a new system of spatial strategies called Local Nature Recovery Strategies to target action for nature and to drive the use of nature-based solutions to tackle environmental challenges like climate change. It is expected that there will be approximately 50 Local Nature Recovery Strategies covering the whole of England with no gaps and no overlaps. Preparation of each Strategy will be locally led and collaborative, with local government taking a critical role. This will provide local government with a new tool through which they can work with local partners to identify where effort to create or restore habitat would have greatest benefit for climate mitigation, whilst also having positive benefits for nature and the wider environment. Between 2021 and 2027, we will be doubling our overall investment in flooding and coastal erosion to £5.2 billion.

36. In addition, £200 million will be invested in the Innovative Flood and Coastal Resilience Innovation Programme. This will help over 25 local areas over six years to take forward wider innovative actions that improve their resilience to flooding and coastal erosion. The Environment Agency is also working with coastal authorities on a £1 million refresh of Shoreline Management Plans.

A universal offer to harness opportunities across the UK

37. We are committed to supporting all local areas and communities, ensuring that none are left behind and creating net zero solutions which work for all of them. As we are reducing emissions across the economy, we must also ensure that the transition to net zero is a fair one.

38. As outlined above, BEIS has been successfully running the Local Programme (previously known as the Local Energy Programme) to support all local areas capability and capacity to meet net zero and government has committed to continuing the Programme. The programme has developed over time and now takes a place-based approach to tackling net zero in the round, covering all net zero issues. The programme will continue to help places make faster progress towards net zero, improve cost-effectiveness, and significantly increase the economic benefits of the green industrial revolution by attracting commercial investment and supporting green jobs.

39. The programme will focus on all areas of England, including those lacking capacity and capability, or those facing unique challenges, such as rural and coastal communities. The programme will ensure that all local areas can engage on issues relating to net zero.

Case study: Investing in industrial heartlands

The government has invested £95 million for two new offshore wind ports to be constructed in the Humber region and Teesside, boosting the UK's world-leading industry, and creating thousands of new jobs in the North.

Able Marine Energy Park, on the South Bank of the River Humber, will receive up to £75 million government investment, and Teesworks Offshore Manufacturing Centre, on the River Tees, will benefit from up to £20 million. Construction will begin later this year to upgrade the two ports with new infrastructure - helping to revitalise these historic industrial heartlands. Together these new ports will have the capacity to house up to 7 manufacturers to support the development of the next-generation offshore wind projects, boosting the UK's offshore wind manufacturing base while directly creating up to 3,600 new green jobs.

40. The Government has embedded a net zero principle in initiatives which target different types of places, such as the Levelling Up Fund, the Towns Fund, and the Community Renewal Fund. This is to ensure that all funded schemes have considered how to align with our net zero ambitions. We will continue to monitor the impacts of these schemes and strengthen these criteria if necessary. We will take the same approach with other new schemes and priority places such as Freeports. Investment into places through the UK Shared Prosperity Fund should also align with the government's net zero objectives.

41. This year we are working with local businesses on the future role of Local Enterprise Partnerships (LEPs), ensuring local businesses continue to have clear representation and support in their area to drive the green recovery from the COVID-19 pandemic. LEPs have played a significant role in providing advice and incentives for businesses to reach net zero. As part of the LEP review, we are committed to ensuring a strong local business voice is retained, particularly to support businesses to transition to net zero.

42. In England, the government works closely with local government, and Defra hosts the Local Adaptation Advisory Panel (LAAP), a forum for dialogue on climate change adaptation between local authorities, central government, and delivery bodies. This supported the production of a guide on adaptation for local government, published in 2019 by the Association of Directors of Environment, Economy, Planning and Transport (ADEPT).

Case study: the Green Recovery Challenge Fund

The government's £80 million Green Recovery Challenge Fund is kickstarting over 150 nature projects across England. For example, the Wildfowl and Wetlands Trust was awarded £1.58 million to create and restore 130 hectares of nature-rich wetland habitat along the Somerset coast. This habitat will help increase flood resilience, improve soil, water quality, and help absorb carbon, increasing the robustness of the county's coastline overall. The GRCF is also support green jobs and is currently on track to support up to 2,000 jobs by the end of 2021, rising to up to 2,500 by the time all projects are completed in March 2023.

Working with local communities

43. To ensure that all parts of the UK benefit from the transition to net zero we also want local communities to take bold action that supports the transition. Local communities benefit from strong relationships and ties to their areas and their local authorities; these can be key to reducing emissions across the economy and making sure people stay engaged in the process. Where local authorities and communities work together effectively, we have already seen significant improvements in both delivery and in wider public engagement.

44. Some very ambitious campaigns on food, recycling, water, and other areas critical to climate action, have been launched and run by pioneering local communities and activists. Community projects can also act as a catalyst for raising public awareness and promoting green choices.

45. Community groups can bring together people, finance, and ideas to have a real impact on the behaviours, infrastructure, and attitudes locally. Community cohesion and grassroots initiatives are also central to locally based resilience to climate change risks, such as flooding and heatwaves.

46. Government understands the important role that communities have in the transition to net zero. Through the introduction of UK-wide growth funding schemes, such as the Community Renewal Fund, the Levelling Up Fund, and the Towns Fund, Government is enabling local areas to tackle net zero goals in ways that best suit their needs. For example, under the Towns Fund, Clay Cross in Northeast Derbyshire developed a Town Investment Plan setting out their low carbon energy ambitions. Government also works with community groups, both geographic and communities of interest, such as sports clubs, faith groups, and youth groups, on key behaviour change strategies and communications.

Case study: Clay Cross

Clay Cross, in Northeast Derbyshire, was one of the 101 Towns invited to develop a Town Investment Plan. The plan, submitted to Government in October 2020, set out their ambition to establish the town as an exemplar at the forefront of the low carbon revolution. This involved working with established local businesses, including the key local employer Worcester Bosch, to deliver innovation in clean energy and showing the potential to deliver a net zero economy. By 2030 they hope to be able to show significant reductions in the overall levels of emissions by ensuring clean growth principles underpin investment. These ambitions will be realised through a cohort of projects which include the development of a low carbon energy strategy for the town, a low carbon energy demonstrator project linked to the rebuilding of the local leisure centre, low carbon workspace and housing proposals, and a skills and enterprise training centre, which will have an emphasis on providing energy industry related skills.

Community Energy

47. Community Energy is an example of how communities can come together to reach local and national net zero targets. Community Energy England's 2021 *State of the Sector Report* outlined that there are 424 community energy organisations working across the UK to deliver a net zero future and with the appropriate support, they estimate that the community energy sector could contribute up to 5,270 MW, power 2.2 million homes, support 8,700 jobs and add £1.8 billion to the economy each year.[45]

48. Government has provided support to community energy projects through the Rural Community Energy Fund (RCEF), a £10 million fund to supporting community-run projects in England that benefit the energy transition to net zero. The fund has provided development stage grants to projects focusing on a variety of technologies including solar, wind, low carbon heating and electric vehicle charging. Communities have predominantly financed their schemes commercially through share offers and borrowing.

49. The Government has also supported Community Energy England to develop and maintain their knowledge sharing role which includes peer mentoring. This resource can help communities develop their own schemes across heat and power generation, transport, energy efficiency, and also wider approaches to net zero.

Case Study: Cuckmere Community Solar – a world first

Cuckmere Community Solar has an ambition to power the rail network in East Sussex with solar energy – a world first. Working in collaboration with Riding Sunbeams, an innovator focused on decarbonising rail networks, the organisation aims to establish a template for similar projects.

Cuckmere Community Solar plans to build a new 4 MW solar farm at Berwick, East Sussex. This will enable the local community to benefit from a higher income from renewable energy generation, and for the rail network to benefit from cheaper, low carbon power. The Rural Community Energy Fund has provided grant funding for the development stage of the project which includes the cost of studies, land agreements, investigation of the connection point, and legal work.

The project has also recently received capital funding support from the South East Local Enterprise Partnership's £85 million share of the government's Getting Building Fund, which aims to help economic recovery.

50. Ofgem also supports community energy projects and following a consultation process has announced that from February 2022 it plans to welcome applications from community interest groups, co-operative societies, and community benefit societies to the Industry Voluntary Redress Scheme. This will allow groups to apply for funds to deliver energy related projects that support energy consumers in vulnerable situations, support decarbonisation, and will benefit people in England, Scotland, and Wales.

51. To build on our existing actions, we intend to continue to work closely with Community Energy England and will reintroduce the Community Energy Contact Group. Since 2017, this group has been merged in a wider Local Energy Contact Group, but given the scale and pace of work being taken forward, and with the development of the Local Net Zero Forum, we believe that it makes sense to strengthen our engagement with the community sector further by reintroducing a dedicated forum for community groups to engage across Government.

4vi. Empowering the Public and Business to Make Green Choices

Moving towards a net zero society together

Our Key Commitments

- Explore how to improve and enhance public facing climate content and advice on gov.uk. We will also enhance our digitally-led Simple Energy Advice (SEA) service to provide homeowners with personal, tailored advice on improving and decarbonising their homes, including tailored retrofit advice in local areas, and links to local, accredited, trusted installers.
- Continue supporting UK businesses to meet their net zero commitments, including exploring a government-led advice service that consolidates and simplifies advice and other support on net zero.
- Increase awareness of net zero and empower businesses and the public to make green choices, by building on government communications and engagement, and exploring providing environmental impact labelling of products, goods, and services.
- Make green choices affordable and easy by working with businesses and industry to set strong regulatory signals and collaborating to reduce costs and provide better quality, longer lasting and lower environmental impact products, and services.

The challenge

1. Together we are moving towards a net zero society, led by technological innovation. We will see transformations to our economy, society, and the way we live and work: new low carbon technologies, infrastructure and job opportunities; cleaner air, greener spaces and reduced flooding; and changes to everyday life such as in the way we travel, heat our homes and save our money. To reach net zero, everyone will need to play their part. We know that public concern about climate change is high – with 80% in the UK either concerned or very concerned.[46] We also know that people and businesses recognise that change must happen – 80% of respondents in a recent survey believe the way we live our lives will need to change to address climate change.[47] Equally, however we know that the public is unsure of what net zero will mean in practice, what steps they can take, or they face barriers that stop them from acting.[48] This chapter sets out how government will support individuals and businesses to make green choices – an act of choosing the more, or most, sustainable option from a range of possibilities, such as using an electric vehicle instead of a petrol or diesel vehicle when it is time to change your family car, replacing an old gas boiler with a heat pump, or switching to innovative green financial products.

Our Goal

2. Our goal is to make the act of choosing green significantly easier, clearer and cheaper. We recognise that the best way to do this is to go with the grain of existing behaviour and trends and by working closely with partners like Local Authorities, voluntary sector organisations, social enterprise regulators, and businesses, who all play an important role in how we use and choose different services.

The role of green choices in meeting net zero

3. There are numerous individual actions – some one-off and some we take regularly – that people can take to contribute to our pathway to net zero. These individual actions combine to create wider systemic change required to meet net zero. New analysis on green choices,[49] has helped us to identify choices and behaviours that impact on net zero, broadly falling into three categories:

- **Adopting new low carbon technologies,** such as switching to zero emission vehicles.
- **Using energy, technologies, or services more efficiently,** such as using smart meter-enabled 'time of use' tariffs which reward consumers financially for using energy at off-peak times, or when there is excess clean energy available.
- **Everyday business and consumer choices,** such as choosing green financial products like the recently launched NS&I Green Savings Bond, or seeking more responsibly invested pension schemes.

4. We want to better understand the behavioural factors that need to be considered in the policies required to meet net zero. The Government Chief Scientific Adviser and Government Office for Science will be producing a scenario-based foresight report to understand the system wide implications of these factors, to be published in 2022.

Our approach for supporting green choices

5. We know that people want to play their part in achieving net zero. Our approach for how government will empower everyone to make green choices is underpinned by six principles.[50] Although they were developed with the public in mind, many of them equally apply to green choices taken by businesses, particularly medium or small enterprises. The principles reflects wider public engagement from across the country and Parliament.

6. Public engagement, including through communications campaigns such as Together for Our Planet, plays a significant role in driving green choices. We will deliver public engagement on net zero to:

a. Communicate a vision of a net zero 2050, build a sense of collective action, improve understanding of the role different actors play in reaching net zero, and how and when choices can be made;

b. Ensure there is trusted advice and support for people and businesses to make green choices;

c. Mobilise a range of actors and stakeholders to increase and amplify their communication and action on net zero and green choices; and

d. Give people opportunities to participate in and shape our plans for reaching net zero, thereby improving policy design, buy-in and uptake of policies.

Principles underpinning green public and business choices

Principle 1: Minimise the 'ask' by sending clear regulatory signals

7. By targeting measures at an industry level, rather than at the individual consumer, we can make green choices much simpler for the consumer. This will also help grow a stronger market for low carbon goods and give businesses clear, early signals. For example, the 2030 phase out date for petrol and diesel cars and vans sends a signal to industry and will improve the availability and quality of zero emission vehicles on the market. Similarly, as set out in the *Heat and Buildings Strategy* there are a range of policies we will introduce that will bolster the low carbon heating market, creating new opportunities for business, and better choice for the consumer.

8. We are taking action to ensure that products are more sustainable, both in relation to their energy efficiency during use and use of materials over their lifetime (resource efficiency) through developing proposals for new regulatory product standards and better consumer information. We are exploring updating and expanding 'Ecodesign' product regulation which sets minimum requirements to phase out the least energy and resource efficient products from the market.

Principle 2: Make the green choice the easiest

9. By addressing all the major, practical barriers to individual behaviours we can make it easier for people to make green choices. We will ensure that we take a consumer-centred approach to net zero policy design, removing frictions and minimising disruptions to people's lives.

10. In our *Transport Decarbonisation Plan*, we have committed to better integrating transport modes, with more bus routes serving railway stations and improved integration of cycling and walking networks, so that opting to make a green travel choice is easier. This is in addition to delivering interventions to enable more people to walk and cycle for short journeys such as a national e-cycle support programme. Our vision is that half of all journeys in towns and cities will be cycled or walked by 2030. We are also committed to increasing road vehicle occupancy. This will help decarbonise and decongest our roads. We will publish guidance for local authorities on support for shared car ownership and shared occupancy schemes and services and are continuing to build our evidence base to understand the barriers and potential policies to increase the uptake of shared mobility.

11. We are committed to removing inconvenience and increasing availability of green choices. Following the commitments made in our Resources and Waste Strategy, the Environment Bill will introduce powers that will allow us to require separate food waste collections in all local authorities in England, which will help people to reduce emissions from food waste with ease.

Principle 3: Make the green choice affordable

12. We are already seeing the upfront cost of green choices, such as electric vehicles, drop. We are looking across all sectors to see how we can continue this trend and make green choices more affordable.

13. Through the Smart Export Guarantee (SEG) energy suppliers are moving to increasingly innovative tariffs which support electric vehicle deployment while continuing to enable households to access a market-led route for exporting and receiving payment for their unused electricity. As committed to in our *Heat and Buildings Strategy*, the Boiler Upgrade Scheme will provide grants to help households transition to low carbon heating. We are also supporting motorists through plug-in vehicle grants, which provide support towards the upfront purchase of eligible cars, vans, motorcycles, and trucks.

14. We are supporting the public to both save and contribute towards public spending that helps the UK reduce its emissions through the NS&I Green Savings Bond. The Green Finance Institute and Abundance Investment, supported by UK100, Local Partnerships and Innovate UK, have also launched a national campaign to help local authorities issue a type of municipal finance investment – Local Climate Bonds. For citizens, the Local Climate Bond provides a low-risk and fixed return investment, and a way to mobilise their savings to help tackle the climate change in their area.

Principle 4: Empower people and businesses to make their own choice.

15. Consumer preference can shape producers' decisions, but sometimes consumers and businesses lack clear information to make informed choices. As announced by the chancellor in his Mansion House speech in July 2021, we will work with the Financial Conduct Authority to introduce a sustainable investment label - a quality stamp - so that consumers and retail investors can clearly compare the impacts and sustainability of their investments for the first time.

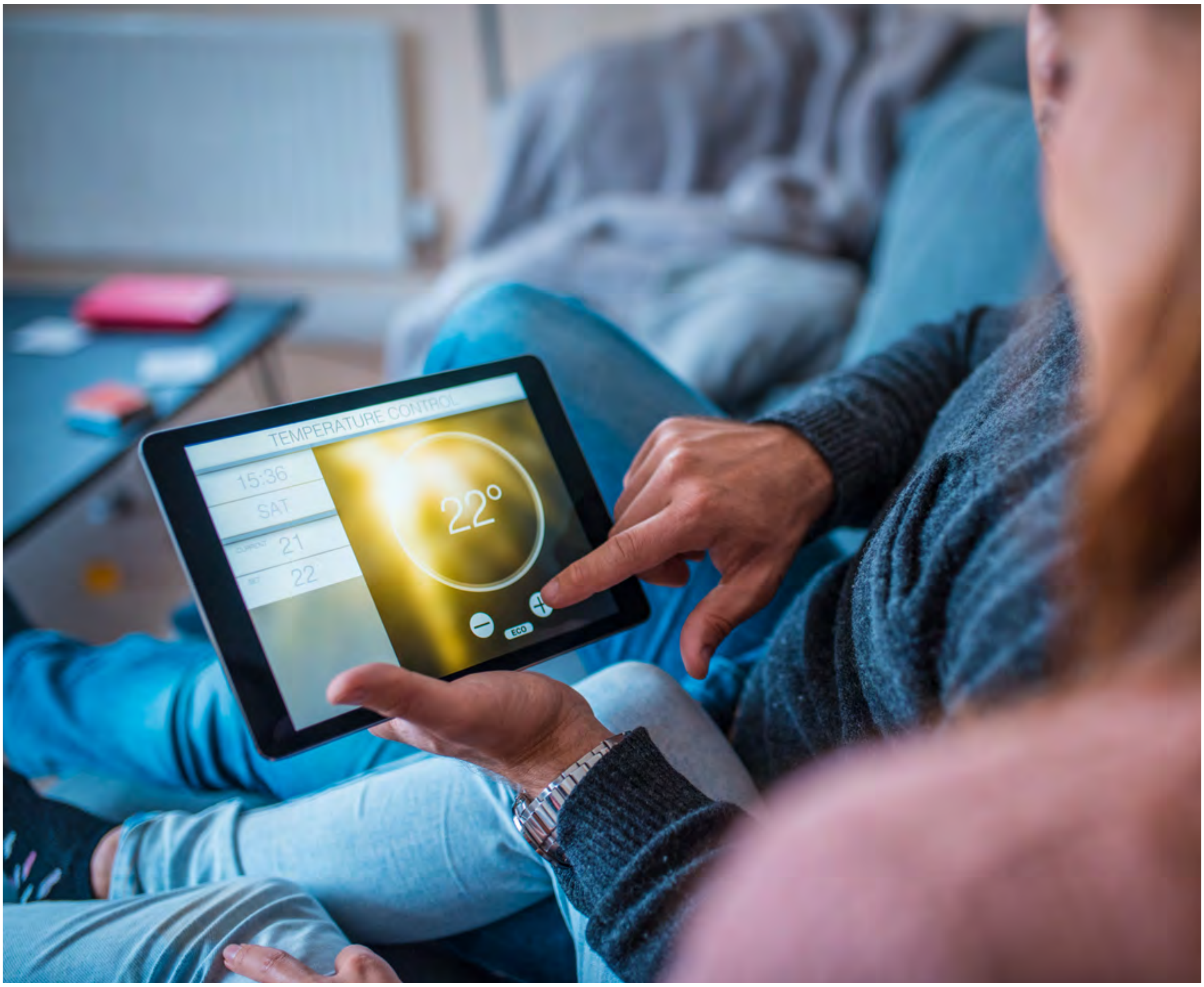
We plan to help empower people to make informed choices about the goods and products they buy and services they use by exploring how we better label these with their emission intensity and environmental impact. We are also exploring the use of product labelling to show the durability, repairability and recyclability of products, as well as their environmental footprint with a view to stimulating demand for better quality items. We continue to explore the evidence base for environmental labelling within food production and disposal, including the most accurate methodologies to monitor and verify the carbon emissions, and environmental impact, of food items.

16. Our *Transport Decarbonisation Plan* outlines how we will explore the feasibility of a travel reward scheme that uses peer-driven motivation and encourages individuals to switch to, or continue to use, sustainable modes of travel.

17. We are providing tailored advice and support to homeowners on what they can do to improve their homes. Our Simple Energy Advice service has already had over 1.5 million users, providing homeowners with personal, tailored advice for improving and decarbonising their homes and links to local, accredited, trusted installers. Homeowners can also find out about government schemes for which they may be eligible. We will enhance the digitally led service and are considering options to support tailored retrofit advice in local areas, supported by tailored local advice. This includes moving our Simple Energy Advice service to gov.uk, which will improve user experience, and supporting local advice provision.

18. We are also reviewing other existing digital information and advice services related to net zero and exploring how to improve wider existing public-facing net zero content and advice on gov.uk

19. We know that technologies can also improve public understanding of energy use and energy efficiency. In-Home Displays for smart meters give accurate information about energy consumption to help households easily understand how to use less energy and save money on their bills. Building on this, the Smart Energy Savings initiative is trialling how innovative products and services can use smart meter data to provide consumers with advice on how to manage their energy use. At the end of June 2021, there were 25.2 million smart and advanced meters in homes and small businesses across Great Britain.[51]



Principle 5: Motivate & build public acceptability for major changes

20. Achieving our net zero target must be a shared endeavour. It is therefore vital that we listen to the publics views on how to reach net zero. We already regularly invite the public to shape policies on net zero through consultations and deliberative dialogues. Since 2019, we have run, funded, or are still running deliberative dialogues on a range of net zero issues, such as green choices, homes, heating, transport decarbonisation, green savings, hydrogen, food, Carbon Capture Use and Storage (CCUS) and Advanced Nuclear Technologies (ANT).

21. To ensure that the transition to net zero is fair and affordable, and does not negatively impact disadvantaged groups, we are committed to assessing the impact of our net zero policies. We consult on policy changes and we will continue to make it easier for people and businesses, including those who are most marginalised, to feed into key policy decisions on net zero.

22. The Devolved Administrations have a range of initiatives aimed at engaging and motivating the public around net zero and climate action:

a. The Scottish Government launched a draft *Public Engagement Strategy for Climate Change* in December 2020, and the final report of Scotland's Climate Assembly was laid in Scottish Parliament in June 2021.

b. The *Welsh Government Engagement Approach for Low Carbon Delivery Plan 2* was published in June 2021, encouraging collective action on climate change through four Calls to Action.

c. In March 2021, the Northern Ireland Executive unveiled a new digital climate action campaign, delivered by MyNI in the run up to the COP26 conference. It aims to raise climate awareness, encourage change, enable action, and exemplify climate leadership.

Principle 6: Present a clear vision of how we will get to net zero and what the role of people and business will be

The role of business in delivering net zero

Businesses have significant power to drive change towards achieving our domestic net zero goal. Our approach to supporting businesses to deliver this change will need to be differentiated by business size and sector, as these factors will influence the ease with which a net zero target and other relevant actions can be adopted. We have seen significant numbers of companies signing up to science based targets alongside sector-specific ambition being put forward already. For example, Water UK has launched the world's first sector-wide plan to deliver net zero carbon emissions by 2030.

We know that businesses account for 18% of UK territorial emissions and so encouraging them to take action to reduce their emissions is important.[52] But just as vital is the role businesses are playing in designing the ground-breaking new technologies, world leading products and innovative approaches that we need to develop the low carbon economy and enable others to reach net zero. Collaboration across sectors and value chains will enable us to innovate faster, create stronger incentives for investment and drive down costs for low carbon alternatives through the global mechanisms laid out in the Paris Agreement.

To underline the importance of this area, the Prime Minister appointed a net zero Business Champion, Andrew Griffith MP, to spearhead business engagement nationwide in the year to COP26. Already over half of the FTSE100 companies have committed to Science-Based Targets by joining the global Race to Zero campaign. Alongside engaging large corporates, the Net Zero Business Champion has led a campaign targeting small and micro businesses across the UK. Over 1,900 have joined the Race to Zero to date by visiting the Business Climate Hub, developed in partnership with a global business coalition led by the International Chambers of commerce. Companies, particularly large businesses, once they have joined the Race to Zero, should work with others to drive breakthroughs in their sectors, regions, and support SMEs in their value chains to take action. We're encouraging Business Representative Organisations (BROs) to become Race to Zero Accelerators by recruiting members into the Race to Zero. To be recognised officially as an Accelerator, businesses must recruit at least 20% of members not already in Race to Zero by COP26.

Many businesses across the UK have said they want to tackle climate change, but that they don't know where to start[53]. Through the small business campaign, government has taken an important step towards making net zero relevant to SMEs by helping them access the support they need. Beyond COP26 we will continue to support UK businesses to meet their net zero commitments, including exploring a government-led digital advice service that consolidates and simplifies advice, funding, and other support on net zero.

For larger businesses, we want to ensure businesses are aware of their energy and carbon use so they can take action towards reaching net zero. Climate risks must be assessed and disclosed through the Task Force on Climate-related Finance Disclosures (TCFD). This is complemented by Streamlined Energy and Carbon Reporting, which requires energy and emissions reporting in all UK large businesses to improve awareness of energy costs. We also require large businesses and their corporate groups to carry out a broader assessment of their energy use from buildings, transport and industrial processes every 4 years under the Energy Savings Opportunity Scheme (ESOS), which is designed to identify practicable and cost-effective energy saving opportunities. In the future building users and decision makers will be able to compare the performance of their buildings to other similar buildings using a performance-based energy rating to support targeted investments.

Government will work in partnership not just with businesses themselves, BROs, sector-based trade associations, business groups in the Devolved Administrations and local and regional organisations to translate the pathways within this strategy into business specific plans to reach net zero.

23. Supporting people to make green choices will be a collective effort between government, businesses, voluntary sector, social enterprise and community groups, local authorities, media organisations and others. However, we know that others look to Government to set the narrative on how we should get to net zero and what people's role will be.

24. We will build on government communications and engagement on net zero to increase awareness of how we plan to deliver the net zero target in the UK. Building on the momentum of COP26, the Together for our Planet campaign is showcasing how people across the UK are going "One Step Greener" to tackle climate change - from the engineers working on the offshore wind farms now powering our homes and businesses, to local initiatives encouraging children and parents to walk to school. The campaign demonstrates that taking a single step can have a positive impact on the environment, using the inspiring stories of 26 One Step Greener Ambassadors who are playing their part for the planet - be it by walking to work, repairing their clothes, or reducing their food waste - to encourage others to join them. The 'One Step Greener' Ambassadors come from all walks of life in their pursuit of a greener future and demonstrate how going one green step can culminate in a large collective impact in helping to make the UK a more sustainable place.

25. We will build on the success of Together for Our Planet, through which the UK business community is demonstrating global leadership in efforts to combat climate change, with over 1,900 SMEs signed up to reach net zero by 2050. Up and down the country, local high street shops are proudly displaying their climate leadership by sharing their net zero journey on social media. Examples include Caribe Coffee, a family run coffee business in Northumbria, John Sankey, a sustainable furniture maker in Derbyshire, and SilverHare, a jewellery maker in West Cornwall. In doing so, they are acting as changemakers in their local communities. The focus of the campaign in the run-up to COP26 has been on encouraging business to make net zero pledges. After COP26, we commit to continuing to support businesses to meet their commitments whilst developing their climate resilience.

4vii. International Leadership and Collaboration

Accelerating the global transition to a resilient net zero future

Our Key Commitments

- Increase global climate action through our push for global net zero, including our COP26 Presidency objective to keep 1.5˚C within reach. As part of this, strengthen international collaboration in key sectors including by working with others to accelerate the innovation and deployment of clean technology and continue to convene the Zero Emission Vehicle Transition Council, the Energy Transition Council, the FACT dialogue, and other flagship initiatives that will be announced at COP26.
- Deliver against net zero on a trajectory in line with the Paris Agreement, decreasing UK emissions by at least 68% by 2030 as set out in our Nationally Determined Contribution,[54] 78% by 2035 compared to 1990 levels in line with our Sixth Carbon Budget.
- Double our International Climate Finance to at least £11.6 billion between 2021 and 2025 to support net zero support adaptation and build resilience internationally. Within this, invest at least £3 billion in solutions that protect and restore nature, and £200 million at a minimum to help countries access technical exprtise to limit emissions and build back greener.
- Drive international innovation in key low carbon technologies through Mission Innovation, including co-leading the Green Powered Future and Clean Hydrogen Missions.
- Lead by example internationally on inclusive climate policies, Action for Climate Empowerment and support for the UNFCCC Gender Action Plan.
- Set out a clear vision and priorities to guide UK international climate and nature action in the coming decade through a 2030 Strategic Framework, and publish a refreshed Export Strategy outlining HMG support for exporters in the low carbon economy.

The challenge

1. Meeting our shared objective of avoiding dangerous climate change requires a dramatic, global acceleration of progress towards net zero CO_2 emissions by mid-century and net zero greenhouse gas emissions (GHG) by around 2070.[55] Over 2020-21 there has been considerable progress, with all G7 countries, over half of the G20, and around 75% of global emissions now covered by net zero targets. However, the world is still not on track to reach the Paris Agreement temperature goal, which aims to limit global warming to well below 2°C and pursue efforts to limit warming to 1.5°C, compared to pre-industrial levels. More must be done to turn these targets into immediate action.

2. UK emissions account for about 1% of the global total.[56] To accelerate progress towards a resilient net zero future, we need to play a prominent role in promoting collective global action, working together to ensure the transition is quicker, cheaper, and easier for all building on a strong foundation of domestic action.

3. The transition to net zero must be supported by a joined-up approach to halting biodiversity loss. The two are inextricably linked: the greatest drivers of biodiversity loss, land use change and agriculture are also responsible for approximately one fifth of global GHG emissions. Simultaneously, climate change itself is a direct driver of biodiversity loss, and terrestrial and marine ecosystems act as carbon sinks for human-driven CO_2 emissions.[57]

Our goal

4. As set out in the *Integrated Review of Security, Defence, Development and Foreign Policy* (the Integrated Review), tackling climate change and biodiversity loss is the number one international priority for the UK for the coming decade.[58]

5. As the world recovers from the COVID-19 pandemic our actions must be aligned with the Paris Agreement to ensure a fair and inclusive ransition to net zero. This includes enhancing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change.

6. The international emissions reductions required to keep 1.5 degrees warming within reach are only achievable if the international community works together. And by working together, we can create stronger incentives for investment, we can innovate faster, we can achieve economies of scale more quickly and we can create level playing fields. This international collaboration will make the transition to net zero cheaper, faster, and more accessible for all countries. This is not a matter of shouldering a burden between us, but of sharing an opportunity. It will support the UK's own transition and stimulate UK jobs and prosperity.[59] Over the past decade alone, we have seen over an 80% drop in the costs of clean energy technologies thanks to technology innovation, learning-by-doing, and greater deployment at scale domestically and globally.[60]

7. Collaboration across borders and society is a key aim for our COP26 and G7 Presidencies. Beyond these, we will continue to advocate for enhanced international collaboration, and coordinate action across science, innovation, finance, and trade.

Delivering our Paris Agreement commitments

Mitigation

8. Parties to the Paris Agreement shall communicate ambitious short-term targets to reduce greenhouse gas (GHG) emissions through Nationally Determined Contributions (NDCs) and should strive to underpin these targets with credible pathways set out in Long Term Strategies (LTSs).

9. The UK's NDC commits us to reducing our economy-wide GHG emissions by at least 68% by 2030, compared to 1990 levels.[61] This strategy sets out the UK's plans to deliver on the NDC and reach net zero by 2050 and will be submitted to the UNFCCC as our revised LTS under the Paris Agreement.

International Climate Finance (ICF)

10. The UK's ICF helps over 100 developing countries mitigate and adapt to the impacts of climate change. This includes supporting countries' resilience to the damaging effects of climate change, accelerating the clean energy transition, supporting low carbon infrastructure, and investing in climate change solutions that protect and restore nature and biodiversity.

11. The UK has committed to doubling our ICF to at least £11.6 billion between 2021-2025, including at least £3 billion for nature and biodiversity.[62] This forms part of an ambition by developed countries to mobilise $100 billion in climate finance annually. We have also committed to aligning all UK Official Development Assistance (ODA) with the Paris Agreement and ensuring that all new UK bilateral aid spending does no harm to nature. This delivers on our Integrated Review objective of investing in a nature-positive economy.

2021 cumulative UK ICF Achieved results

(2011-2021, last year's in brackets)

88 million
people supported to cope with the effects of climate change
(66 million)

41 million
people improved access to clean energy
(33 million)

180 million
people avoided or reduced tonnes of greenhouse gas emissions
(31 million)

2,400 MW
capacity of clean energy installed
(2,000 MW)

£5.2 billion
public finance mobilised for climate change
(£4.1 billion)

£3.3 billion
private finance mobilised for climate change
(£2.2 billion)

Source: BEIS analysis (2021)

12. UK ICF is stimulating a shift in private finance mobilisation for climate action from the billions to the trillions. Between 2011 and 2021, UK ICF mobilised £3.3 billion of private finance for climate change purposes in developing countries.[63] We target investment in dveloping economies with the highest potential to accelerate the global transition to net zero, ensuring that everyone can share the opportunities of clean growth sooner.

13. We support the work of key multilateral funds and have significant bilateral programming drawing on UK experience and expertise, enabled by the diplomatic work of our climate, energy and environment attaché network embedded in UK Embassies and High Commissions. UK Partnering for Accelerated Climate Transitions (UK PACT) is supporting developing countries with potential for high emissions reductions to build the knowledge and expertise required to both develop and implement the ambitious plans needed to limit emissions and realise the opportunities of clean growth.

14. For all new and existing International Climate Finance programmes, we will ask delivery and monitoring partners to include analysis of the impacts of programmes on certain groups of people to manage any negative impacts.[64]

Case study: UK-Colombia Partnership for Sustainable Growth

Through our Partnership for Sustainable Growth, the UK is working with Colombia to help drive real world emissions reductions and global climate ambition. The partnership and UK programmes are supporting Colombia to reduce deforestation, accelerate the energy transition, and conserve biodiversity. For example, UK technical assistance helped deliver Colombia’s first renewable energy auction in 2020 – which will increase solar and wind capacity in the country from 50 MW to nearly 2,500 MW – as well as the development of the country’s strategic planning for a low carbon energy sector through skill-shares with UK experts. Our strong climate partnership has also supported increased ambition in line with the goals of the Paris Agreement and a net-zero future, with Colombia committing in 2020 to cut 51% of greenhouse gas emissions by 2030, compared to a projected scenario.

15. Climate change disproportionately affects the world's poorest and can exacerbate economic and social disparities. However, local communities and indigenous knowledge systems can also play a key role in solutions.

16. As part of our incoming COP26 Presidency, the UK has developed a framework that aims to guide investment towards a global net zero transition that also supports the UN's Sustainable Development Goals. The framework will indicate how support for developing countries and emerging economies can accelerate climate ambition and enable a global green recovery in an inclusive way. This is the first time donor countries will have set out how they will support this transition, including through financial flows for quality local jobs in the most vulnerable communities.

17. Low carbon transitions should be fair and affordable and not negatively impact disadvantaged groups.[65] We are committed to monitoring the impacts of our climate and clean energy policies, and any disparities which arise, to assess the need for targeted support for disproportionately impacted groups, in line with the UNFCCC Gender Action Plan and domestic law.

Influencing global action

COP26 Presidency

18. The four goals of our COP26 Presidency are: (1) mitigation to secure global net zero by mid-century to keep 1.5°C within reach; (2) adapting to protect communities and natural habitats; (3) mobilising finance and (4) collaboration: working together to deliver, finalising the Paris Rulebook and accelerate action to tackle the climate crisis through collaboration between governments, businesses, and civil society.

19. There will also be a renewed focus on accelerating near-term action in the top priority areas of coal phase out, zero-emission vehicles, climate finance and halting deforestation. We will ask countries to sign up to initiatives under each goal:

- **Coal:** to push for an immediate end to new unabated coal power and international coal financing, and the scaling up of low carbon power to rapidly move away from existing coal.
- **Trees:** to halt natural forest loss by 2030 and restoring millions of hectares of degraded landscapes and forestlands. This is alongside improving governance and increasing forest finance.
- **Cash:** developed countries to make good on their promise to mobilise at least $100 billion in climate finance per year through to 2025.
- **Cars:** to accelerate the shift to zero emission vehicles (ZEVs), pushing for all new car sales in leading markets to be ZEV by 2035.

20. Our COP26 Presidency has defined five areas vital to a zero-carbon future: energy transitions, clean transport, nature-based solutions, adaptation and resilience, and, tying it all together, finance. We are working with those affected by climate change and with wider civil society to harness innovation and commitment in these areas and will continue this work throughout our COP26 Presidency year up to November 2022.

Case study: 2020 Climate Ambition Summit

A major milestone ahead of COP26 was the 2020 Climate Ambition Summit, co-convened by the UK, UN, and France, in partnership with Chile and Italy. This landmark event demonstrated how we can help drive collective ambition by combining major domestic commitments with diplomatic engagement, working closely with multilateral organisations and international partners.

Achievements included more ambitious Nationally Determined Contributions (NDCs) from 45 leaders. We also saw 24 countries announce new commitments, plans or strategies to reach net zero, and a UK announcement on ending direct government support the for fossil fuel energy sector overseas. When the UK was confirmed as host of COP26, less than 30% of global GDP was signed up to net zero or carbon neutrality commitments. Again, thanks in part to UK leadership, that figure is now over 80% - and rising.

We will continue to encourage all countries to set targets to get to net zero by 2050, and more ambitious 2030 emissions reduction targets to get us there. We are also encouraging countries to publish Adaptation Communications or National Adaptation Plans. We will use COP26 and our Presidency year to turn these commitments into action to make the next ten years the decade of delivery.

G7 Presidency and G20

21. Under our 2021 G7 Presidency, members committed to becoming 'a net zero G7 by 2050 at the latest'; ensuring a green recovery from COVID-19 that is sustainable, resilient, and inclusive; phasing out new direct government support for international fossil fuel energy, and pursuing commitments to support those most vulnerable to the impacts of climate change and environmental degradation. These have helped to lay the foundation for COP26.

22. As inclusivity was at the heart of the UK's G7 Presidency, these commitments are underpinned by pledges to support affected workers and sectors so that no person, group, or geographic region is left behind.

23. As part of our G7 Presidency, the UK hosted several follow-up workshops including on Net Zero Sectors and the Industrial Decarbonisation Agenda (IDA). G7 members supported the idea of using the IDA to unlock market potential through high-level G7 government coordination and collaboration on ambitious industrial decarbonisation initiatives. Driving international cooperation on decarbonisation will help to diffuse 'first mover' risks and address carbon leakage risks at the outset. The IDA is due to be integrated into the rotating G7 Presidency with Germany taking ownership in 2022. During the rest of our G7 Presidency, we will work with our partners to consider how best to coordinate efforts on the pricing of carbon to mitigate emissions, and to explore international solutions to prevent carbon leakage, helping us deliver the transformational change required by the Paris Agreement.

Key G7 climate commitments

- Submitting net zero-aligned NDCs to 2030 and LTSs to 2050 ahead of COP26;
- Reaffirming the collective developed country goal to jointly mobilise $100 billion per year through to 2025;
- Increasing adaptation finance, including a commitment to submit adaptation communications ahead of COP26;
- Accelerating the transition away from unabated coal capacity and to an overwhelmingly decarbonised power system in the 2030s;
- Ending new direct government support for unabated international thermal coal power generation by the end of 2021, alongside phasing out new direct government support for international fossil fuel energy as soon as possible;
- Increasing the pace of the global decarbonisation of the road transport sector throughout the 2020s and beyond;
- Decarbonising hard-to-abate sectors, including through a new UK-US-led Industrial Decarbonisation Agenda;
- Launching a new partnership to modernise development finance tools to build back better for the world, including for resilient infrastructure and technologies to address the impacts of climate change;
- Pledging cooperation on the risk of carbon leakage and to aligning trading practices with the Paris Agreement; and
- Recognising the potential of carbon pricing to foster emission reductions, while ensuring environmental and social considerations are accounted for.

24. The G20 includes both developed and developing nations. Its members are jointly responsible for approximately 80% of global emissions[66] and more than 80% of global GDP[67]: it must play a leading role in global efforts to tackle climate change. In July 2021, UK Climate and Energy Ministers met with their G20 counterparts in Naples to agree to accelerate action in the 2020s, to submit ambitious 2030 targets by COP26, and to urge each other to develop long term strategies in line with keeping the 1.5°C temperature goal within reach. The UK will advocate for further action from the G20 to meet the commitments of the Paris Agreement. The Leaders' Summit in Rome in October, on the eve of COP26, will be a crucial moment to build consensus for urgent and ambitious action on climate change and the clean energy transition.

Facilitating a global transition

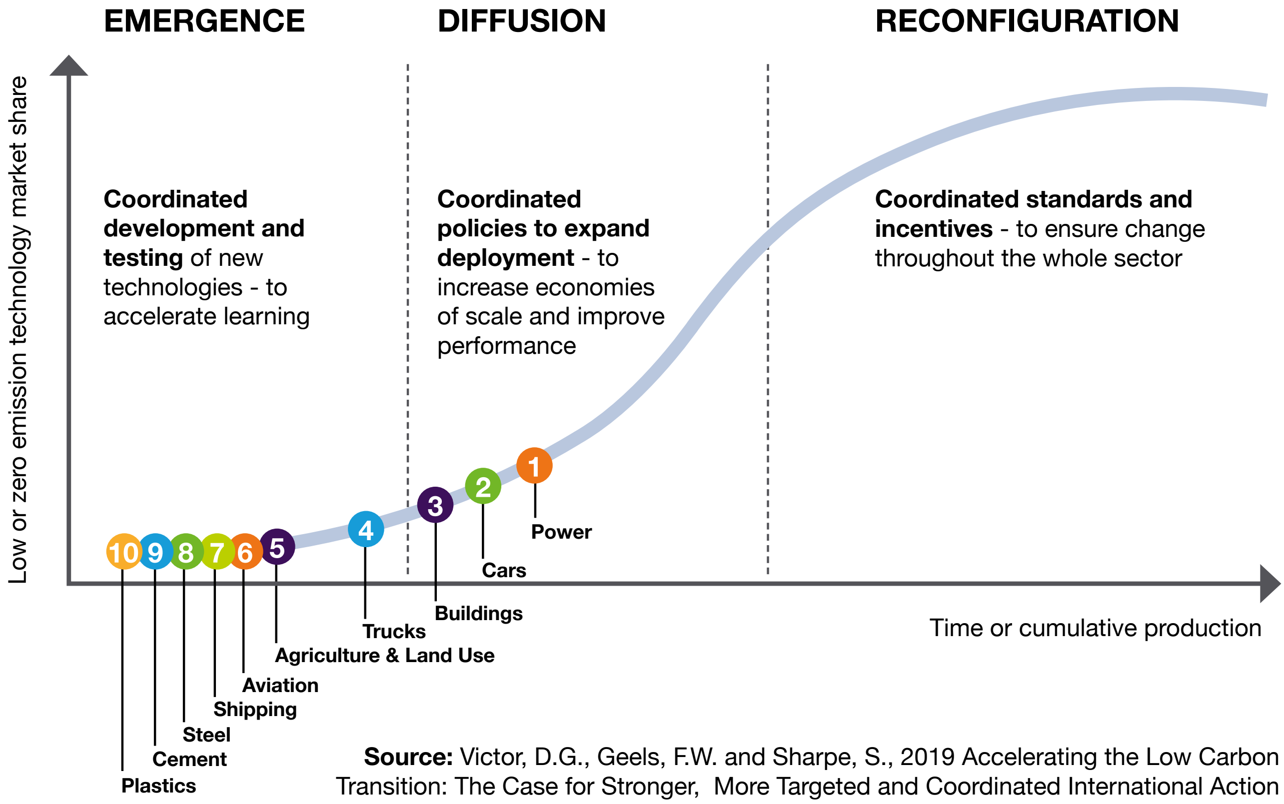
25. The global move to a green and net zero economy will require accelerated transitions across all major emitting sectors – including power, transport, buildings, industry and agriculture, forests and land-use. All countries, including the UK, can benefit from greater collaboration to help achieve their net zero targets more quickly and more cheaply.

26. Across the global economy, different sectors are experiencing the transition at different speeds (see infographic below for one interpretation of the progress by sector). International collaboration focused at the sector level can accelerate action towards our global goals, which is why it is a key focus for the UK. This includes delivering faster innovation through coordinating on research, development, and demonstration of clean technologies, as well as faster deployment of technologies, by coordinating on policy, finance, and trade measures to create new demand, economies of scale, and supply chains for clean technologies.

27. Collaborative action also sends clearer market signals to businesses and consumers about the global direction of travel. This confidence in a credible global net zero pathway is especially important for the harder to abate sectors, such as heavy industry, where we know that the pace of emissions reduction will progress more slowly up to 2030. However, action is needed in these sectors now to lay the significant groundwork required to set the path for future emission reductions.

28. We will therefore continue to work with countries to accelerate sectoral technologies at COP26 and beyond – including continuing to convene the Zero Emission Vehicle Transition Council, the FACT Dialogue, and the Energy Transition Council – as well as working with partners to set a common vision for the next decade of clean technology innovation and deployment at COP26.

Figure 30: The sectoral S-curve



Source: Victor, D.G., Geels, F.W. and Sharpe, S., 2019 Accelerating the Low Carbon Transition: The Case for Stronger, More Targeted and Coordinated International Action

Case study: COP26 Energy Transition Campaign

Our COP26 Energy Transition Campaign will help accelerate the global transition from coal to renewables, enabling the energy sector to achieve net zero. The UK is working through the Powering Past Coal Alliance (PPCA) and the Energy Transition Council (ETC) up to, and beyond, COP26. This will strengthen the coalition of countries, sub-national governments, and businesses phasing out unabated coal power and reduce international coal finance.

Solar and wind power are now cheaper than new coal and gas power plants in two-thirds of the world.[68] The Energy Campaign will bring together countries, development banks, investors and civil society to strengthen low carbon power investment and assistance so that it is viable for every country.

The UK has also worked with the IEA to launch a COP26 Product Efficiency Call to Action, to double the efficiency of four key products (air conditioners, refrigerators, industrial motors, and lighting) by 2030. These four products combined currently account for more than a third of global electricity consumption. Global action to improve product efficiency will lead to a significant reduction in the energy sector's carbon emissions.

The UK driving inclusive climate action

29. We will drive forward our commitment under the 'Equal by 30 Campaign' to work towards equal pay, leadership, and opportunities for women in the global clean energy sector by 2030, and champion increased gender representation across the UK's international organisations.

30. The UK remains committed to strengthening the evidence base and understanding of differentiated impacts of climate change on men and women, the role of women as agents of change and on equal opportunities for women. We continue to support amongst other things, increasing the proportion of women and girls in decision-making and leadership positions, supporting their access to finance, education, building their resilience to climate change, and improving data on gender and inclusion.

Science and innovation

31. Science and innovation are essential to achieve global climate goals. The UK will continue to work closely with countries to drive innovation, research, and aligned policy to ensure that clean technologies become cheaper and more readily available. The UK will also continue to promote the vital role of the Intergovernmental Panel on Climate Change (IPCC) and other scientific research, ensuring the best available science is accessible and understood by all, enabling informed decision-making across the world.

32. The UK will continue to use its world-leading position in climate-related science and innovation to build global multidisciplinary networks and facilitate knowledge exchange to support effective global climate action through initiatives such as Mission Innovation, the Adaptation Research Alliance, and the Visions for a Net-Zero Future project.

Case study: Mission Innovation

The UK has played a leading role in Mission Innovation (MI) since it launched at COP21 as the primary intergovernmental forum focused on clean energy innovation essential to achieving net zero. We have more than doubled our MI baseline clean energy innovation spend over the past five years, exceeding our MI commitment.

The second phase of Mission Innovation (MI 2.0) was launched in June 2021, bringing together countries responsible for more than 90% of global R&D clean energy investment and committed to a decade of action and investment in innovation for clean energy solutions. Commitments included developing National Innovation Pathways describing enhanced ambition to pioneer clean energy technologies and sectors.

The UK is co-leading two of the three Missions. Launched as part of MI 2.0, The Green Powered Future Mission is bringing together governments and businesses to enable the transition to variable renewable power. The Clean Hydrogen Mission aims to make clean hydrogen cost competitive. The UK is also participating in the Zero-Emission Shipping Mission which aims for ships capable of running on zero-emission fuels to comprise at least 5% of the global deep sea fleet by 2030.

Trade

33. The whole system shift that will be required for the UK to reach net zero will also mean changes to how and what we trade. Taking a leading role in the global shift to net zero presents a significant economic opportunity for the UK. Estimates suggest the UK's low carbon economy could deliver up to £170 billion of export sales of goods and services by 2030.[69] The UK will seek to improve market access for green goods and services through our trade policy, our growing array of free trade agreements (FTAs) and our seat at the World Trade Organization (WTO). For example, when we exited the EU, we unilaterally removed tariffs on over 100 additional products used in renewable energy generation, energy efficiency, carbon capture, and the circular economy as part of the UK's Global Tariff.[70]

34. We will seek to reaffirm our commitment to the Paris Agreement in all UK trade agreements and will ensure that they preserve our regulatory autonomy to pursue our climate targets including our Carbon Budgets, enhanced 2030 NDC and 2050 net zero commitment. We will use our multilateral fora to galvanise international partners to adopt climate-ambitious trade policy, and to promote global trade rules that are aligned to net zero and the Paris Agreement, for example through the WTO committees and the new Trade and Environmental Sustainability Structured Discussions.

35. While there are significant opportunities for UK trade to support our climate and nature ambitions as we transition to net zero, it is important we ensure that our policy interventions support global emissions reductions. The UK is at the forefront of measuring and publishing statistics of emissions generated overseas in the production of goods and services consumed by UK residents. We recognise there is much more to do on consumption emissions globally which is why we are urging and supporting other countries to raise ambition on climate change, including on effectively pricing carbon, as well as considering this issue as we negotiate new FTAs.

36. Decisions on the liberalisation of partners goods must account for their environmental and climate impact. Where there is evidence that liberalisation could lead to significant carbon leakage the case for maintaining tariffs or pursuing conditional market access, through clauses on standards or eco/carbon intensity, should be carefully considered.

37. We will publish a refreshed Export Strategy by the end of 2021. The Strategy will help deliver jobs and growth and maximise export opportunities for green UK technologies and innovation. It will also support our transition to net zero, enabling the UK to take advantage of the window to boost UK competitiveness in key low carbon technologies, services and systems. The Strategy will also help developing countries mitigate and adapt to climate change and nature loss by reducing trade barriers to help them benefit from the green transition.

38. UK Export Finance is also expanding its suite of green products and published the UK Export Finance Climate Change Strategy in September 2021. The UK is also one of the founding signatories of the Export Finance for Future initiative, a coalition of countries which endorsed a statement of principles to better integrate climate in export finance.

Finance

39. At COP26 the UK is working to achieve the finance goal, agreed in Article 2.1.c of the Paris Agreement, to make finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development. The UK Presidency published our Priorities for Public Finance earlier in 2021, and Priorities for Private Finance in 2020.[71]

40. Following COP26, the UK will continue to strive for greater ambition on finance. Achieving the global transition requires renewed action from all stakeholders to support the needs of developing countries. From the global to the local level, we need to put in place the conditions for a sustainable recovery and climate action, creating the right investment environments and aligning national budgets and planning processes with the goals of the Paris Agreement and 2030 Sustainable Development Agenda.

41. However, international public finance alone will never be enough to achieve the trillions of investment needed and put the world on a sustainable footing; the private sector will be key. Achieving net zero and our finance goals requires changes from the whole economy – we need every company, bank, insurer, and investor to adjust their business models, develop credible plans for the transition and implement them.

UK global climate action beyond COP26

42. Beyond our COP26 and G7 Presidencies, and the commitments outlined in this chapter, the UK will continue championing the fight against climate change and biodiversity loss internationally and at home in the decade to come.

43. The UK COP26 Presidency will formally begin at the Summit in November 2021 and run until COP27 in November 2022. Throughout our Presidency year, we will build on the outcomes from COP26 and the COP26 campaigns, including further strengthening the architecture for collaboration in key sectors, and work with international partners to keep the 1.5°C temperature goal alive. This entails continuing to advocate for our four Presidency goals with a focus on progress against our agreed targets in critical sectors and building the conditions for further ambition and a successful Global Stocktake in 2023.

44. Building on our COP26 Presidency, we are developing a 2030 Strategic Framework due to be published in 2022. The Framework will provide a coordinated approach to deliver against the climate and biodiversity commitments set out in the Integrated Review. It will also establish a common vision and clear priorities to guide UK international climate and nature action over the next decade. The UK will continue to play a leadership role in delivering the change needed by capitalising on our areas of strengths including diplomacy, finance, science, technology and innovation, trade, and domestic leadership.

45. On top of the 2030 Strategic Framework, we will aim to mobilise greater finance for nature, tackle the key drivers of biodiversity loss, and deliver against the targets contained in the post-2020 Global Biodiversity Framework.

46. The upcoming International Climate Finance Strategy will set out how we will use our £11.6 billion ICF to deliver transformational programmes in support of mitigation and adaptation action in developing countries across the four themes of clean energy, nature, resilience, and infrastructure.

Endnotes

[1] Mission Innovation is a global initiative of 24 countries, including the UK and the European Commission, working to accelerate clean energy innovation. It was established in 2015.

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[3] This includes legacy funding from government's previous £505 million Energy Innovation Programme.

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[5] BEIS analysis based on the methodology used in the Energy Innovation Needs Assessments. BEIS (2019), 'Energy Innovation Needs Assessments'.

[6] The Industrial Strategy Challenge Fund (ISCF) aims to bring together our world-leading research base with Britain's best businesses to address the biggest challenges society faces, including clean growth. The fund, which is part of government's £4.7 billion investment in R&D over 4 years is delivered by UK Research and Innovation (UKRI) and its partners.

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[9] This diagram is not an entirely accurate representation of the stages of development at which these institutions and funds intervene and it is simplification of the varied programmes and impacts they have on different sectors, businesses and technologies. However, it demonstrates roughly where these government interventions have greatest impact and have a key role to play in delivering economy-wide net zero solutions.

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Net Zero Strategy: Build Back Greener

Technical Annex

Technical Annex

UK carbon budgets and international emissions targets

Climate Change Act

1. Parliament passed the Climate Change Act[1] (the Act) in 2008, establishing the UK's 2050 target and the supporting framework of carbon budgets. The Act also established the Committee on Climate Change, now the Climate Change Committee (CCC), an independent statutory body, to advise the Government and the Devolved Administrations on setting and meeting carbon budgets. The CCC advises on the level of each budget, the respective contributions that different sectors could make and the extent to which carbon budgets could be met through the use of permitted "flexibilities" (such as surpluses from previous carbon budgets or the purchase of good quality international carbon credits).

2. Under the Act, the UK was legally required to reduce greenhouse gas emissions by at least 80 per cent by 2050 on 1990 levels. In 2019, on advice of the CCC[2,] the UK committed to reaching net zero emissions by 2050 and consequently the target reduction in the Act was increased to at least 100%.

3. To keep the UK on a pathway to achieving the 2050 target, the Government is obliged to set legally binding, five-year caps on emissions – carbon budgets – twelve years in advance and then to publish a report setting out policies and proposals for meeting that budget and those budgets previously set.

4. The Net Zero Strategy is the means by which we satisfy the requirements of the Act in relation to policies and proposals for meeting the current carbon budgets.[3]

Legislated carbon budgets

5. Six carbon budgets have been set to date, covering 2008 to 2037. The sixth carbon budget, the first to be decided under the UK's new net zero target, was set in June 2021. The UK has already met, and overachieved, its first (2008-2012) and second (2013-2017) carbon budgets, and is on track to meet its current third (2018-2022) carbon budget.[4]

6. To show how we will meet our climate targets, including legislated carbon budgets up to and including the sixth carbon budget, the Net Zero Strategy contains both an indicative delivery pathway and illustrative 2050 net zero scenarios. The pathway, which stretches to the end of the Sixth Carbon Budget period in 2037, provides an indicative trajectory of emissions reductions which we aim to achieve through the Strategy and through delivery of the policies and proposals outlined. It therefore indicates the timescales over which we expect those policies and proposals to take effect to deliver our targets. The pathway is designed to be broadly consistent with all three of the illustrative 2050 scenarios set out in the Journey to Net Zero chapter of the *Net Zero Strategy*. There is uncertainty associated with our decarbonisation pathway through to 2037 and the 2050 scenarios – the exact path we take to meet our climate targets is likely to differ and must respond flexibly to changes that arise over time.

International emissions targets

7. The 2015 Paris Agreement[5] under the UN established the goal of keeping the global mean temperature rise to well below 2°C, whilst pursuing efforts to limit the rise to under 1.5°C. Under the Kigali amendment to the Montreal Protocol, the UK has also committed to reducing F-gas emissions by 85% on 2011-2013 levels by 2036.

8. Under the Paris Agreement, the UK announced its Nationally Determined Contribution (NDC) in December 2020, which commits the UK to reduce net greenhouse gas (GHG) emissions by at least 68% by 2030 compared to 1990 reference year levels.[6] This represents an increase of ambition on the fifth carbon budget, which covers the years 2028-2032.

9. The UK will therefore need to overachieve on the fifth carbon budget to meet its international climate targets and stay on track for the sixth carbon budget. Accordingly, the policies and proposals, delivery pathway, deployment assumptions and any other analysis presented in the Net Zero Strategy for the fifth carbon budget period are consistent with the action required to meet the UK's 2030 NDC.

10. The Net Zero Strategy also constitutes the UK's updated Long-Term Low Greenhouse Gas Emission Development Strategy for the purposes of the Paris Agreement.

Accounting for UK emissions

The UK greenhouse gas inventory

11. The UK's performance against its 2050 target and carbon budgets is assessed through the UK's net carbon account,[7] measured in tonnes of carbon dioxide equivalent (tCO_2e). The net carbon account comprises GHG emissions from the UK net of emissions which are captured and stored from land use, land-use change and forestry (LULUCF). The UK greenhouse gas inventory[8] is the basis for calculating the UK's domestic greenhouse gas emissions. Performance against a carbon budget is assessed against the earliest GHG inventory that covers the whole of the carbon budget period, which is published two years after the carbon budget period in question ends. For example, the sixth carbon budget will be assessed in 2039 based on the 1990-2037 GHG inventory.

12. The net carbon account also includes the UK's net purchases/sales of international carbon units, if any. Carbon units include allowances issued under cap-and-trade systems, and international carbon credits issued under international schemes. While the UK intends to meet its climate targets for each of carbon budgets 3 to 6 through reducing emissions domestically and the proposals and policies set out in this Strategy have been prepared on that basis, it reserves the right to use such voluntary cooperation under Article 6 of the Paris Agreement. This could occur through linking the UK ETS to another emissions trading system, or through the use of international emissions reductions or removals units.

13. The net carbon account for each budget is calculated according to rules set in Carbon Accounting Regulations.[9] The accounting regulations that apply to each of the carbon budgets may not be in place until after the carbon budget periods are over, so assumptions are required on what accounting rules will apply. Some key assumptions are outlined in the remainder of this section.

14. The international science behind measuring emissions is continually evolving and the assumptions made here do not preclude future decisions on emissions accounting at both the domestic and international level. If future accounting decisions turn out to differ from the assumptions made here, this would not automatically lead to a change in the budget levels. The Climate Change Act allows for legislated carbon budget levels to be amended if the government believes that, since the budget level was originally set, there have been significant changes affecting the basis on which the previous decision was made. Where such changes happen but no reset occurs, significant policy changes may be needed to meet the carbon budget.

Peatland emissions

15. Emissions from peatlands were only partially captured in the UK GHG inventory when the first five carbon budgets were set. A major revision to the inventory was implemented in February 2021 for the 1990-2019 inventory[10] to represent these emissions with methodologies consistent with the IPCC Wetlands Supplement[11], which will count towards all current and future carbon budgets. All analysis in this document includes peatland emissions in line with the updated inventory. This revision increased estimated emissions in 2019 by approximately 16 $MtCO_2e$ relative to the methods used in the previous inventory.

International aviation and shipping

16. The sixth carbon budget is the first that will include international aviation and shipping (IAS) emissions. Previous budgets have not included IAS emissions but were set such that headroom for IAS emissions was left. We have used bunker fuel sales to calculate IAS emissions for the sixth carbon budget. Under this method, IAS emissions are estimated from the amount of refuelling from bunkers at UK airports and ports, whether by UK or non-UK operators, for onward international journeys.

Global warming potentials

17. Emissions of each greenhouse gas (carbon dioxide, methane, nitrous oxide, fluorinated gases) are expressed in terms of carbon dioxide equivalent (CO_2e), recognising the different global warming potentials (GWP) of the different gases.

18. The UK greenhouse gas inventory currently uses 100-year GWPs published in the IPCC's Fourth Assessment Report (AR4).[12] However, it was agreed by the international community that GHG emissions would be reported under the Paris Agreement transparency framework using an updated set of 100-year GWPs from the IPCC's Fifth Assessment Report (AR5).[13, 14] Two sets of values for 100-year AR5 GWPs were published (with and without climate-carbon feedbacks, which reflect more indirect effects of GHG emissions on the climate system - included in their methodologies) and it is not yet clear which will be used. Therefore, to ensure that carbon budgets can still be met under either methodology, emissions pathways in the main body of the Net Zero Strategy are based on the higher AR5 GWPs with feedback methodology (consistent with the approach taken in setting the sixth carbon budget). However, this does not preclude any future decisions on which methodology will be used, and emissions pathways based on AR5 GWPs without feedback are also presented in this technical annex.

19. The use of AR5 GWPs without feedback results in a lower CO_2-equivalent value for UK GHG emissions compared to AR5 GWPs with feedback, meaning that less abatement would be required to meet the same carbon budget. As a result, it may appear that the policies and proposals in this strategy overachieve on our carbon budgets when based on AR5 GWPs without feedback. However, these provide additional headroom with which the Government could seek to manage uncertainty in emissions projections. We would review the cost effectiveness of maintaining this headroom as the necessary policies and proposals are implemented. Conversely, since the 2030 NDC is a percentage-based target and the base year to which that percentage relates comprises disproportionately high non-CO_2 emissions, slightly more abatement is actually required to meet the NDC under the lower AR5 GWPs without feedback compared to AR5 GWPs with feedback.

20. The Working Group I Contribution to the IPCC's Sixth Assessment Report (AR6)[15] was published in August 2021, which included updated estimates of 100-year AR6 GWPs. However, it is not yet certain if or when these will be used for GHG emissions reporting under the UNFCCC or Paris Agreement. UK GHG emissions based on AR6 GWPs would be closer to UK emissions based on AR5 GWPs without feedback than based on AR5 GWPs with feedback.

The UK Emissions Trading Scheme (ETS)

21. Calculations of carbon emissions by HMG historically followed a net accounting framework[16] that constructed the total carbon budget as a sum of two individual components: i) emissions covered by the EU Emissions Trading System (ETS), known as traded sector emissions (around one third of all UK emissions); and ii) emissions outside the EU ETS known as non-traded sector emissions. When the UK was part of the EU ETS, the UK share of EU ETS allowances was used to calculate traded sector emissions, and emissions in the non-traded sector were measured as actually emitted. The sum of these was the net carbon account.

22. Now that the UK is no longer participating in the EU ETS, UK operators are not trading emissions allowances with operators outside the UK. The new UK ETS came into operation on 1 January 2021, and it is only currently necessary to count emissions within the UK territory towards carbon budgets. We assume that all years from 2021 onwards will be accounted on this basis. If the UK ETS were later linked with another ETS it may be decided that an adjustment needs to be made to account for any trading of allowances.[17]

The UK's 2030 Nationally Determined Contribution

23. Accounting for the UK's nationally determined contribution is different from that for carbon budgets. In particular, the NDC is a fixed percentage-based target. This means that any changes to the inventory in the baseline year will change the level of effort required to meet the NDC, while the carbon budgets are fixed targets in $MtCO_2e$.

Accounting for UK climate targets

24. The above assumptions are summarised in Table 1, alongside the coverage and level of the UK's climate targets.

Table 1: Accounting basis of UK climate targets

	Carbon Budget 3	Carbon Budget 4	Carbon Budget 5	NDC	Carbon Budget 6
Years	2018-2022	2023-2027	2028-2032	2030	2033-2037
$MtCO_2e$ limit (annual equivalent)	2,544 (509)	1,950 (390)	1,725 (345)	% based target (estimated 262-275*)	965 (193)
Accounting basis	Traded/ non-traded split for 2018-2020 Territorial for 2021-22	Territorial UK emissions	Territorial UK emissions	Territorial UK emissions	Territorial UK emissions
International Aviation and Shipping (IAS)	Excluded	Excluded	Excluded	Excluded	Included
Base year (1990) emissions**	859.6	859.6	859.6	TBC*** (859.6)	883.3****
Percentage reduction on 1990 (implied for carbon budgets)*****	41%	55%	60%	68%	78%

*The range of emissions required to meet the NDC reflects uncertainty over whether AR5 with or without feedback GWPs are used. Uncertainty over baseline emissions in the 1990-2030 GHG inventory means the actual limit may lie outside this range.

**Base year emissions are calculated as emissions of CO_2, N_2O and CH_4 in 1990, and fluorinated gases in 1995.

***The baseline for the NDC will be determined by the GHG inventory 1990-2030, meaning that the abatement required to meet the NDC is dependent on future estimates of baseline emissions. Our estimate of that abatement is based on the UK 1990-2019 GHG inventory.

****The baseline for the sixth carbon budget includes 23.7 $MtCO_2e$ for IAS, based on bunker fuel sales.

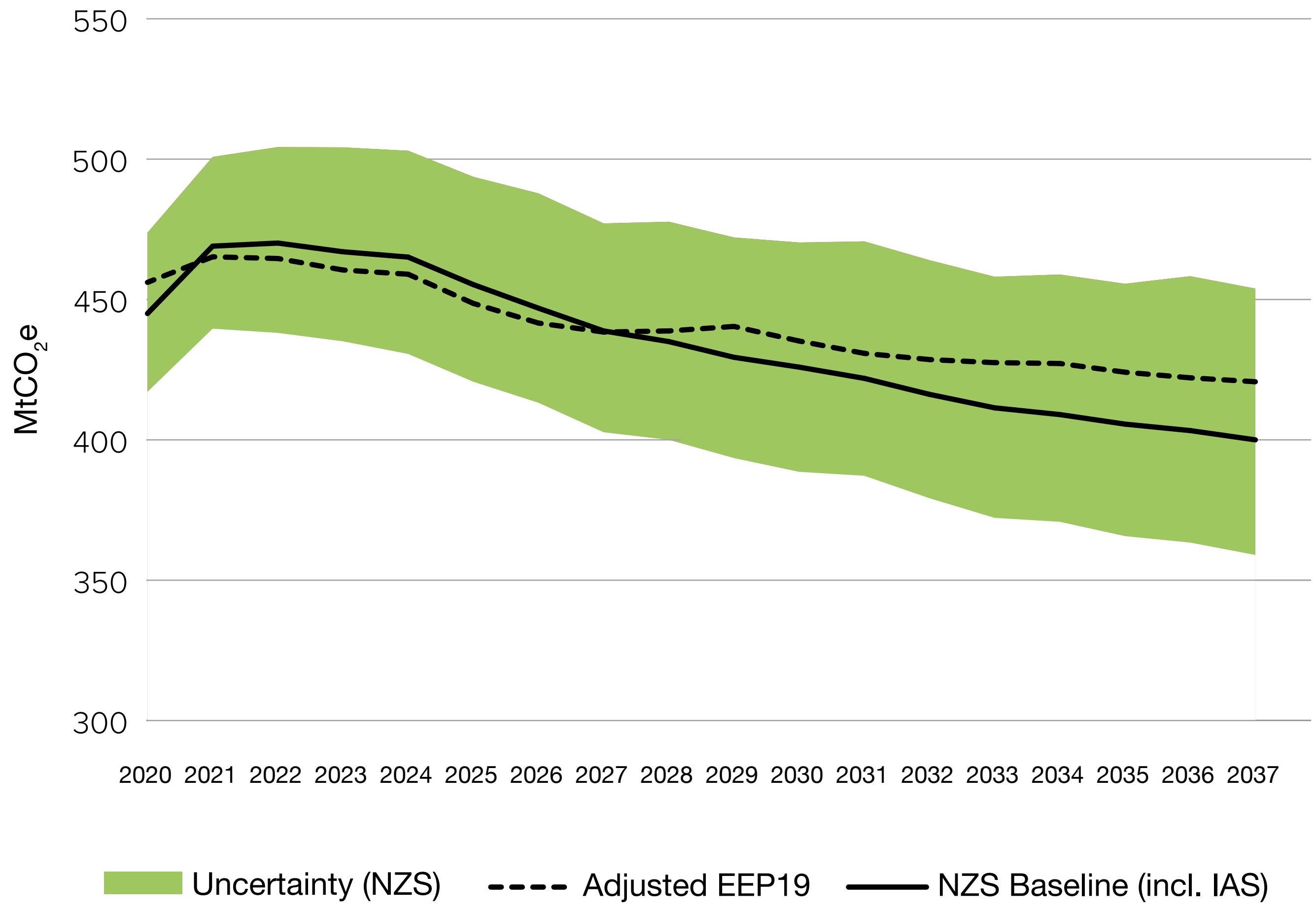
*****Estimates of historic UK GHG emissions are revised annually to incorporate methodological improvements, updated data and changes to international guidelines. The percentage reductions implied by CB levels are therefore subject to change.

Baseline emissions projections

25. While the GHG inventory is the source for historical emissions data, a combination of sector modelling and the BEIS Energy and Emissions Projections (EEP)[18] are used to project future emissions. This section sets out the assumptions about the baseline used for the purpose of this analysis. These projections determine baseline emissions for the indicative delivery pathway, based on policies implemented, adopted, or planned as of August 2019, and thus the further total emissions savings required to meet the carbon budgets. The baseline does not include policies announced in the Ten Point Plan, Energy White Paper, Transport Decarbonisation Plan, or the Industrial Decarbonisation Strategy.

26. In some sectors, adjustments to the EEP 2019 reference case,[19] published in October 2020, have been made to reflect developments in the evidence base since publication and to tailor it to ensure it is suitable as a baseline for the Net Zero Strategy. The adjusted EEP, referred to as the "baseline", incorporates the Office for Budget Responsibility's (OBR) central forecast of economic growth available in July 2020.[20] The baseline also includes some planned methodological improvements and corrections brought forward from the forthcoming EEP 2020, but no updates to policies beyond those included in EEP 2019. Table 2 provides details of these changes, and Figure 1 compares the differences across the series. The uncertainty range is explained further in paragraphs 45-48.[21]

Figure 1: Net Zero Strategy baseline compared to EEP 2019[22]



27. In accordance with the accounting rules represented in Table 1, all baselines are adjusted where relevant to be consistent with accounting assumptions for the relevant carbon budget.

Table 2: Differences between Net Zero Strategy baseline and EEP 2019 reference case

Sector	Change between EEP 2019 and Net Zero Strategy baseline	Impact on total CB6 emissions, 2033-37 ($MtCO_2e$)
All	Update of economic growth projections to the latest available OBR forecasts as of July 2020.	-42
All	Conversion of GHGs to CO_2e using Global Warming Potentials from AR5 with feedback compared to AR4 in EEP 2019.	+75
Buildings	Improvement of energy demand projections for domestic buildings. EEP 2019 did not fully account for technology improvements in new build dwellings beyond those directly attributable to Building Regulations.	-35
Buildings, Industry and Agriculture	Improvement to the methodology for alignment with UK Greenhouse Gas Inventory estimates for mobile machinery and other oil emissions. This results in lower emissions in agriculture and buildings, and higher emissions in industry.	Negligible net impact.
Buildings	Inclusion of estimates of short-term behaviour change in 2020 on energy demand in public buildings.	Impact limited to 2020-2021.
Buildings	Inclusion of estimates of short-term behaviour change in 2020 on energy demand in domestic buildings.	Impact limited to 2020-2021.
Industry	Improvement of energy demand projection methodology for chemicals and construction industry subsectors.	+38
Industry	Alignment of projections of emissions from refineries with the Net Zero Industrial Pathways model to reflect the impact of UK and global decarbonisation under a net zero consistent world scenario.	-22
Fuel supply	Alignment of projections for offshore oil and gas with projections from the Oil and Gas Authority (OGA).	-42
Power	Power sector evidence base has been updated to latest data available. This includes a revision to Energy from Waste (EfW) emissions where EEP2019 underestimated these due to an error in the percentage of EfW that is renewable. In addition, some policies included in EEP2019 have been removed as these are considered to be pre-Energy White Paper, in particular further Nuclear beyond HPC, and building one Gas CCS plant. Offshore Wind capacity is 15 GW higher in 2035 than in EEP2019 as further CfD auctions and planning means more capacity is on track to be built. There is also more large solar capacity building due to lower costs for this technology in up to date evidence.	-9

Sector	Change between EEP 2019 and Net Zero Strategy baseline	Impact on total CB6 emissions, 2033-37 ($MtCO_2e$)
Transport	Inclusion of estimates of short-term behaviour change in 2020 in road transport and domestic aviation.	Impact limited to 2020-2021.
Transport	Correction of a calibration error in EEP 2019 which led to an underestimation of the amount of oil in the historic fuel mix for transport.	+14
Transport	Closer alignment of national navigation and fishing emissions estimates with research commissioned by the Department for Transport.	+<5
International Aviation and Shipping	Inclusion of estimates of short-term behaviour change in 2020 on international aviation.	Impact limited to 2020-2021.
International Aviation and Shipping	Closer alignment of international shipping estimates with research commissioned by the Department for Transport.	+7

28. There is ongoing uncertainty over how the COVID-19 pandemic will affect emissions in the long term. In 2020, emissions fell,[23] but it is not yet clear what the effect will be on future emissions. We have assumed that there is no long-term behavioural change due to the pandemic. However, as stated above, the baseline is adjusted for the reduction in economic growth and the short-term behaviour changes occurring due to the COVID-19 pandemic. [24]

Sector definitions

29. The precise definition of the sectors used by the Net Zero Strategy, marked against IPCC categories, is published separately to this document.[25] A summary of the coverage of each sector is shown in Table 3. Where sector chapters cover more than one of these sectors, the below table shows which sectors are covered by which chapter.

Table 3: Net Zero Strategy sector definitions

NZS Sector	Sector chapter	Sector definition
Power	Power	Emissions from power stations (Major Power Producers only), including those generating energy from waste.
Fuel Supply	Fuel Supply and Hydrogen	Emissions from the extraction, processing, and production of fuels (chiefly oil, coal, gas and hydrogen).
Industry	Industry	Emissions from industrial processes, manufacturing, and production, including fuel combustion and product use in industrial buildings, as well as emissions from refineries and construction machinery. Includes emissions from non-Major Power Producers auto-generation and Combined Heat and Power.
Heat and Buildings	Heat and Buildings	Emissions from public, commercial, and residential buildings, including domestic product use such as garden machinery and composting.
Domestic Transport	Transport	Emissions from all forms of road and rail transport, domestic aviation and domestic shipping (including fishing vessels).
International Aviation and Shipping		Emissions from fuel used in international aviation and international shipping, as measured by UK bunker fuel.
Agriculture	Natural Resources, Waste and F- Gases	Covers emissions from livestock, crop soils and agricultural machinery.
Forestry and Other Land Use		Emissions and removals from land use change, forestry, peatlands and other carbon stock change from land use (e.g. in the biomass pool).
Resources and Waste		Emissions from the treatment and disposal of solid and liquid waste and landfill, including emissions from incineration not used to generate energy (e.g. incineration of chemical waste).
Fluorinated Gases (F-gases)		Fluorinated gas emissions, primarily from refrigeration, air-conditioning, heat pumps, aerosols, and high voltage switchgear.
Greenhouse Gas Removals	Greenhouse Gas Removals	Negative emissions from engineered removal technologies, including direct air and bio-energy carbon capture and storage.

Illustrative 2050 net zero scenarios

30. The Net Zero Strategy explores three possible net zero scenarios in 2050 in chapter 2, building on the pathways developed for the sixth carbon budget Impact Assessment. These have been deliberately selected to illustrate a wide range of outcomes for the economy that are possible by 2050. However, different outcomes within this range or beyond this range are also possible.

31. This analysis has primarily two objectives:

a. First, to examine three different scenarios of economy-wide decarbonisation to understand the range of possible long-term outcomes and therefore inform the short-term delivery pathways. Through previous modelling and research, BEIS has identified three areas of technology and resource uncertainty likely to have a substantial impact on the 2050 energy system.[26] The scenarios have been developed in consultation with internal experts to illustrate feasible avenues to achieving net zero emissions based on:

- The relative role of electrification and hydrogen in fuel switching;
- The role of land-use and bioenergy to produce negative emissions; and
- The role of further innovations to address the hardest to abate sectors of the economy.

b. Second, it confirms that all three scenarios are consistent with the policies and proposals set out in the Strategy to meet the sixth carbon budget.

32. This section explains the methodology that was used for this analysis and summarises the differences between the three scenarios. It also shows illustrative sectoral emissions in 2050 and accompanying deployment characteristics.

Overview of the methodology used to develop the 2050 scenarios

33. The net zero scenario modelling primarily uses the UK TIMES Model (UKTM), a least-cost, optimisation model covering all UK emissions (including land use) and the UK energy system over the period 2010 to 2060.[27] The model includes assumptions about technology costs, availability, performance, and build rates.[28] It also includes assumptions for future fossil fuel prices and energy services demand by end-use sector. These inputs are pre-determined for each model run and do not vary with deployment. Based on the input assumptions, the model identifies the least-cost way of meeting a given GHG reduction trajectory while also meeting assumed end-use demand for energy services. Further information on the methodology and assumptions used in the UK TIMES model can be found in Annex A.2 of the sixth carbon budget impact assessment.[29]

34. An extensive exercise has been undertaken to ensure UKTM is aligned with the latest evidence base and assumptions used across government. Where this was not possible, off-model adjustments have been made to the net zero scenarios.

35. A particular advantage of UKTM is that it identifies the least-cost technology pathway for a given set of assumptions, taking account of interactions across energy supply and end-use sectors over time. The model is therefore useful for identifying which technologies could be essential or important in the long run for achieving a low cost, net zero consistent energy system. It also helps identify the appropriate sequencing of abatement opportunities.

36. However, there are a number of limitations to the modelling:

- The model does not directly take account of uncertainty of any kind over future technology costs and availability. Uncertainty is only displayed through the range of outputs given by the different scenarios.
- Technology cost reductions over time are based on fixed assumptions and do not directly account for cost reductions through widescale deployment in the model. i.e. costs are not a function of deployment.
- No additional barriers beside cost and technical build rates are considered, no potential industrial benefits from developing and deploying new low-carbon technologies are considered. Modelling does not consider any upside or downside risks to the economy arising from the transition.
- Behavioural or other practical considerations that might make certain pathways more or less expensive to achieve are not accounted for (other than where they are reflected in costs or build rates).
- The model varies in detail by sector. In some areas only high-level representations are provided and the model is not spatially disaggregated.

37. The three scenarios are summarised below:

- **High electrification:** explores the impact of using widespread electrification to support transport, heating, and industry decarbonisation coupled with deep decarbonisation of electricity supply.
- **High resource:** explores the impact of using low-carbon hydrogen more extensively, particularly for decarbonising buildings and heavy vehicles. It assumes higher levels of tree-planting are achievable, increasing the ‘negative emissions’ available from land-use sinks.
- **High innovation:** explores a world in which successful innovations, such as synthetic fuels and zero emission aircraft, enable lower residual emissions to be reached sooner in aviation. Higher capture rates – above baseline assumptions – increase the impact of carbon capture technologies, particularly higher deployment of direct air capture.

38. The scenarios were constructed in the UKTM by varying input assumptions for:

- The extent to which technologies can be rolled out. For example, in the high electrification scenario 100% of buildings are set to be heated by electricity in 2050, whereas in the high resource scenario heat pump deployment is constrained and this figure drops to 40%.
- Availability of resources and technologies. For example, in the high resource scenario, we assume 50kha afforestation per annum by 2050 (compared to 30kha in the other scenarios). Higher efficiency capture technologies are only available in the high innovation scenarios (for example CCUS capture rates of 99% compared to 95% in most cases in the other scenarios).
- For sectors such as industry and aviation, where the UKTM does not represent the full range of known abatement options, supplementary adjustments to emissions, energy demand, and key deployment requirements have been made. These have been taken into account in the optimisation of other sectors via the specification of the emission targets.

39. Other assumptions were kept the same across the scenarios. For instance, projections of final demand for end-use sectors are consistent with those used in the central 2037 delivery pathway and are the same for each of the modelled 2050 scenarios. Technology and resource cost assumptions, including fossil fuel prices, are also the same across each scenario. Sensitivity analysis conducted as part of the sixth carbon budget Impact Assessment showed that the impact of economic growth and fossil fuel prices on the technology mix in 2050 is relatively small, therefore these effects were not considered further.[30] Finally, sector emissions to 2037 were aligned to those in the delivery pathway described in the Strategy. For further key assumptions by sector see the evidence base section of this annex.

40. Table 4 shows the level of emissions in 2050 implied by each of the three illustrative scenarios. All scenarios meet net zero in 2050, with removals technologies compensating for any residual emissions.

Table 4: Illustrative total territorial emissions under the different scenarios

Sectors	2019 emissions ($MtCO_2e$)	2050 illustrative emissions ($MtCO_2e$) High electrification	High resource	High innovation
Power	58	3	2	1
Industry	78	3	3	10
Fuel Supply	26	0	5	8
Heat and Buildings	88	0	0	2
Domestic Transport	122	3	4	5
International Aviation and Shipping	45	35	35	21
Agriculture and LULUCF	63	20	14	21
Waste and F-gases	40	12	13	13
Greenhouse Gas Removals	0	-75	-76	-81
Total emissions	**520**	**0**	**0**	**0**

41. Given the long-term scientific uncertainty and to err on the side of caution, the analysis above assumes AR5 with feedback GWPs. On the basis of AR5 without feedback GWPs the scenarios would reach c.-9 $MtCO_2e$ in 2050 as a result of primarily lower emissions from methane. This uncertainty represents less than 2% of the overall abatement requirement. Because of this, detailed sensitivity analysis on GWPs has not been carried out for the purposes of this strategy. However, lower GWPs could allow less reliance on removals in 2050 thereby lowering the requirements for sustainable biomass, or alternatively slightly higher end-use sector emissions.

Characteristics of the 2050 scenarios

42. To illustrate the assumptions underpinning the 2050 scenarios, Table 5 shows deployment characteristics for each sector. These are illustrative of the levels of deployment required for each of the three scenarios. Not all technology deployment required to meet net zero is represented.

Table 5: Illustrative characteristics in 2050

Sector	Deployment assumptions	Unit	2019	2050 illustrative range
Power	Electricity generation	TWh	320	610-690
	Low carbon GB generation as a percentage of total projected generation	%	56%	99-100%
Industry	Low carbon fuel switching*	TWh	110	190-210
	Resource and energy efficiency savings	$MtCO_2e$	0	13
	Industry demand for industrial CCUS (not including BECCS)	$MtCO_2e$	0	6-9
Fuel Supply	Low carbon hydrogen production	TWh	0	240-500
	Steam methane reformation with CCS (as a percentage of total hydrogen generation)	%	0	0-75%
	Electrolysis as a percentage of total hydrogen generation	%	0	15-75%
	Biomass gassification with CCS as a percentage of total hydrogen generation	%	0	0-20%
Heat and Buildings	Cumulative heat pumps installed domestically	Million installations	0.2	12-28
	Cumulative homes converted to 100% hydrogen	Million homes	0	0-14
	Demand reduction as a result of energy efficiency measures	%	0	15-20%
	Low carbon fuels* consumption as a percentage of total fuel consumption in commercial buildings	%	62%	90-100%
	Heat supplied via heat networks	TWh	14	70
	Biomethane injected into gird	TWh	3	0-20
Agriculture and LULUCF	Total area of peatland under restoration	kha	n/a	380
	Yearly area of afforestation UK	kha	13.6	30-50
	Yearly area of perennial energy crop and short rotation forestry planted	kha	0	53
	Farmers engaging with low carbon farming practices as a percentage of total farmers	%	60%	100%
Waste and F-gases	Level of HFC consumption relative to a 2015 baseline level	%	63%	15%

Sector	Deployment assumptions	Unit	2019	2050 illustrative range
Greenhouse Gas Removals	BECCS (all technologies)	$MtCO_2e$	0	52-58
	DACCS	$MtCO_2e$	0	18-29
Transport and IAS	ZEVs as a percentage of total car fleet	%	0.3%	96-97%
	ZEVs as a percentage of total van fleet	%	0.2%	88-90%
	ZEVs as a percentage of total HGV fleet	%	0%	95-97%
	ZEVs as a percentage of total bus and coach fleet	%	0.3%	91-95%
	Low carbon fuels* use in road transport as a percentage of total fuel use (in litres)	%	5%	30-60%
	SAF use in domestic and international aviation as a percentage of total fuel use (in tonnes)	%	0%	5-30%
	Low carbon fuels use in domestic and international shipping as a percentage of total fuel use (in TWh)	%	0%	97%
Overall	GDP carbon intensity	tCO_2e/ GDP £m2020	194	0
	GDP energy intensity	MWh/ GDP £m2020	700	270-310

*The table includes several deployment assumptions covering relevant low carbon fuels in different sectors. The low carbon fuels included are the following: electricity, biofuels, solid biomass, hydrogen, ammonia, and methanol. All these deployment assumptions include electricity and hydrogen both in the numerator and denominator, with the exception of low carbon fuels used in road transport (from which electricity and hydrogen are completely excluded).

Meeting the carbon budgets

43. This section sets out historic performance against carbon budgets and future performance implied by the delivery pathway, including emissions broken down by sector for each future carbon budget. Deployment assumptions that illustrate some of the real-world changes required to meet carbon budgets are also presented.

44. The UK has overperformed on its carbon budgets so far, by 37 Mt CO_2e for the first carbon budget and 384 Mt CO_2e for the second carbon budget. Table 6 shows the current baseline projections for future carbon budgets (reflecting policies as of August 2019),[31] and also the overall pathway for emissions as set out in the *Net Zero Strategy*.

Table 6: Projected emissions implied by pathway against current and future carbon budgets

	CB3	CB4	CB5	CB6 (incl. IAS)
Years covered	2018-2022	2023-2027	2028-2032	2033-2037
Baseline	2,499	2,052	1,889	2,029
Budget limit	2,544	1,950	1,725	965
NZS emissions pathway	2,499	1,854	1,312	962
Performance against carbon budget	-45	-96	-413	-3

Uncertainty over future emissions

45. Table 7 shows an indicative annual range over the sixth carbon budget period.[32] The lower and upper ranges are based on Monte Carlo analysis of the EEP, conducted in 2018 and assessed to represent the best evidence of the uncertainty in the projections for the sixth carbon budget period.[33] The analysis reflects a 95% confidence interval around the baseline to reflect uncertainty in future macro trends (such as GDP, and population size), uncertainty in the impacts of certain existing policies on emissions and uncertainty in the current evidence base on emissions (such as land use emissions). It also uses regression residuals to account for structural modelling uncertainty in the EEP. The analysis does not capture uncertainty in the policies and proposals brought forward under the Strategy.

46. Due to accounting changes, further emissions have recently come in scope of the sixth carbon budget period. The Monte Carlo analysis has therefore been augmented to include these emissions. The range around historical emissions for international aviation and shipping is estimated based on statistical volatility in historical emissions. Emissions added following the adoption of the Wetlands Supplement assume the uncertainty is proportional to the overall uncertainty in the LULUCF sector.[34]

47. The pathway is highly ambitious meaning there are downside risks to the estimated policy savings (for example, delays to delivery), as well as upside risks (for example, no long-run behavioural impacts are assumed as a result of the COVID-19 pandemic). Government will monitor progress against the pathway as set out in the Embedding net zero in Government chapter, and will prepare further proposals and policies to enable the carbon budgets to be met as necessary.

Table 7: Provisional indicative range of the carbon account over the sixth carbon budget

	2033	2034	2035	2036	2037
Upper	279	265	240	226	207
Central	232	215	190	171	153
Lower	193	177	150	131	112

48. Emissions across the period prior to the sixth carbon budget are also uncertain: the Government will provide further analysis in future Energy and Emissions Projections.

Sectoral emissions over the carbon budgets

49. Table 8 shows an indicative emissions pathway, broken down by sector across the fourth, fifth and sixth carbon budgets. The fifth carbon budget figures are aligned with the UK's NDC, and 2030 values have been used for this column. To reflect uncertainty from macroeconomic trends and in underlying baseline emissions, emissions for each sector are shown as a range. These ranges are calibrated to the uncertainty range set out in the economy wide EEP Monte Carlo analysis.[35]

50. Whilst the ranges below represent our current assessment of the right trajectory to meet our carbon budgets, developments in climate science, accounting regulations, baseline emissions, technological progress and/or policy impacts may alter the expected impact of policies set out in the strategy, or the optimal distribution of policy effort across sectors. Future climate strategies will update this sectoral emissions pathway where necessary using the latest evidence.

Table 8: Sectoral emissions across the carbon budgets: $MtCO_2e$ per year (using AR5 with feedback GWPs)

Sector	Current (2019)	CB4 (average 2023-27)	NDC (2030)	CB6 (average 2033-37)
Agriculture and LULUCF	63	51 to 57	44 to 52	38 to 48
Buildings	88	73 to 82	55 to 66	34 to 47
Domestic Transport	122	100 to 111	67 to 80	29 to 43
Fuel Supply	26	18 to 20	14 to 16	10 to 12
Industry	78	58 to 65	36 to 45	19 to 29
Power	58	28 to 31	14 to 17	9 to 11
Waste and F-gases	40	24 to 27	17 to 20	12 to 15
Greenhouse Gas Removals	0	0 to 0	-12 to -1	-33 to -11
Intl Aviation and Shipping*	45	(42 to 46)	(44 to 50)	39 to 46
Total (incl. IAS)	**520**			**192**
Total (excl. IAS)	**476**	**371**	**262**	

*Figures in parentheses indicate that IAS is not counted towards that target

51. As set out above, there is some uncertainty which set of Global Warming Potentials the UK will adopt. We have therefore also translated these pathways using alternative AR5 without feedback GWPs, assuming it were optimal in cost- and non-cost terms to implement the same set of policies and proposals modelled in the AR5 with feedback pathways.

Table 9: Sectoral emissions across the carbon budgets: $MtCO_2e$ per year (using AR5 without feedback GWPs)

Sector	Current (2019)	CB4 (average 2023-27)	NDC (average 2030)	CB6 (average 2033-37)
Agriculture and LULUCF	54	43 to 48	37 to 44	31 to 39
Buildings	88	73 to 82	55 to 66	34 to 47
Domestic Transport	122	100 to 111	67 to 80	29 to 43
Fuel Supply	25	18 to 20	13 to 16	10 to 11
Industry	78	58 to 65	36 to 45	19 to 29
Power	58	28 to 31	14 to 17	9 to 11
Waste and F-gases	34	21 to 23	14 to 17	10 to 13
Greenhouse Gas Removals	0	-1 to 0	-12 to -1	-33 to -11
Intl Aviation and Shipping*	44	(42 to 46)	(44 to 50)	39 to 46
Total incl. IAS	**503**			**182**
Total excl. IAS	**458**	**359**	**251**	

* Figures in parentheses indicate that IAS is not counted towards that target[36]

Illustrative deployment assumptions to meet the carbon budgets

52. To illustrate some of the deployment assumptions underpinning the emissions pathway, Table 10 below shows real-world deployment assumptions for each sector. Not all of the policies and proposals underlying the delivery pathway are represented by these assumptions. Ranges indicate where values differ between the electrification and hydrogen pathways set out in the strategy for the heat and buildings sector. In some cases, these assumptions represent early-stage assessments based on maximum technical potential. Given ongoing uncertainties, the policy mix that will meet carbon budgets, and related deployment assumptions, are subject to change; these are illustrative and should not be interpreted as government targets.

Table 10: Deployment assumptions underpinning pathway

Sector	Deployment assumptions	Unit	2019	2025	2030	2035
Power	Electricity generation	TWh	320	315	370	460*-510
	Low carbon GB generation as a percentage of total projected generation required in 2035	%	29%-33%*	38%-42%*	62%-69%*	99%
Industry	Low carbon fuel switching[a]	TWh	110	115	125	157
	Resource and energy efficiency savings	$MtCO_2e$	0	1	10	11
	Industry demand for Industrial CCUS (not including BECCS)[b]	$MtCO_2e$	0	2	5	7
Fuel Supply	Low carbon hydrogen production	TWh	0	10**	40	80-140*
	Electrical power demand from offshore oil and gas installations as a percentage of their total power demand	%	0%	0%	31%	43%
Heat and Buildings	Cumulative heat pumps installed domestically	Million installations	0.2	1.1	4*- 4.3	6.9* - 11.3
	Cumulative homes converted to 100% hydrogen for heat	Million homes	0	0	0-0.2*	0-4*
	Yearly homes treated by new domestic energy efficiency measures	Million homes	0	0.5	1	0.5
	Low carbon fuels[a] consumption as a percentage of total fuel consumption in commercial buildings (excluding heat networks)	%	62%	63%	67%	78%-81%*
	Yearly heat supplied via heat networks	TWh	14	16	22	29
	Yearly biomethane injected into the grid	TWh	3	8	12	12

Sector	Deployment assumptions	Unit	2019	2025	2030	2035
Agriculture and LULUCF	Yearly area of peatland under restoration in England	Ha	2,000-5,000***	7,000	10,290	10,290
	Yearly area of afforestation in the UK	Ha	13,600	30,000	40,000	50,000
	Yearly area of perennial energy crop and short rotation forestry planted	Ha	0	7,440	21,275	26,350
	Farmers engaging with low carbon farming practices as a percentage of total farmers	%	60%	70%	75%	85%
Waste and F-gases	Level of HFC consumption relative to a 2015 baseline level	%	63%	31%	21%	15%
Greenhouse Gas Removals	BECCS and DACCS	$MtCO_2e$	0	0	6	23
Domestic transport	ZEVs as a percentage of total car fleet	%	0.3%	6%	24%	53%
	ZEVs as a percentage of total van fleet	%	0.2%	2%	14%	40%
	ZEVs as a percentage of total HGV fleet	%	0%	0%	9%	37%
	ZEVs as a percentage of total bus and coach fleet	%	0.3%	9%	25%	48%
	Single track kilometres electrified per year	Km	0	350	650	650
	Low carbon fuels[a] use in road transport as a percentage of total fuel use (in litres)	%	5%	7%	8%	8%
	Journeys in towns and cities that are cycled and walk as a percentage of total journeys in towns and cities	%	42%	46%	50%	55%
	SAF use in domestic aviation as a percentage of total fuel use (in tonnes)	%	0%	1%	3%	6%
	Low carbon fuels use[a] in domestic shipping as a percentage of total fuel use (in TWh)	%	0%	0%	1%	42%

Sector	Deployment assumptions	Unit	2019	2025	2030	2035
International Aviation and Shipping (IAS)	SAF use in international aviation as a percentage of total fuel use (in tonnes)	%	0%	1%	3%	6%
	Low carbon fuels*** use in international shipping as a percentage of total fuel use (in TWh)	%	0%	0%	1%	28%
Overall	GDP carbon intensity	tCO_2e/ GDP £m2020	194	144	93	62
	GDP energy intensity	MWh/ GDP £m2020	700	600	480	380-400*

* Reflects deployment in hydrogen pathway.

** Figure reflects hydrogen demand in the mid-2020s (rather than 2025 specifically).

*** The 2019 range for peat reflects different estimates of peat restoration in England, including both public and externally funded work.

[a] The table includes several deployment assumptions covering relevant low carbon fuels in different sectors. The low-carbon fuels included are the following: electricity, biofuels, solid biomass, hydrogen, ammonia and methanol. All of these deployment assumptions include electricity and hydrogen both in the numerator and denominator, with the exception of low-carbon fuels used in road transport (from which electricity and hydrogen are completely excluded).

[b] Industrial carbon capture deployment starts in the mid-2020s, reaching a total of 6Mt in 2030 and 9Mt in 2035 including carbon capture from biomass use.

Costs and economic impacts of the transition

Costs of the transition

53. Table 11 shows the additional investment costs for the indicative delivery pathway in each of the future carbon budgets relative to a baseline of existing policies. These represent in-year capital expenditure requirements, excluding financing costs, and do not cover operational costs or savings, or policy costs. Costs are expressed in real 2020 prices as average annual values over the carbon budget periods. The costs of the delivery pathway remain highly uncertain and will depend on factors such as technology costs and fuel prices. Ranges, where given, represent the implication of higher or lower demand from end-use sectors consistent with the electrification and hydrogen scenarios.

Table 11: Estimates of additional investment requirements for Net Zero Strategy pathway (£bn pa, undiscounted, 2020 prices)

Sector	Carbon Budget 3 (average 2020-2022)	Carbon Budget 4 (average 2023-2027)	Carbon Budget 5 (average 2028-2032)	Carbon Budget 6 (average 2033-2037)
Power*	1	7-8	11-22	12-23
Fuel Supply	0.3	2.0	1.3-2.3	0.6-1.9
Industry	0.0	0.9	1.1	0.9
Heat and Buildings**	2	12	12	14
Transport	2	8	17	18
Natural Resources, Waste, and F-Gases[37]	0.6	1.2	1.7	2.6
Greenhouse Gas Removals	0.0	0.7	1.6	1.7
CCUS (T&S Infrastructure)	0.0	0.6	1.2-1.4	0.8-1.0
Total	5-6	32-33	48-59	52-61

*Figures exclude additional Transmission and Distribution Network investment requirements.

**Costs represent a scenario where heat is predominantly decarbonised via electrification through heat pumps.

54. Table 11 excludes operating costs to avoid double counting (e.g. where CAPEX in an energy supply sector is OPEX in an end-use sector). Over the same period, we could see additional resource savings of around £180 billion as a result of our reduced use of oil/petroleum products and natural gas. This has been calculated by multiplying the change in energy demand (relative to the baseline) by the corresponding long-run variable cost of energy supply (LRVCs) from The Green Book. This is based on the central price and the savings could be higher or lower, depending on how future prices evolve.

Other economic and fiscal considerations

Economic considerations

55. There are many economic impacts of the transition to net zero to consider. As shown above, there are significant capital investment requirements, and although the exact requirements are uncertain it is clear that patterns of investment will have to change. New jobs will also be created, and these jobs may require different skills and education. Consumption and production behaviours will shift towards greener choices, and different places and sectors in the UK could face different economic opportunities and challenges.

56. Previous cost benefit analysis of the sixth carbon budget showed that there are significant co-benefits to the transition to net zero.[38] As well as the benefits from reduced greenhouse gas emissions, improvements to air quality were valued at £35 billion to 2050, fuel savings at £123 billion and other benefits to natural capital at £5 billion. The net present value of meeting the sixth carbon budget and net zero target, compared to no further action, was estimated as a net benefit of £266 billion.[39] This calculation does not include many other potential co-benefits, such as reduced noise pollution from cars, improved health from walking and cycling and warmer homes from energy efficiency measures, nor indirect costs from macroeconomic impacts.

57. In terms of the macroeconomic impact of the transition to net zero, the Office for Budget Responsibility (OBR) finds that the costs of failing to get climate change under control, which relies on global effort, would be much larger than those of bringing emissions down to net zero.[40] In terms of transition costs, the OBR has presented scenarios in which the level of UK GDP changes relative to the baseline by between -4.6% and +1.6% by 2050, with a central estimate of -1.4% for early action on climate change compared to -4.6% for late action. These changes are small when set against expected growth of over 50% in real GDP to 2050 compared to today's levels. Further information on the economic impacts of the transition to net zero are set out in the HMT ***Net Zero Review***.[41]

Competitiveness

58. The transition to net zero can stimulate innovation that increases domestic competitiveness and global comparative advantage for some UK industries, providing potential export opportunities. Updated internal analysis based on the Energy Innovation Needs Assessment estimates that just over half of the £60 billion GVA potential from sectoral decarbonisation in 2050 comes from export related opportunities.[42] However, there will also be risks to sectors and industries susceptible to competitiveness impacts, particularly those that are trade-exposed and/or carbon intensive. Where UK firms lose market share to international firms with lower environmental standards, there is a risk of carbon leakage. There is little empirical evidence of this occurring in the UK to date, but risks could increase as further policy is implemented.

59. Historically, the UK's approach to mitigating competitiveness impacts and carbon leakage risk has been through issuing free allowances under the EU ETS.[43] This approach has been carried over to the UK ETS, and possible changes to free allowances are currently under review.[44] BEIS also provides compensation to certain energy intensive industries for the indirect emission cost due to the UK ETS and some sectors receive a reduction in energy consumption tax via Climate Change Agreements. The eventual impact of decarbonisation on firms at risk will depend on future policy development, particularly relating to the UK ETS.

60. The magnitude of competitiveness effects in international markets is dependent on global climate ambition as well as domestic policy. If other countries, particularly the UK's trading partners, increase their industrial decarbonisation ambition in line with the UK's, and face similar transition impacts, then competitiveness effects will be smaller. Similarly, where the UK's path to net zero creates export opportunities for UK businesses, the size of these will depend on the actions of the rest of the world. High global climate ambition will result in a large market for decarbonisation technologies and services but may also result in more global competition in those markets.

Fiscal considerations

61. The overall fiscal impacts of the transition to net zero will depend on many as yet unknown factors, including the financing mechanisms used to fund the policies and proposals set out in the Net Zero Strategy, and the macroeconomic impacts of the transition, for example through changes in GDP growth or inflation. There are some known fiscal impacts, such as the erosion of direct tax receipts like fuel duty that depend on carbon intensive activity, and increased tax receipts from other policies, such as revenue from the UK ETS.

62. HMT's *Net Zero Review*[45] and the OBR's recent fiscal risks report[46] provide a more detailed overview of the channels through which the net zero transition can impact the UK's fiscal position, and the factors which will determine the overall magnitude of this impact. While noting uncertainties, the OBR concluded that there could be significant fiscal benefits from transitioning to net zero sooner rather than later. However, governments public spending will be dependent on the economic, fiscal and decarbonisation context of the time.

Jobs

63. The policies and sectoral ambitions across the *Net Zero Strategy* are estimated to support up to 190,000 jobs in low carbon and green sectors by the middle of the 2020s, and up to 440,000 by 2030. The breakdown of jobs by chapter is as follows. Information on the methodology used to calculate these numbers can be found in the evidence base section of this annex.

Table 12: Estimate of jobs supported in Net Zero Strategy pathways, by sector and date

Sector	Jobs supported by 2024/5	Jobs supported in 2030
Power	59,000	120,000
Fuel Supply	N/A	10,000
Industry	5,000	54,000
Heat and buildings	100,000	175,000
Transport	22,000	74,000
Natural resources, waste and F-gases (forestry only)	2,000	2,000
Greenhouse Gas Removals	N/A	N/A
Total	190,000	440,000

64. *The Ten Point Plan for a Green industrial Revolution*[47] published in November 2019 set out plans to support up to 250,000 jobs by 2030, which was based on specific sectors included within the *Ten Point Plan*. The figures in this *Net Zero Strategy* include areas not covered by the *Ten Point Plan*, such as solar and onshore wind. In several cases, most notably around Heat and Buildings and Transport, figures have been updated since the *Ten Point Plan* was announced.

65. Government has also set out its ambition to pivot towards a green economy supporting up to 2 million green jobs by 2030. This is a wider ambition which includes areas of economic activity not included in the Net Zero Strategy but which support other environmental goals, such as climate adaptation and the circular economy.

Wider impacts of the transition to net zero

66. Section 10 of the Climate Change Act lists various factors that must be taken into consideration by all decisions relating to carbon budgets, while Section 13 requires that the policies and proposals set out in the *Net Zero Strategy* as a whole contribute to sustainable development. These factors have been taken into account in relation to proposals and policies that will enable the UK to meet its carbon budgets, as set out throughout this annex and in the main body of the Strategy.

Table 13: Summary of wider considerations

Factor	Consideration in Net Zero Strategy	Conclusions
Scientific knowledge	See Climate Science Annex	The scientific case for strong action on climate change remains definitive.
Technology	See Journey to Net Zero, sector chapters, Technical Annex	The latest evidence on relevant climate technologies has been used for all analysis across the strategy.
Economic	See Technical Annex, Why Net Zero, Green Jobs, Skills, and Industries, Investment, Innovation, Green Choices and Local Climate Action chapters	There are many economic and competitiveness impacts of the transition, some of which are positive and some negative. We make no overall conclusion.
Fiscal	See Technical Annex	The full fiscal impact of the transition is not yet known and will depend on varied policy decisions and economic outcomes.
Sustainable development	See Reducing Emissions across the Economy chapters, Technical Annex, Embedding Net Zero chapter	There are both positive and negative natural capital impacts associated with emissions reduction policies but the overall contribution to sustainable development is likely positive. Other aspects of sustainable development are addressed in the economic, fiscal and social sections.
Energy policy	See Journey to Net Zero and Power chapters, and Technical Annex	Delivering our carbon budgets has the potential to reduce demand for gas, coal, oil and transport fuels which could improve security of supply by diversifying away from primarily imported fossil fuels. Other measures will mean increases in electrification and the simultaneous deep decarbonisation of electricity supply, which carries security of supply risks. Estimations of the future energy and carbon intensity of the economy are presented in Table 10 of the Technical Annex.
Social	See Technical Annex, Green Choices, and Buildings chapters	Price and bill impacts will depend on electricity market developments and consumption patterns. Policies that improve energy efficiency of homes will reduce bills and benefit fuel poor households.
IAS	See Technical Annex, Transport chapter	IAS emissions will be included from the sixth carbon budget onwards and will use the bunker fuel sales method to calculate emissions. Projected IAS emissions are set out in Table 8.
International and European	See International climate leadership and Why Net Zero chapters	The UK has world leading ambition on climate change and is committed to advancing global climate action. The UK has now left the EU and is no longer bound by EU climate policies.

Factor	Consideration in Net Zero Strategy	Conclusions
Devolved circumstances	See sector chapters and Technical Annex	The NZS pathway analysis includes modelling of the scope to reduce emissions in each nation, considering their differing circumstances. These assumptions are broadly in line with the CCC's distributions of abatement by nation. Key assumptions are outlined in the evidence base section below.

67. The following section considers two of these impacts in more detail: sustainable development, which is considered through analysis of the effects of policies and proposals on natural capital; and social considerations, including the potential impacts on energy bills and fuel poverty.

Sustainable development and natural capital

68. Sustainable development concerns the stability and prosperity of society, and its capacity to provide for future generations. Sustainable development also incorporates social, economic, and environmental dimensions of sustainability. The Act requires carbon budget proposals and policies as a whole to contribute to sustainable development. The main outcomes of the policies and proposals in this Strategy will have a positive impact on the UK's contribution to the global Sustainable Development Goals, in particular goal 7, targeting affordable and clean energy, and goal 13, targeting climate action.

69. In this section, we assess the sustainability implications of the net zero transition in terms of its impact on the continuation and improvement of environmental functions, and stability and renewal of natural assets. This is most relevant to the Sustainable Development Goals 6, 14 and 15, which target protection of water and life on land and marine habitats.

70. In line with HM Treasury Green Book, a natural capital perspective is taken to analyse these implications, whereby the impact of policies and proposals on the natural assets on which the economy depends is assessed.[48] It is not yet possible to provide a complete assessment of the delivery implications of policies and proposals, as many are still subject to designs and implementations upon which the impacts are dependent. The extent that the natural capital impacts are mitigated will be dependent on the options considered in policy specific delivery analysis.

71. To assess the potential natural capital impacts of a policy, a series of screening questions are used.[49] Following this, the main benefits and risks associated with net zero policies are listed for different natural capital stocks. This is an indicative assessment of the natural capital impacts due to the limitations described above. As such, the large majority of measures in this strategy require further natural capital assessment. All policies will be assessed for natural capital benefits and risks in their impact assessments and business cases according to Green Book guidance. This includes considering the implications of policies for natural assets and any associated effects on wider economic welfare. More information on the natural capital approach can be found in the Green Book supplementary guidance and the Enabling a Natural Capital Approach guidance.[50]

72. Delivery of net zero policies and proposals will need to consider the UK's other legally binding environmental commitments (for example, new legally binding targets stemming from the Environment Bill), and any trade-offs against these acknowledged and mitigated through careful planning policies and actions can be designed that deliver multiple outcomes in support of the UK's net zero and 25 Year Environment Plan ambitions. For instance, the planting of broadleaf trees and restoration of peatland or grassland can deliver carbon sequestration as well as environmental benefits including improved biodiversity and water quality, if done in the right way. Conversely, certain interventions such as planting of maize for biomass or food may risk soil health and water quality. It will be important to assess the wider impacts of proposed net zero actions and seek synergies with environmental ambitions wherever possible, so that the twin challenges of biodiversity loss and climate change are tackled in an efficient way.

73. The independent Natural Capital Committee defined natural capital as 'those elements of the natural environment which provide valuable goods and services to people'.[51] Nature underpins the UK's economy and society: the energy, food, and water we consume; the air we breathe; our access to green space; and biodiversity, which is crucial in underpinning all our ecosystem and abiotic services, and in maintaining ecological function.[52] Nature is a major economic sector in its own right – as a productive asset it provides market and non-market services of £25 billion each year.[53]

74. The policies and proposals taken together within the Net Zero Strategy are expected to have a significant net benefit to natural capital and thus sustainable development. Moving away from i) fossil fuels towards a greater share of renewable energy, ii) petrol and diesel cars towards green alternatives such as electric vehicles iii) gas boilers to lower carbon heating sources and iv) high carbon land uses towards afforestation and other land-based carbon dioxide removals, are just a few examples that will provide significant benefits.

75. However, some negative impacts to some natural capital stocks are likely to arise from realising climate targets; impacts will likely be specific and localised. For example, the development of BECCS technology could lead to a rise in PM2.5 released in these areas. The direction of impact from the significant land use change required to meet net zero will depend on how and where this change is enacted, with a systemic and spatial approach more likely to deliver on net zero while providing natural capital benefits. Further in-depth exploration of the natural capital impacts of specific policies and policy mixes will need to be undertaken through the normal channels of Impact Assessments and Business Cases, to ensure trade-offs are managed and impacts mitigated.

76. **Air Quality:** As climate change and air pollution have many of the same contributing emission sources, the decarbonisation of the UK economy offers major opportunities to significantly reduce air pollution and therefore improve human health and reduce the impact of some air pollutants on ecosystems. This is primarily driven through the reduction of petrol and diesel cars towards green alternatives, as well as the continual shift away from fossil fuels in heat and power generation. However, some policies and proposals could result in significant negative air quality impacts at both regional and local scales, for example emissions of fine particulate matter from biomass combustion, ammonia from the use of anaerobic digestion, and NOx emissions from hydrogen combustion in domestic or industrial settings. These are likely to impact our ability to reach statutory national emissions ceilings, increase exposure to harmful pollutants and cause some uneven health burdens. Furthermore, the impacts of air pollution can also impact the delivery of net zero. For example, all of England's forests and peatlands continue to be damaged by harmful emissions – particularly ammonia – which impact their ability to provide the ecosystem services required to meet net zero, including carbon sequestration and flood mitigation. Historic pollution loading across all habitats may also need to be ameliorated to maximise the potential of restoring them to meet the biodiversity targets in the Environment Bill. Further work will be undertaken to assess this and provide advice on tailoring our pathway to minimise these impacts. Continuous improvements in emission requirements and innovation in abatement technologies will also be necessary to deliver a pathway to net zero that maximises environmental benefits.

77. **Recreation:** Achieving climate targets could have positive impacts for recreation and the provision of landscape amenity, with a transition to a low carbon economy providing spaces to enjoy nature. This will primarily be driven by new woodland creation for recreation and forestry more widely (where access permitted), woodland management and restoring peatlands. Green transport will also provide the opportunity to regularly access green spaces, parks and woodlands. Some policies may cause landscape issues for example, solar and onshore wind generation.

78. **Biodiversity:** In the long-term, net zero policies, for example, afforestation and peatland restoration, can be positive for biodiversity, preservation, connectivity, resilience and reducing ecological stress caused by climate change. However, biodiversity and habitats are spatially explicit, meaning locations and extent of future policies must seek to minimise any negative impacts, including displacement, air and noise pollution, and habitat loss, for example through housing or industry development. This could be minimised through further work on net gain principles which would seek to leave the environment in a better position. Other risks include ensuring land use changes (i.e. afforestation, biomass feedstocks, settlement expansion) do not lead to biodiversity loss. Mitigating actions and trade-offs will be considered when designing policies for reaching climate targets, including for low carbon technologies, greenhouse gas removals, marine policies, land management, and agricultural intensification.

79. **Floods:** Global temperature rise is leading to increased precipitation levels within the UK. There are a number of nature-based solutions such as the creation of new woodlands, planting of biomass crops such as willow, increased levels of upland peatland restoration, and strategically located natural flood management measures which can have positive impacts on flood risk management. For example, increased upland water storage improves the capacity of the UK's waterbodies to prevent floods downstream. This will have varied benefits through reducing damages from floods to property, agricultural land and health, and reduced carbon emissions from floods. Conversely, rewetting lowland peatlands may reduce the water storage capacity of those landscapes with possible impacts on local flood risk.

80. **Water availability and quality:** Whilst many policies have positive impacts on water availability and quality, for example through upland peatland restoration and strategic planting of trees, some low carbon technologies are water-intensive and large-scale implementation could result in pressures on water demand. For example, nuclear power and hydrogen production require high levels of water input for cooling and electrolysis, respectively and certain biomass crops (for use in BECCS) have high water demand. This is set against a backdrop of increasing global water scarcity in a changing climate. The UK is no exception, with increasing likelihood of warmer, drier summers. Therefore, water demand both regionally and nationally should be considered at a systems level, to ensure sustainable demand.

81. **Raw materials:** Resource efficiency policies will have a net benefit to pressures on raw material availability, reducing raw material demand and consumption. Reduced resource extraction and processing will also benefit other natural capital assets. For example, 90% of global biodiversity loss and water stress is caused by resource extraction and processing.[54] Moving towards a circular economy, where priority is placed on extending the lifetime and lifecycle of a product through sharing, reusing, repairing, redesign and recycling, is likely to have a positive impact on a number of natural capital stocks, primarily water quality and availability, air quality and reducing pressures on land use.

82. **Rare metals:** Materials are finite. Some low carbon technologies are dependent on critical raw materials, many of which are rare, found in unique locations and in high demand globally, for example cobalt, lithium and nickel. Many of these rare metals are sourced internationally and extraction of them may place pressure on the natural capital stock in the country of origin. There are risks associated with overreliance on specific technologies where raw material scarcity may grow and geopolitics may determine access, for example, rare earth elements such as neodymium for use in magnets. These risks will be assessed in relevant policy delivery analysis.

83. **Land Use:** Land is finite. Meeting climate targets will require significant and competing demands from land, for example, for food, shelter, goods and service production, ecosystem services and greenhouse gas abatement. This will result in large changes to land use and management. The pathway in the Net Zero Strategy is reliant on land use change linked to tree planting, peat restoration and growing perennial energy crops or short rotation forestry for use as biomass. This change will impact on the extent and condition of natural capital assets and the ecosystem services they provide. The direction of impact (positive or negative) and its magnitude will depend on how and where land conversion happens. A systemic and spatial approach to land use, that considers net zero, socio-environmental objectives, and various socio-economic factors such as population and economic growth, is necessary to enact land use changes that delivers net zero as well as environmental outcomes in line with the 25 Year Environment Plan. Such an approach enables trade-offs to be managed among different objectives while facilitating win-win outcomes- for instance with flood protection and recreation.

Social considerations

84. Over the last decade there have been changes in the underlying costs of energy bills, which have been mitigated through energy efficiency measures, helping consumers to use less energy. Electricity prices have trended upwards due to rising network costs and support for low carbon infrastructure and vulnerable households. Gas prices have fluctuated due to international wholesale gas prices, which in recent months have been particularly volatile.

85. Government energy saving schemes have been targeted towards low-income or vulnerable households, and the retail energy price cap has helped protect those customers on default energy tariffs. Steps have also been taken to protect industries most exposed to the UK's relatively higher industrial electricity prices.

86. The policies set out in the *Net Zero Strategy* will help insulate consumers from the over-reliance on fossil fuels which they face today, and help to shield households, business, and the wider economy from the destabilising effects of this reliance.

87. How electricity and gas bills will change on the path to net zero depends on factors such as technology costs, patterns of consumer energy use and the government's gradual approach to rebalancing where social and policy costs fall. The nature of costs in a smart, clean energy system will be different. The largest part of the electricity bill is currently the cost to energy suppliers from buying power. This cost has traditionally been determined by the underlying price of gas or coal, but this is changing. Gas will continue to play a role in setting the electricity price for some years to come but, over time, will do so less frequently, as more and more low carbon generation (such as wind and solar) connect to the electricity system - consistent with the commitment to a fully decarbonised power system by 2035. This will help put downward pressured on wholesale electricity prices.

88. Patterns of energy consumption will also change. Most households and businesses are likely to increase their use of electricity, but reduce gas and petrol/diesel consumption, as they shift to low carbon forms of transport and heating (such as electric vehicles and heat pumps). It is essential to ensure that price incentives are fair and help support this transition away from relying on fossil fuel prices.

89. It will remain the case that households and businesses who install energy saving measures will reap significant savings.

90. As we progress towards net zero, the Government is committed to ensuring the costs of decarbonising the energy system are fair and affordable for all energy users. We are considering both the benefits and the costs of different pathways holistically across the economy and will work with industry and consumers to keep costs down.

91. The impact of decarbonisation on progress in tackling fuel poverty will be determined by changes in electricity and fuel prices, and higher energy efficiency in the housing stock. In particular, policies to improve energy efficiency in homes - such as the Social Housing Decarbonisation Fund, Home Upgrade Grant, Energy Company Obligation and proposals on Minimum Energy Efficiency Standards - will help to improve the building performance for the homes of those in or at risk of fuel poverty. The Warm Homes Discount will support fuel poor homes through reduced bill costs. Fuel poverty is a devolved matter. In England we are committed to our target for fuel poor households, as far as reasonably practicable, to be living in a home rated EPC Band C or better by 2030. Scotland, Wales and Northern Ireland have their own fuel poverty targets and are also working to improve the energy efficiency of their building stock.

Evidence base

Sectoral evidence

Power

BEIS' Dynamic Dispatch Model (DDM) has been used to generate technically feasible pathways that are consistent with achieving the NDC in 2030, the sixth carbon budget in 2033-37 and net zero in 2050.[55] This model was developed by BEIS and is used for all power sector analysis within the department. This includes the Modelling 2050 – Electricity System Analysis report that was published with the *Energy White Paper* and the Energy and Emissions projections.[56] It was also used for the power sector analysis in the CCC's *Sixth Carbon Budget* report although the CCC used their own assumptions and off-model adjustments for this.[57] Assumptions for the Northern Ireland power sector demand and emission pathway are based on the CCC's Sixth Carbon Budget advice.

The DDM relies on many exogenous assumptions and inputs, and results can be sensitive to changes in these assumptions. This includes using electricity demand from UKTM and other sectors analysis and evidence on different technologies costs and characteristics from BEIS' generation costs report.[58] Both full pathway runs and single year analysis is used to underpin the strategy set out in the power sector chapter.

Distribution Network outcomes are modelled in the Distributions Networks Model (DNM). The DNM conducts electricity power flow analysis across 10 representative regional networks to estimate future distribution network constraints (thermal violations and voltage imbalances). The results of the constraint analysis are then fed into a separate investment model to calculate reinforcement costs up to 2050.

Investment costs for power plant generation capacity and flexible assets are calculated from the DDM based on technological costs assumptions. Transmission and Distribution Network costs have been calculated separately. The costs for networks provided are in Allowed Revenues terms. Allowed Revenue estimates are the costs that network operators will be allowed to recover annually – as decided by Ofgem as part of their RIIO price control process. These are therefore the network costs that will be passed through each year. They do not represent the total value of investment in assets.

The 2050 illustrative scenarios represent the power sector at a less granular level than DDM. Supplementary adjustments and results were validated by DDM but should not be read as predictive of the optimal technology mix in 2050. For a detailed assessment of potential scenarios for the 2050 electricity system please consult the *Modelling 2050: electricity system analysis* published alongside the *Energy White Paper*.[59] The high electrification scenario assumes no hydrogen availability for power to illustrate an alternative power sector trajectory.

Fuel Supply and Hydrogen

Hydrogen: The hydrogen demand needed to meet the sixth carbon budget in industry, power, buildings and transport was estimated as set out in the evidence base sections for those sectors. The hydrogen production capacity needed to meet this demand has been calculated assuming hydrogen production plants run at a 95% load factor. Evidence on hydrogen supply and demand has also been drawn from the *Hydrogen Strategy*: further detail can be found in the *Hydrogen Strategy* analytical annex.[60, 61] Estimates of hydrogen production costs are based on the evidence set out in the hydrogen production cost report.[62]

Upstream Oil and Gas: The pathway for upstream oil and gas was developed using the OGA's projected abatement from offshore electrification and flaring.

Estimates of potential abatement from offshore electrification (scope 1 emissions only) were developed using the best available data provided to the OGA by industry as of August 2021, and assumes that there will be a mixture of some installations being partially electrified and some being fully electrified (the list of these installations was provided by industry). Fully electrified installations were estimated, in line with industry representatives' assessment, to have 70% of power demand provided by electrification, while partially electrified ones have 43%. Additionally, it is assumed that project phasing is one year and that electrification of the installation would not affect previously reported economic cessation of production dates.

The estimate of GHG emissions abatement via flaring reduction from offshore oil and gas infrastructure was developed assuming that zero routine flaring will be in place across all UKCS assets in 2030. Routine flaring is assumed to be broadly consistent with category 1 flaring (now defined by the OGA as category A flaring). Future expected flare volumes were calculated by subtracting the routine element of flaring from total anticipated flaring per facility after 2030, with data taken from the *UK Stewardship Survey*. Flared gas values, in both mass and volume units, have been converted to CO2 emissions using emission factors observed in published datasets (e.g. EEMS).[63]

Capex assumptions for Upstream Oil and Gas abatement measures have been sourced from the CCC's *Sixth Carbon Budget advice*. The overall cost profile has been calculated by BEIS and is aligned to the deployment trajectory underpinning the sector's illustrative emissions pathway. This is an early analysis with significant uncertainties. Through discussion with the OGA BEIS is confident that these estimates are in the right order of magnitude, however actual costs might end up being higher.

Hydrogen and other fuel supply assumptions for 2050 are aligned with those used in the *Sixth Carbon Budget Impact Assessment*. The level of curtailment available for electrolysis was taken directly from the power sector modelling.

Industry

A model of the UK industrial sector called Net Zero Industrial Pathways (NZIP) has been used to generate a technically feasible pathway to achieve a net zero industry sector by 2050. The model was developed by Element Energy for BEIS and the Climate Change Committee (CCC)[64] and was used to underpin the manufacturing and construction sector analysis in the CCC's *Sixth Carbon Budget report*[65] and the Government's *Industrial Decarbonisation Strategy* (IDS),[66] published in March 2021. The industry pathway required to reach net zero is based on the IDS National Networks scenario but achieves a faster trajectory through earlier decarbonisation of the Iron and Steel sector and increased CCS ambition by 2030. The model calculates the least cost pathway for a range of technologies, assessed on their capital and operating costs, along with cost reductions over time due to technology learning, and a number of key constraints impacting their deployment (e.g. technology readiness level, hydrogen and CO_2 transport and storage availability, supply chain capacity).

The 2050 scenario analysis includes supplementary adjustments to align the UKTM emissions, energy demands and CCS requirements with the evidence base in NZIP IDS 2050 scenarios. In the high electrification and high resource scenarios these align with the National Networks scenario, whilst the high innovation scenario is more representative of the Cluster Networks scenario.

Heat and Buildings

Both heat and buildings scenarios are developed to be consistent with completely decarbonising buildings by 2050 to meet a net zero target. With the assumption that a typical heating appliance has a lifetime of 15 years, this implies that no new fossil fuel heating systems can be installed after 2035. The high electrification scenario assumes that hydrogen is not available as an option for heating buildings, so the level of heat pump deployment grows from its current level of around 35,000 in 2020 to be able to meet the turnover of fossil fuel systems in 2035. In scenarios involving hydrogen, heat pump deployment meets the common ambition of 600,000 heat pumps by 2028, and further growth is dependent on the level of hydrogen deployment to generate the same level of carbon savings between scenarios. Installation of energy efficiency measures and deployment of low carbon heat networks is assumed to be same in all scenarios.

Domestic Energy Efficiency: The domestic energy efficiency modelling was carried out using the National Household Model.[67] This model estimates the impact of installing different measures in different properties by applying the Standard Assessment Procedure[68] to a representative sample of the housing stock based on the English Housing Survey.[69] Further adjustments are made to modelled savings to account for factors such as the real-life performance of measures and people heating their homes to a more comfortable temperature when their energy bills are reduced. Cost data for different measures comes from a variety of published sources, as well as some internal data.[70, 71, 72] The deployment profile for measures was estimated based on current and planned policies and proposals.

Non-Domestic Buildings - Commercial and public: The sixth carbon budget pathway for commercial and public sector buildings was created using BEIS Non-Domestic Buildings Model (NDBM). This models the deployment of low carbon heating and energy efficiency measures in non-domestic buildings. The NDBM uses building stock characteristics and potential energy efficiency information from the Building Energy Efficiency Survey (BEES) dataset.[73] Data on energy consumption and emissions come from the Digest of UK Energy Statistics, Energy and Emissions Projections, and ECUK.[74, 75, 76] The model has been supplemented with updated information on off-gas grid buildings from the Non-domestic National Energy Efficiency Data-Framework (ND-NEED); and updated cost and efficiency assumptions for Heating Ventilation and Cooling (HVAC) technologies in non-domestic buildings.[77] Modelling assumptions for public sector buildings have been further refined through monitoring the on-going rollout of phase 1 and 2 of the Public Sector Decarbonisation Scheme.

Products Policy: For products policies, as well as the sources listed above, additional data is taken from the ONS, consultation with trade associations and research provided by external contractors to develop the evidence base. The average energy consumption of products in the pathway are compared to the market average to calculate energy savings, taking into account product lifetime, usage and different technology types. Costs associated with products price increases, staff labour and training and installation costs are also taken into account, as well as interaction with EU and international trade and product regulations.

Domestic Heat Pumps: Deployment of domestic heat pumps is based on simple analysis of the residential stock, segmenting homes by heating fuel, and considering natural replacement cycles. The trajectory of heat pumps is based on estimates of deployment from current and planned policies, supply chain growth required to meet phasing out of new fossil fuel heating systems, and use of the natural replacement cycle to remove all fossil fuel heating in homes by 2050. Assumptions on appliance costs and performance, and on potential supply chain growth, are based on published research.[78, 79, 80] Assumptions on the current building stock and heat demand are from the NHM and domestic NEED.[81, 82] Assumptions on new build homes are based on DHLUC's 2019 FHS Consultation stage Impact Assessment - these were produced externally by consultants and an independent consortium.[83] These are for appraisal purposes only, and are not an official forecast of housing supply.

Hydrogen: Deployment of hydrogen for heat in buildings up to the sixth carbon budget has been modelled using a spatial analysis approach considering the metered gas demand from residential, commercial and public buildings within an expanding radius around potential industrial cluster sites producing hydrogen. Spatial gas demand has been derived from NEED data and assumptions on rollout rate have been taken from the CCC's residential heat decarbonisation scenarios from their Sixth Carbon Budget advice.[84, 85, 86] Additional assumptions on overall demand for scaling are from DUKES.[87]

Heat Networks: Deployment of heat networks has been derived from the expected impact of capital support and regulation, informed by the heat network opportunity areas.[88] The analysis appraises the impact of low-carbon heat network policies, and on fuel demand relative to a predominately gas-fired counterfactual, to estimate carbon savings. The costs technical assumption come from a AECOM report, but a number of assumptions have been updated since using learning from the Heat Network Investment Projects (HNIP).[89, 90]

Biomethane: Plant deployment scenarios are based on a combination of historic deployment under the Renewable Heat Incentive (RHI), and commercial intelligence. Heat generated is estimated from plant deployment scenarios and using estimates for biomethane injection as proportion of capacity.[91] The internal BEIS Biomass Heat Pathways Tool provides assumptions on biogeneration emissions, feedstock costs, capex and opex costs.[92] These capex and opex costs have also been verified against cost information collected through market intelligence, the Non-Domestic RHI Evaluation, and a review of AD plant costs commissioned by BEIS and awarded to the National Non-Food Crops Centre (NNFCC). Rothamsted Research has provided assumptions on upstream carbon savings, linked to diverting feedstocks from counterfactual uses to AD, and ammonia impacts.[93] Downstream carbon savings, linked to the displacement of natural gas with biomethane, are estimated using emissions factors provided in the HMT Green Book supplementary guidance.[94] Fertiliser savings are valued using the average of fertiliser prices published by the Agriculture and Horticulture Development Board across multiple years.[95] Full methodology and assumptions can be found in the final stage impact assessment for the Green Gas Support Scheme.[96]

The 2050 UKTM scenarios represent the housing stock at a less granular level but have been calibrated to the sectoral evidence base. The high electrification scenario assumes no availability of hydrogen for heating, the high resource scenario limits the deployment of electric heating, whilst the high innovation scenario is left to optimise outcomes.

Transport

Domestic Transport: The pathway for domestic transport covers road transport, rail, domestic shipping and domestic aviation. The *Net Zero Strategy* pathway for road transport, rail and domestic aviation was developed using projections from the recently published *Transport Decarbonisation Plan* (TDP).[97] These projections were produced using a range of models and analysis, including the National Transport Model (road transport), Traction Decarbonisation Network Strategy (rail), and the Aviation model, adjusted for decarbonising transport measures.[98] The forecasts presented in the TDP considered a number of scenarios. The *Net Zero Strategy* pathway for road transport, rail and domestic aviation assumes an ambitious policy package within the range of policy outcomes explored in the TDP. These emissions savings are applied to a central demand scenario. The Net Zero Strategy pathway for domestic shipping is based on research commissioned by the Department for Transport (DfT) – see below for further details.

International Aviation and Shipping: The *Net Zero Strategy* pathway for international aviation was developed using projections from the TDP and the *Jet Zero Consultation*.[99] This uses the same Aviation model and assumptions as used for the domestic aviation projections. The DfT's Aviation model is an established suite of interrelated components used to produce forecasts for aviation demand at the national level, and the associated passenger numbers, aircrafts and CO_2 emissions from flights departing from UK airports.[100] Three abatement measures are considered within the modelling; system efficiencies, sustainable aviation fuels (SAF), and zero emission aircraft.

As with the *Net Zero Strategy* pathway for domestic shipping, the pathway for international shipping is based on research commissioned by the Department for Transport (DfT).[101] For both pathways, the estimates from this research have been adjusted to align them with the latest UK greenhouse gas emissions national statistics.[102] Therefore, the pathways for domestic shipping and international shipping are consistent with the definitions of domestic shipping and international shipping used in these national statistics.[103] Given the emerging nature of zero emission shipping fuels, the NZS pathways for domestic shipping and international shipping should be interpreted as a possible scenario for meeting the government's commitment to achieving net zero in maritime rather than estimates of the impact of specific policies.

The illustrative 2050 scenarios rely on the same evidence base for transport as the Sixth Carbon Budget Impact Assessment with the exception of the high innovation scenarios, where modelling updates on aviation to reflect DfT's Jet Zero consultation high ambition scenario, and the scenarios for shipping which have been aligned with the NZS pathways described above. To support the sustainable fuel production requirements additional assumptions have been taken from the Advanced Gasification Technology review.[104]

Natural Resources and Waste

Agriculture: The agriculture emissions trajectory is based on estimates of maximum technical GHG mitigation potential (MTP) for each technology from the Clean Growth through Sustainable Intensification (CGSI) Project and building upon previous work by the CCC. MTP quantifies the impact if all farms which could technically adopt a measure do so, whilst considering any current uptake to avoid double counting.[105] MTP was derived from expert review of published literature and modelling to scale experimental data to national level. These estimates have been independently peer reviewed. CGSI used the MTP values to derive the trajectory based on ambitious but feasible deployment rates. The trajectory was informed by academic, industry and policy experts to reflect barriers, technology readiness and R&D lead in times.

Additional stretch options were modelled through Defra analysis using CGSI and CCC data, generally through adjustments to implementation rates. Additional modelling addressing agricultural mobile machinery aligned to CCC analysis in its *Sixth Carbon Budget* Report. England only data was scaled to a UK basis using the relative emission share between England and the Devolved Administrations as an estimator of Devolved Administration potential, pending publication of the Devolved Administrations pathways.

The UKTM modelling for the 2050 scenarios uses the same evidence base as the agriculture emissions trajectory. A set of crop and livestock measures are characterised by their cost and maximum technical potential to reduce emissions, and these assumptions are the same across the three scenarios.

Biomass: The biomass analysis is an indicative technical assessment of potential carbon abatement assuming optimal species/site/climate matching and a relatively simplistic approach to modelling carbon removals. Five biomass crop categories were modelled, deployed in fixed proportions: exotic SRF (14%); conifer SRF (23%); broadleaf SRF (poplar, aspen) (12%); SRC willow (27%); miscanthus (25%). A high-level analysis of land availability has been undertaken, indicating that the *Net Zero Strategy* pathway deployment profile is feasible. To calculate carbon stocks, a simple linear approach to yield modelling has been adopted which could overestimate initial growth and thus abatement. For all crops, appropriate biomass expansion coefficients were applied to account for branches and/or roots, as appropriate. All biomass was converted to carbon, assuming carbon comprises 50% of biomass. Emissions savings are modelled as the time-averaged increase in biomass carbon stocks resulting from planting of the crop, assuming the land use change is permanent.

In addition, the 2050 scenarios assume a maximum technical potential of 53 kha domestic bioenergy crop planting rate by 2050. Bioresource import assumptions in 2050 do not exceed current levels of imports.

Forestry: Emissions/removals are estimated using output from Forest Research's CSORT model, an off-line version of Carbine, the greenhouse gas accounting model used to calculate the forestry contribution to the UK LULUCF GHG inventory.[106, 107] Three indicative woodland types are represented in the model: productive conifer, productive broadleaf, and unmanaged. The modelled abatement is for England only and adjusted to a UK basis to be broadly aligned to the CCC share of afforestation by country in the "Balanced Net Zero pathway" scenario.[108] Linear expansion of deployment is assumed between 2025 and 2035. Non-market benefits are calculated using various research, compatible with the Enabling a Natural Capital Approach services data book.[109]

The 2050 scenarios vary the maximum afforestation/tree planting rate assumptions between 30 kha (in the high electrification/innovation scenario) and 50 kha pa (in the high resource scenario).

Peatland: The peatland trajectory covers restoration as well as technical potential modelling covering abatement from responsible management and the ending of peat extraction. Emissions savings from peatland restoration are based on upland, lowland cropland and lowland grassland emissions factors, which are applied to the peatland restoration deployment profile, delivered via the Nature for Climate Fund and Blended finance up to 2050.[110] The technical potential modelling covering responsible management measures (management activity that does not seek to re-establish peat habitats, but which significantly reduces the impact of using peatland for its current purpose) assumes abatement to be 1/3 of respective cropland/grassland restoration abatement. Biodiversity and water quality benefits are monetized using central values, whilst upfront restoration costs are estimated using 2017 Defra grant scheme data.[111, 112] The peatland modelling from Defra is England only, including an early stage assessment of how emissions factors from wasted peat may be revised in future inventories. Abatement potential in DAs is assumed to be in line with CCC analysis.

Peatland assumptions are the same across the three 2050 scenarios and there are two separate evidence bases – one that covers England, and one that covers Scotland. Both evidence bases consist of a set of restoration measures characterised by cost and maximum technical potential to reduce emissions. Assumptions for England come from Defra but for Scotland, data comes from the Scottish TIMES model and are uplifted to account for Wales and Northern Ireland.

Resources and Waste: For municipal wastewater, water companies use the Carbon Accounting Workbook developed by UK Water Industry Research to estimate operational GHG emissions across the industry. The workbook has been in place since 2004 and is updated annually to reflect the needs of the industry, including changes in carbon accounting practices with updated emission factors to align with the latest UK and international data. There are no internal models for private or industrial emissions and there are still significant gaps in our understanding of the magnitude and main sources of these. The Water UK Routemap to 2030 sets out industry plans to achieve net zero by 2030.[113] This routemap has been used as the basis for Defra to develop net zero consistent policies, for example, using assumptions from industry on cost and feasibility of policy deployment.

For landfill emissions estimation, the Landfill Environmental and Financial (LEAF) model has been used. This was developed by Resource and Waste Solutions, and more detail can be found in their report.[114] This is a high-level and strategic model of non-hazardous waste flows in England. LEAF allows the different scenarios to be described numerically and their effects on landfill emissions and costs of landfill to be calculated. The model considers the impacts of changes on landfill gas, leachate and void space consumption. The model is England only, but to provide an indication of Devolved Administration potential, emission savings are scaled to a UK level using relative emissions shares between England and the Devolved Administrations. It is assumed that there is a linear increase in diversion from landfill after 2021.

F-Gases: The *Net Zero Strategy* pathway for F-gas Emissions was estimated primarily using the UK-Level HFC Outlook Model developed by Gluckman Consulting. Non-HFC F-gas emissions are estimated using the BEIS Energy and Emissions Projections. The level of ambition for metered dose inhalers is derived from the ambition within the NHS report 'Delivering a 'Net Zero' National Health Service'.[115] Costs were developed using the CCC report 'Assessment of the potential to reduce UK F-gas emissions beyond the ambition of the F-gas Regulation and Kigali Amendment'.[116] Uplift of HFC GWPs to AR5 with Carbon Cycle Feedback values was taken from BEIS Methodology.

Assumptions on maximum technical potential for resources, waste, and F-gases in the 2050 scenarios are aligned with the sectoral evidence base for the pathway analysis.

Greenhouse Gas Removals

The engineered removals include the following technologies: Power Bionenergy with Carbon Capture and Storage (Power BECCS), Industry BECCS, Direct Air Carbon Capture and Storage (DACCS), and BECCS applications based on advanced gasification technologies (Hydrogen generation with waste, Hydrogen generation with biomass, Biofuels, Biogas, and Biomethane generation with CCS). Other engineered removals solutions, such as enhanced weathering, carbon-negative cements, ocean carbon sequestration and biochar have not been included in the modelling at this stage given the underlying uncertainty and need for further development.

The pathway was developed through a combination of bottom-up sectoral modelling, as well as UKTM whole-system modelling. The pathway analysis (including build rates, energy demand, and costs) relied on assumptions from published sources on BECCS and DACCS, alongside a benchmarking study commissioned by BEIS.[117, 118, 119, 120, 121] The study presented evidence based on an original review of the published literature, feedback received through the GGR Call for Evidence and additional stakeholder engagement.[122]

An investment lead-in time of four years is assumed for power BECCS, and five years for hydrogen BECCS and DACCS. Costs for power BECCS and hydrogen BECCS represent both the cost of generation (electricity/hydrogen) and of CO_2 removal. Power and hydrogen generation with BECCS are assumed to operate at baseload. DACCS is assumed to rely on low carbon energy inputs.

UKTM modelling for the 2050 scenarios uses the same technology assumptions as the pathway analysis where possible. In addition to the benchmarking study, assumptions on maximum technical potential and technology performance have been sourced from the sectoral models such as NZIP and from the Advanced Gasification Technology review.

Supporting the transition across the economy

Green Jobs, Skills and Industries

Skills evidence presented in the *Net Zero Strategy* is largely drawn from the work carried out by the Green Jobs Taskforce and found in the published Green Jobs Taskforce report.[123] The joint BEIS and DfE Ministerially led independent Taskforce included representatives from across business, trade unions and the skills/education sector and it was supported by a secretariat comprised of civil servants from BEIS and the DfE. The secretariat facilitated the drawing together of its evidence review and supported the Green Jobs Taskforce reviewing over 200 reports published by industry, academia, and government to form a robust evidence base upon which to build recommendations. The Annex published alongside the Green Jobs Taskforce brings together a wide range of information about how certain sectors, occupations, skills requirements and qualification levels (L)1 will change as the UK transitions to a net zero economy gathered by the secretariat.

Green Investment

Research referenced in the Green Investment chapter is drawn from external sources. This includes the Climate Change Committee's *The Road to Net Zero Finance*, which was a report prepared by the Advisory Group on Finance to critically assess the UK financial systems ability to deliver net zero.[124] This report provides an estimate for the total amount of capital investment needed in technologies to achieve net zero and therefore does not deliver a full picture of investment needs given the exclusion of operational costs.

Innovation for Net Zero

The published Energy Innovation Needs Assessments (EINAs) are the main source of evidence base underlying the innovation chapter.[125] It is a whole system analysis used in understanding the sectors and innovations of highest potential benefit to the UK energy system. The analysis is based on cost optimisation modelling carried with the Energy System Modelling Environment (ESME), and extensive engagement with industry to shape input assumptions and guide technical specifications. The EINAs are split into twelve reports, each covering a group of similar technologies and exploring their potential impacts and current barriers to their innovation and deployment. Overall, the EINAs aid understanding of where innovation can help achieve the largest energy system cost reductions and business opportunities when on a net zero trajectory.

GVA figures used in this publication have been updated internally by BEIS using the same EINA methodology to reflect increased net zero ambition, as original EINA publications were on the basis of the previous 80% greenhouse gas reduction target.

Local Climate Action

Analysis of local based decarbonisation policies is based on the Local Net Zero Model. The model takes assumptions from the ELENA programme, an EU fund which leverages public money for local based decarbonisation projects.[126] These assumptions include the expected level of private funding leveraged, energy savings of projects and additionality. The model estimates the public costs, private costs, carbon savings and energy savings of expected projects resulting from the programme.

Empowering the Public and Businesses to Make Green Choices

Much of the research contributing towards this chapter was part of BEIS' Net Zero Societal Change Research Programme 2020-21. Components of the research programme that have fed into this chapter include: 'Climate change and net zero: public awareness and perceptions' (an online survey of circa 7,000 members of the UK public on public perceptions of climate change and net zero); 'Net zero public dialogue' (online workshops with the public exploring their understanding and perceptions of net zero); 'Net Zero Societal Change Analysis Project' (analysis carried out by Energy Systems Catapult exploring the potential impact of different societal changes in reaching net zero); and a research note entitled 'Net zero public engagement and participation'.[127, 128, 129, 130]

Within the chapter, the 'Principles underpinning green public and business choices' section is drawn from 'Net zero: principles for successful behaviour change initiatives', a report BEIS commissioned from the Behavioural Insights Team.[131] The chapter also uses findings from BEIS' Public Attitudes Tracker surveys regarding people's concern about climate change.[132]

Cross-cutting assumptions

Fuel prices: Fossil fuel price assumptions are based on the BEIS Fossil Fuel Prices Assumptions 2020, with the exception of UKTIMES analysis which uses the BEIS Fossil Fuel Prices Assumptions 2016.[133]

Carbon values: Carbon values apply a monetary value to emissions in policy appraisal and are based on a target-consistent approach. The latest 2021 HMG carbon values are consistent with the UK's national and international climate commitments and represent an increase on previous values.[134] Where cost benefit analysis of the sixth carbon budget from the Impact Assessment is quoted, the 2018 carbon values were used. These are consistent with the previous 80% emissions reduction target. To compensate for subsequent increased climate ambition, the high rather than central 2018 carbon values were used in the cost benefit analysis.[135]

Economic growth and demography: The baseline for economic growth used for all analysis is consistent with the July 2020 OBR long term projections of economic growth.[136] When calculating the GDP carbon intensity and GDP energy intensity deployment assumptions, projections from the March 2021 Economic and fiscal outlook were used, for both short and long-term GDP forecasts.[137]

Air quality: Where air quality impacts have been quantified, they have been monetised in line with the national values of the most recent air quality damage costs.[138]

Discount rates: Discount rates are used in line with Green Book guidance.[139] For appraisal periods up to 2050 the discount rate is 3.5%. A 2% cumulative annual health uplift is applied to air quality benefits prior to discounting, effectively reducing the discount rate to 1.5%.

Estimating jobs: The estimate of jobs delivered since the *Ten Point Plan* announcement is based on internal HMG analysis of employment impacts across a range of policies and programmes within the 10 Points of the Plan. The method for estimating the number of jobs supported by *Net Zero Strategy* policies and proposals in 2025 and 2030 is as follows. This varies by sector and in some cases by the period of analysis.

Power: Analysis aggregates projected employment across Power Networks, Offshore wind, Onshore wind, Solar, and Storage and demand side flexibility, all based on BEIS analysis using the EINA methodology and the technology deployment levels implied by the indicative delivery pathway (see Table 11). The 2030 figure also includes 10,000 jobs (peak employment) from the construction of a large nuclear plant. These estimates are based on the number employed directly in the power sector technologies, with the exception of offshore wind, which also includes indirect (supply chain) jobs based on a multiplier of 1 direct job to 1 indirect job.

Fuel supply: The 2025 analysis is an estimate of potential employment by that year in a UK industry in Sustainable Aviation Fuels (SAF) (based on DfT analysis). The 2030 figure is an aggregation of anticipated employment by that year in SAF (based on DfT analysis), along with an estimate of potential employment in a UK hydrogen economy as set out in the Hydrogen Strategy.[140] This is based on BEIS analysis of an updated model from the Energy Innovation Needs Assessment.

Industry: Analysis relates to estimated employment in the UK in Carbon Capture Utilisation and Storage (CCUS), calculated using the Energy Innovation Needs Assessments approach and pro-rated for 2025 based on the anticipated trajectory for the level of carbon captured through CCUS over the decade. These are high-level estimates and actual outturn of employment will depend on several factors, although the jobs estimate is considered broadly consistent with stated government policy for the development of the technology. These estimates cover both power CCUS and CCUS for industrial purposes, but are included in the Industry chapter as the estimates do not directly overlap with any estimates included in the Power chapter.

Heat and Buildings: Analysis aggregates anticipated employment impacts from the decarbonisation of heating (calculated using an update of the *Energy Innovation Needs Assessments* applied to the deployment levels set out in Table 11) and total public and private spending on energy efficiency measures (based on BEIS analysis using a jobs/capex multiplier). These estimates are based on broad assumptions of the policy mix driving carbon savings from domestic buildings over the 2020s. As some of these policies are still not confirmed, there is large uncertainty over the exact timing and job numbers supported by them.

Transport: Both numbers are based on an aggregation of anticipated employment impacts from the Automotive Transformation Fund and the Advanced Propulsion Centre, along with anticipated levels of employment in active travel (cycling and walking), and rail decarbonisation. The active travel and rail decarbonisation estimates are based on DfT analysis of what policy ambitions for active travel and rail decarbonisation are likely to imply for employment in their respective sectors in these years.

Natural Resources, Waste and F-gases: These numbers relate exclusively to direct employment in the UK forestry sector and are based on Defra analysis. These estimates exclude indirect jobs, such as those supported in tourism, the wider forestry supply chain or local farming. Employment in forestry will be supported by policies such as the Nature for Climate Fund. This number does not include potential employment in other areas covered in the chapter such as peat restoration, sustainable agriculture or waste recycling.

Public and private investment estimates

Public investment figures in the strategy refer to sums of government spend committed to a relevant Budgets and Spending Reviews, unless otherwise stated. Private investment estimates are derived through analysis of how much private sector spend is likely to be leveraged from this public spend. Further public and private investment will be delivered as proposals are developed into firm policies. Analysis of the potential GVA generated by decarbonisation has been conducted for a subset of sectors: power, renewables, heat and buildings, industry, CCUS, hydrogen, smart systems and road transport. The analysis follows the methodology developed by Vivid Economics for the Energy Innovation Needs Assessment in 2019.[141] Where possible, it uses whole energy systems modelling to estimate domestic economic opportunities from achieving net zero in the UK in 2050 and, while export opportunities rely on a global scenario limiting global warming to two degrees Celsius above pre-industrial levels.

Endnotes

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[33] BEIS (2019), ‘Updated energy and emissions projections 2018’, Chapter 6 Uncertainty in emissions projections, 2019, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/794590/updated-energy-and-emissions-projections-2018.pdf

[34] IAS emissions increase the width of the range by 7.1mt on average over CB6, and the additional LULUCF emissions increase the width by 11.8 mt. Both ranges are symmetrical.

[35] Whilst sectors are characterised by different sources and magnitudes of uncertainty, we have made the simplifying assumption that uncertainty in 2020 is +3.7%/-3.5% in each sector, broadly in line with the economy wide average. The proportional up-/down-lift applied to produce the rage increases by +0.35%/-0.17% in each subsequent year, again in line with the economy wide average.

[36] AR5 without feedback modelling undertaken for Agriculture, F-gases, Fuel Supply, LULUCF and Waste. Heat & Buildings, International Aviation and Shipping, Industry, Power, Removals and Transport all contain very small amounts of non-CO2 gases and pathways are assumed invariant to GWP.

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Net Zero Strategy: Build Back Greener

Climate Science Annex

Climate Science Annex

Why we must act

Science is clear that the world is warming, that this is occurring because of human activity, and that left unchecked, continued warming would be deeply harmful, not just to the natural world, but also to human security and wellbeing. Global average temperatures have already risen by around 1.1°C[1] and 2020 concluded the earth's warmest 10-year period on record.[2] Without action to reduce the level of greenhouse gas (GHG) emissions emitted globally down to net zero, climate change is set to continue with increasing temperatures across the world.[3]

We are already seeing the impacts of climate change across all parts of the world, with many types of extreme weather becoming more frequent and more intense – causing droughts, wildfires and flooding.[4] The North American heatwave in June 2021, which broke temperature records by over 4°C and reached 49.6°C in Canada, would have been virtually impossible without climate change.[5] The melting of glaciers and ice sheets is accelerating, with sea levels currently rising at 3.7mm annually.[6] In the UK we can see a trend towards warmer and wetter winters, along with hotter summers.[7]

These changes are damaging the land and oceans that support human society and the natural environment. As a result, many species are being driven closer to extinction,[8] food supplies are being disrupted,[9] and the health and livelihood of people across the world are being affected.[10] Climate change disproportionally affects poor and disadvantaged people, with rural, coastal, and indigenous communities facing greater risks from impacts such as rising sea levels, drought, and food shortages.[11]

There is still uncertainty over the responsiveness of global temperatures to GHG emissions; the Intergovernmental Panel on Climate Change (IPCC) estimate that a doubling of pre-industrial CO_2 levels would result in warming in a range of 2.5°C – 4°C.[12] The higher that temperatures rise, the greater the risk of seeing dangerous low-likelihood, high-impact outcomes. These could include abrupt responses and tipping points such as dieback of the Amazon Rainforest, melting of the polar ice sheets, and the collapse of key ocean currents controlling global weather, which cannot be ruled out.[13, 14] To avoid these risks, strong and decisive action is needed to reduce GHG emissions. Limiting further warming decreases the likelihood of more severe and potentially irreversible impacts on people and ecosystems. Action would also provide other co-benefits, such as limiting the rate of ocean acidification and improving air quality. Every additional fraction of a degree of global warming counts – with every 0.5°C of warming there are clearly discernible increases in the intensity of and frequency of impacts.[15] This is why we should aim to reduce global emissions to net zero as quickly as is practically possible.[16]

Global temperature goals and emissions pathways

Rapid and deep cuts to emissions are essential to avoid the most dangerous impacts of climate change.[17] Greenhouse gas concentrations and global temperatures will continue to rise until we reduce GHG emissions to net zero.[18] In 2015 the Paris Agreement was signed, where 196 parties committed to hold “the increase in the global average temperature to well below two degrees above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change”. The Agreement recognised that, to achieve this goal, global emissions of greenhouse gases would need to peak as soon as possible, reduce rapidly thereafter, and reach a net zero level in the second half of this century.

As part of the Paris Agreement, countries also committed to reduce or limit their greenhouse gas emissions. These commitments are contained in their Nationally Determined Contributions (NDCs). A number of studies have assessed how close these commitments bring us to staying below two degrees.

It is worth noting that these assessments use different assumptions regarding both the extent to which countries will meet their NDCs and, crucially, the actions that will be taken by countries to reduce their emissions after 2030. The latter will be a key determinant of whether the world will meet the long-term global temperature goal.

The Climate Action Tracker (CAT)[19] estimates that if there were a continuation of the currently implemented global policies these set us on course for a global average temperature rise of 2.1°C to 3.9°C by the end of the century. But if currently pledged ambitions (i.e. those not yet implemented into tangible policies) are implemented this range decreases to 1.9°C to 3.0°C, with a mid-range estimate of 2.4°C. These estimates are also consistent with projections in the UN Environment Programme’s 2020 Emissions Gap Report.[20] Whilst these assessments show that current NDCs can have a significant impact on projected temperature rises, greater action is still needed if we are to limit global temperature increases to well below two degrees.

Adaptation in the UK

Responding to the complexity of climate change demands a multifaceted approach. Regardless of global success in reducing GHG emissions, some future temperature rises are already locked in by historical emissions up to the present day. Even the most optimistic, ambitious emission reduction scenarios suggest approximately 0.5°C of further warming by mid-century compared to the present day.[21] Furthermore, future global emissions pathways are highly uncertain, so it is essential that the UK’s adaptive capacity is rapidly developed to prepare for, and bolster our resilience to, the inevitable near-term and potential future impacts of climate change.

To prepare for these eventualities, the UK is already considering climate risks and what actions will be required through its five-yearly policy cycle of a Climate Change Risk Assessment followed by a National Adaptation Programme (NAP). The Government’s Third Climate Change Risk Assessment will be published in January 2022 and will outline Government views on the key risks and opportunities the UK will face from climate change. The Climate Change Committee’s 2021 Independent Assessment of UK Climate

Risk identified eight risk areas that will require the most urgent attention in the next two years.[22] These are applicable even if global warming is limited to 1.5°C.

- Risks to the viability and diversity of terrestrial and freshwater habitats and species from multiple hazards
- Risks to soil health from increased flooding and drought
- Risks to natural carbon stores and sequestration from multiple hazards leading to increased emissions
- Risks to crops, livestock and commercial trees from multiple hazards
- Risks to supply of food, good and vital services due to climate-related collapse of supply chains and distribution networks
- Risks to people and the economy from climate-related failure of the power system
- Risks to human health, wellbeing and productivity from increased exposure to heat in homes and other buildings
- Multiple risks to the UK from climate change impacts overseas

The NAP is a cross-department collaboration, bringing together government's policies on managing climate risks in one place. The second NAP sets out how we will address climate risks for the period 2018 to 2023, including risks to terrestrial, coastal, marine, and freshwater ecosystems, soils and biodiversity; and flooding and coastal change risks to communities, businesses and infrastructure.

Future developments in climate science

In recent years the debate and focus of scientific research has shifted from whether climate change is happening and/or is being caused by human activity, to the range of the expected impacts and the level of action required to address climate change through a combination of adaptation and mitigation. We need to better understand the nature, magnitude and rate of climate change. Preparing for unavoidable changes to the climate will require more local analysis and more information on how global warming relates to local-scale changes in weather and climate extremes. Further research is also needed around stronger mitigation actions to inform climate policy that can get us to net zero.

Our knowledge has increased significantly but many key research priorities remain, including deepening our understanding around the four questions Government posed to the Met Office this year.[23]

- What current weather and climate risks and impacts are expected globally and in the UK?
- What are the future risks and impacts from weather and climate that we need to avoid or need to adapt to?
- What are the carbon budget and mitigation scenarios that will avoid the most dangerous impacts of global climate change?
- What impacts and opportunities from mitigation and adaptation actions are needed to proceed towards a resilient and net zero future?

The UK has also recently committed £1.2 billion of funding to develop a new state-of-the-art supercomputer for the Met Office. This will help ensure government, industry and communities are better prepared for the impacts from a changing climate through increased amounts of data. Examples include the provision of very detailed localised climate information to improve city planning and public transport infrastructure.

Climate science continues to rapidly improve and develop. This year saw the publication of the Working Group I (WGI) contribution to the IPCC's Sixth Assessment Report (AR6). The report addresses the most up-to-date physical understanding of the climate system and climate change, bringing together the latest advances in climate science. WGII and WGIII contributions to AR6 will be published in 2022 and respectively cover the impacts of climate change on people and nature, and the options for reducing GHG emissions and removing GHG from the atmosphere.

The main conclusions of WGI are a reinforcement of the consensus on climate science: that there is absolutely no doubt that human activities have warmed the planet and are causing widespread and rapid changes to the climate. Without immediate and drastic action, the impacts will be more severe and frequent. It shows that we are already feeling the effects of climate change and know that some changes to the planet are already irreversible on timescales of centuries to millennia. However, with immediate, concerted action to reduce emissions now, the worst impacts can still be averted. Technologies to remove CO_2 directly from the atmosphere or ocean can also help, but to adhere to the temperature goal of the Paris Agreement ambitious action on emission reductions is still required, and is needed today.

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ENERGY WHITE PAPER

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TOGETHER FOR OUR PLANET

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Powering our Net Zero Future

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by the Secretary of State for Business, Energy and Industrial Strategy
by Command of Her Majesty

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ENERGY WHITE PAPER

Ministerial foreword

The government presents this white paper at a time of unprecedented peacetime challenge to our country.

Coronavirus has taken a heavy toll on our society and on our economy. But we will overcome COVID-19 and rebuild our economy, building back better and levelling up the country.

As we do so, we must address the inter-generational challenge of climate change. Unchecked, the impact of rising global temperatures represents an existential threat to the planet. So, building back better means building back greener.

The UK has set a world–leading net zero target, the first major economy to do so, but simply setting the target is not enough – we need to achieve it. Failing to act will result in natural catastrophes and changing weather patterns, as well as significant economic damage, supply chain disruption and displacement of populations.

Tackling climate change will require decisive global action and significant investment and innovation by the public and private sectors, creating whole new industries, technologies, and professions.

But fighting climate change offers huge opportunity for both growth and job creation. The global markets for low-carbon technologies, electric vehicles and clean energy are fast growing: zero emission vehicles could support 40,000 jobs by 2030, with exports of new technologies such as CCUS having the potential to add £3.6 billion GVA by 2030. The time is now to seize these opportunities.

This white paper puts net zero and our effort to fight climate change at its core, following the Prime Minister’s Ten Point Plan for a Green Industrial Revolution. The Ten Point Plan sets out how government investment will leverage billions of pounds more of private investment and support up to 250,000 jobs by 2030.

This includes building on our leadership in offshore wind to target 40GW by 2030 – enough to power every home in the UK – which alone will support up to 60,000 jobs.

The way we produce and use energy is therefore at the heart of this. Our success will rest on a decisive shift away from fossil fuels to using clean energy for heat and industrial processes, as much as for electricity generation.

These are more than academic considerations; the shift to net zero will affect us all. This white paper presents a vision of how we make the transition to clean energy by 2050 and what this will mean for us as consumers of energy in our homes and places of work, or for how businesses use energy to produce goods and services.

It sets out the changes which will be required. We will reduce emissions through shifting from gas to electricity to heat our homes and by better insulating the buildings in which we live and work. We will end the sale of petrol and diesel cars and vans, and accelerate the transition to clean, zero tailpipe emission vehicles. We will start to capture carbon emissions from power generation and from industry. And we will switch to new, clean fuels such as hydrogen for heat, power and industrial processes.

As we leave fossil fuels behind us and increasingly rely on clean electricity, our experiences as energy consumers will be very different. Smart technologies are revolutionising how we can engage the market. Smart meters and a range of smart appliances, backed by new smart tariffs, will give us control about how we use energy and help us manage our bills – running the washing machine or charging the electric vehicle when demand is low and electricity is cheap, even selling surplus power back to the grid at a profit.

And we will do this with affordability at the front of our minds. The costs of renewables have fallen sharply over the last five years. Offshore wind prices in renewable Contracts for Difference auctions have fallen from £120/MWh in 2015 to around £40/MWh in last year's auction.

Greater competition and more innovation will drive down the costs of our energy system even further. We expect energy companies to ensure that the benefits of a more efficient system result in a fair deal for consumers. Where we use taxpayers' money to fund the transition to clean energy, we will leverage private capital as much as we can.

Across the board, as a result of our polices, energy bills will remain affordable over the 2020s. A major push on improving the energy efficiency of our homes will mean households can significantly reduce demand and save money on their bills.

We understand the effect that COVID-19 has had on household incomes, and therefore commit to protecting those who are particularly vulnerable. Lower income households can receive up to £10,000 to improve the energy efficiency of their homes via the Green Homes Grant scheme, saving up to £600 each year on bills on average. Through this white paper, we are expanding the Warm Home Discount to around three million homes to provide £150 a year off electricity bills, representing £1.9 billion of extra support for households in fuel poverty. This builds on the Ten Point Plan's commitment to extend the Energy Company Obligation to 2026.

This is an ambitious domestic agenda on which we will also seek to secure equally ambitious international action, through the UK's presidency of COP26, the UN's climate conference being held in Glasgow in November 2021. The actions we take as a result of this white paper, as part of our wider climate agenda, are intended to show leadership and vision and demonstrate to our partners around the world that now is the time to take the bold steps to tackle climate change. The UK is leading from the front in the transition to clean energy, while ensuring that we leave no one behind as we build back greener.

Rt Hon Alok Sharma MP
Secretary of State for Business,
Energy and Industrial Strategy

INTRODUCTION

We are on the cusp of a global Green Industrial Revolution.

The Prime Minister's Ten Point Plan has set out the measures that will help ensure the UK is at the forefront of this revolution, just as we led the first over two centuries ago.

As nations move out of the shadow of coronavirus and confront the challenge of climate change with renewed vigour, markets for new green products and services will spring up round the world. Taking action now will help ensure not just that we end our contribution to climate change by achieving our target of net zero emissions. It will help position UK companies and our world class research base to seize the business opportunities which flow from it, creating jobs and wealth for our country.

Following on from the Ten Point Plan and the National Infrastructure Strategy, the Energy White Paper provides further clarity on the Prime Minister's measures and puts in place a strategy for the wider energy system that:

- **Transforms energy**, building a cleaner, greener future for our country, our people and our planet
- **Supports a green recovery**, growing our economy, supporting thousands of green jobs across the country in new green industries and leveraging new green export opportunities
- **Creates a fair deal for consumers,** protecting the fuel poor, providing opportunities to save money on bills, giving us warmer, more comfortable homes and balancing investment against bill impacts

THE COMPELLING CASE FOR TACKLING CLIMATE CHANGE

We are reminded on a daily basis why we need this Green Industrial Revolution: climate change is having a real effect on our planet.

The melting of glaciers and ice sheets is accelerating, contributing to rising sea levels across the globe, with melting rates of ice sheets in Greenland and Antarctica matching the Intergovernmental Panel on Climate Change's worst-case climate warming scenarios.[1] All ten of the warmest years in the UK's temperature record have taken place since 2002.[2] Rainfall over Scotland is up 10 per cent from the start of the 20th century.[3] The record-breaking European summer heatwave of 2003 resulted in at least 70,000 deaths across the continent,[4] and such heatwaves are projected to become the norm in the UK by the 2040s at current rates of warming.[5]

We need to act urgently. The future impacts of climate change depend upon how much we can hold down the rising global temperature. To minimise the risk of dangerous climate change, the landmark Paris Agreement of 2015 aims to halt global warming at well below 2°C, while pursuing efforts to limit it to 1.5°C, increasing measures to adapt to climate change, and aligning financial systems to these goals.[6]

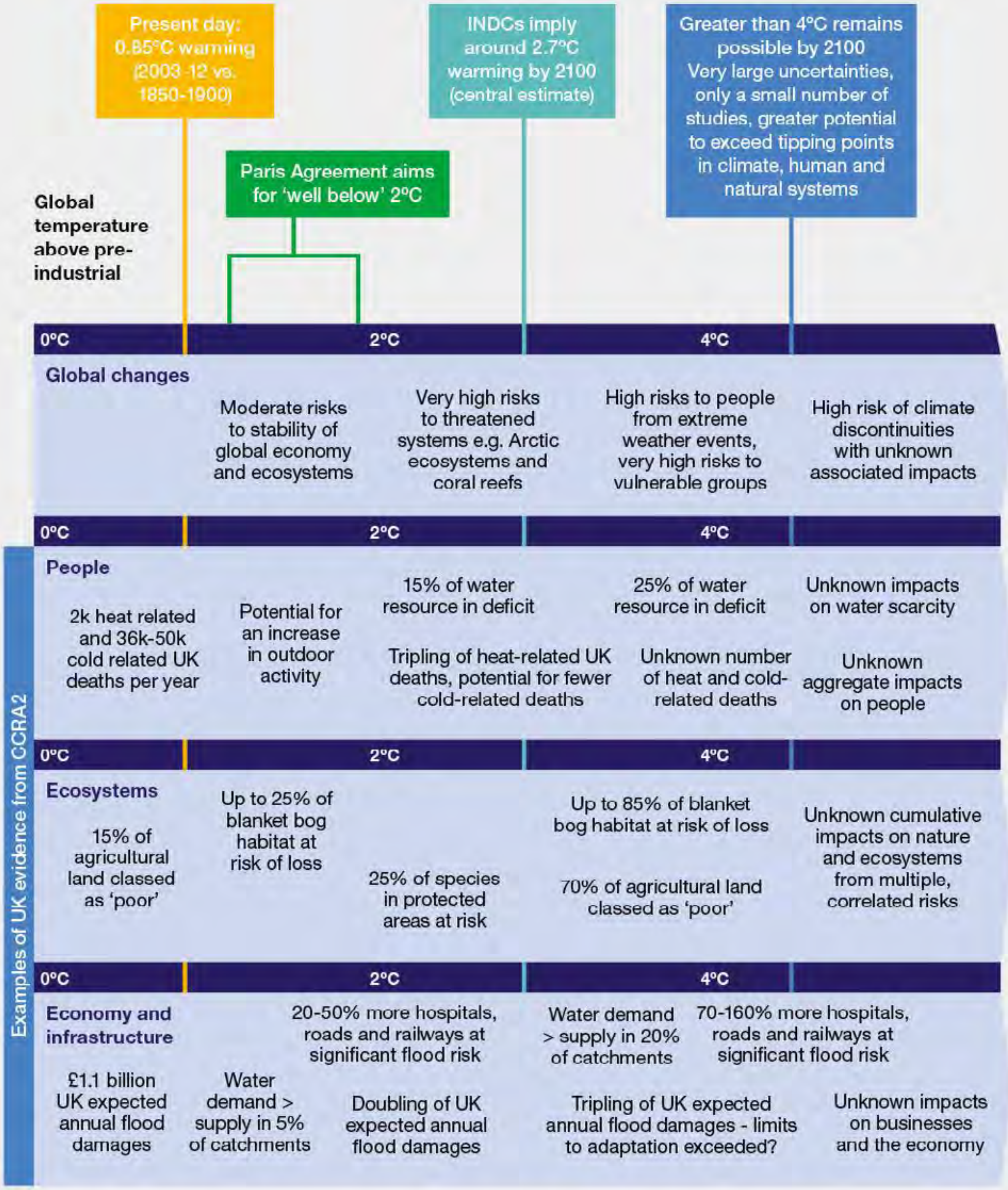
At the global scale, however, we are not presently on track to reach the temperature goal of the Paris Agreement. Based on current national pledges, and assuming the level of ambition does not change, the world is heading for around 3°C of warming by the end of the century.[7]

The cost of inaction is too high.[8] We can expect to see severe impacts under 3°C of warming. Globally, the chances of there being a major heatwave in any given year would increase to about 79 per cent, compared to a five per cent chance now.[9] Many regions of the world would see what is now considered a 1-in-100-year drought happening every two to five years.[10]

At 3°C of global warming, the UK is expected to be significantly affected, seeing sea level rise of up to 0.83 m.[11] River flooding would cause twice as much economic damage and affect twice as many people, compared to today,[12] while by 2050, up to 7,000 people could die every year due to heat, compared to approximately 2,000 today.[13] And, without action now, we cannot rule out 4°C of warming by the end of the century, with real risks of higher warming than that.[14] A warming of 4°C would increase the risk of passing thresholds that would result in large scale and irreversible changes to the global climate, including large-scale methane release from thawing permafrost and the collapse of the Atlantic Meridional Overturning Circulation.[15] The loss of ice sheets could result in multi-metre rises in sea level on time scales of a century to millennia.[16]

To meet the temperature goal of the Paris Agreement, the world must collectively and rapidly reduce global emissions to net zero over the next 30 years. Success will mean we are less exposed to flood and heat risks and preserve our national security, our prosperity, and our natural world which are threatened by the global disruption of climate change.

FIGURE 1.1 – IMPACTS OF INCREASING TEMPERATURES ON UK [17]



Present day: 0.85°C warming (2003-12 vs. 1850-1900)

Paris Agreement aims for 'well below' 2°C

INDCs imply around 2.7°C warming by 2100 (central estimate)

Greater than 4°C remains possible by 2100 Very large uncertainties, only a small number of studies, greater potential to exceed tipping points in climate, human and natural systems

Global changes

Moderate risks to stability of global economy and ecosystems

Very high risks to threatened systems e.g. Arctic ecosystems and coral reefs

High risks to people from extreme weather events, very high risks to vulnerable groups

High risk of climate discontinuities with unknown associated impacts

People

2k heat related and 36k-50k cold related UK deaths per year

Potential for an increase in outdoor activity

15% of water resource in deficit

Tripling of heat-related UK deaths, potential for fewer cold-related deaths

25% of water resource in deficit

Unknown number of heat and cold-related deaths

Unknown impacts on water scarcity

Unknown aggregate impacts on people

Ecosystems

15% of agricultural land classed as 'poor'

Up to 25% of blanket bog habitat at risk of loss

25% of species in protected areas at risk

Up to 85% of blanket bog habitat at risk of loss

70% of agricultural land classed as 'poor'

Unknown cumulative impacts on nature and ecosystems from multiple, correlated risks

Economy and infrastructure

£1.1 billion UK expected annual flood damages

Water demand > supply in 5% of catchments

20-50% more hospitals, roads and railways at significant flood risk

Doubling of UK expected annual flood damages

Water demand > supply in 20% of catchments

Tripling of UK expected annual flood damages - limits to adaptation exceeded?

70-160% more hospitals, roads and railways at significant flood risk

Unknown impacts on businesses and the economy

Source: CCC CCRA 2017

OUR DOMESTIC AGENDA

As we tackle climate change, we will have the interests of consumers at the front of our mind, now and for future generations.

We are committed to ensuring that the cost of the transition to net zero is fair and affordable. We have consistently balanced spending on measures that decarbonise the energy system with the need to help consumers save money on their bills. Thanks to early investment, many low-carbon technologies are now cheaper than their fossil fuel counterparts.

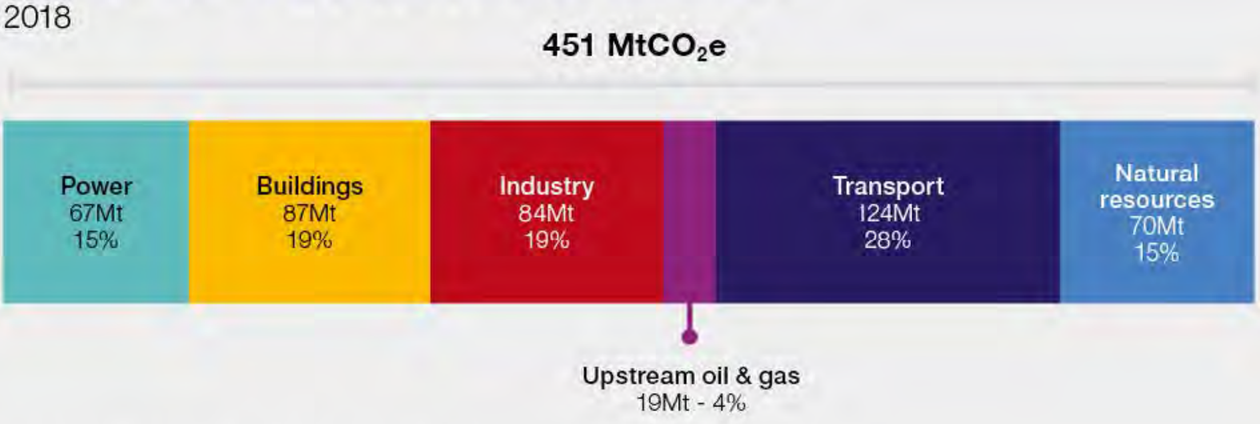
Our vision is of a system with consumers at its heart, able to make money or save on bills through using the new technologies net zero will require. So our approach means not just deploying measures that save energy and reduce bills, but also ensuring the energy system is fit for a net zero world, making markets efficient, incentivising people to move to clean energy solutions, or making sure system rules are agile and flexible to accommodate new technologies and new ways of doing things.

But affordability does not mean compromising our ambition. Achieving our 2050 goal requires action across the economy. The measures in this white paper will reduce emissions from power, buildings, industry, upstream oil and gas, and address the implications for the energy system of electrifying surface transport. We will publish our wider Transport Decarbonisation Plan in the spring.

Action on energy will be consistent with our wider environmental commitments, as we balance new technologies and the need for new infrastructure with protecting the environment, including air quality. Our 25 Year Environment Plan aims to improve the environment within a generation. Through the Environment Bill, we are placing this ambitious set of proposals on a legal footing, including a commitment to bring forward new legally binding environmental targets (on air quality, biodiversity, water, and resource efficiency and waste reduction) by October 2022.

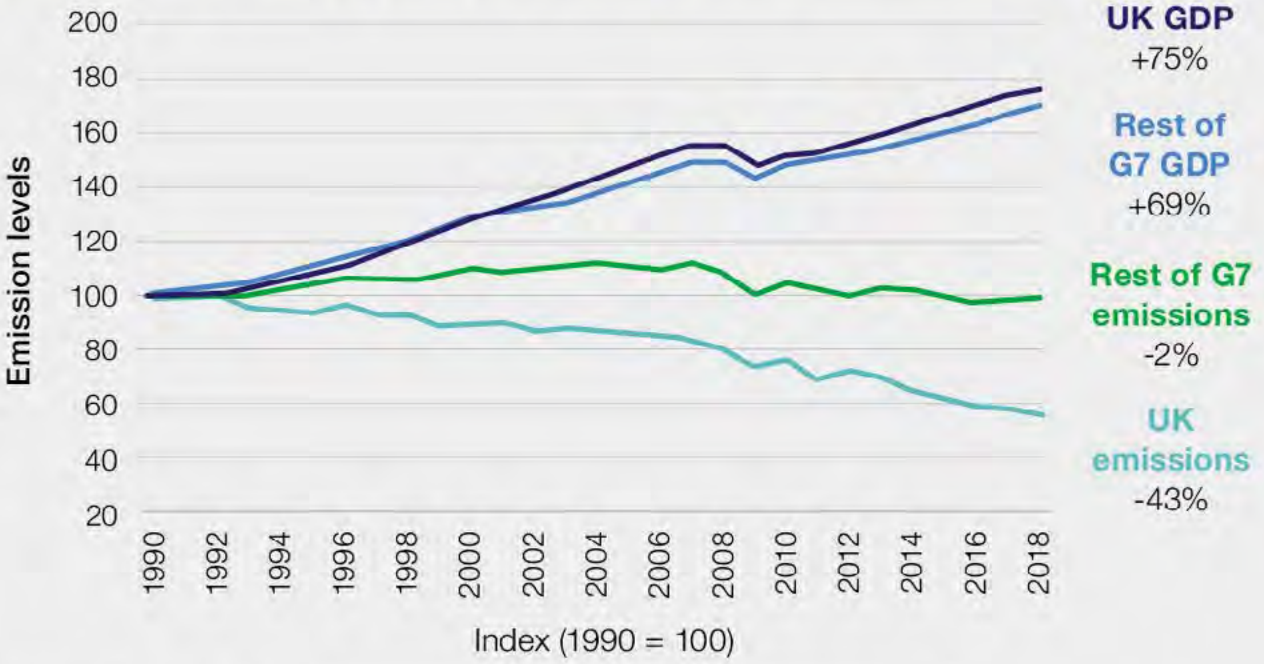
FIGURE 1.2 – UK TERRITORIAL EMISSIONS

2018



Source: BEIS Analysis of 'Final UK GHG emissions national statistics' and NAEI

FIGURE 1.3 – UK VS REST OF G7 GDP AND EMISSIONS



Source: World Bank, UNFCCC National Inventory Submissions, ONS, BEIS Greenhouse Gas Inventory 1990-2018.

Our National Adaptation Programme, which was updated in 2018, sets out the actions which the government is, and will be taking, to address the risks and opportunities posed by climate change in response to the Climate Change Risk Assessment. This includes a dedicated chapter on infrastructure, including actions to build the energy sector's resilience to climate change.

No one doubts the challenge of achieving net zero emissions, but the UK is able to build on 30 years of successfully reducing emissions while simultaneously growing our economy. Between 1990 and 2018, emissions fell by 43 per cent while GDP rose by 75 per cent, with the UK decarbonising faster than any other G20 country since 2000 (Figure 1.3).[18]

Energy has led the way. In 2019, greenhouse gas emissions ($MtCO_2e$) from electricity generation were down 13 per cent on 2018 levels and 72 per cent lower than 1990 levels,[19] as we have switched from coal to gas and renewable power together with the continued contribution of nuclear. In April 2017, the UK experienced its first coal free day since the industrial revolution. From April to June 2020, the total coal-free period lasted 67 days.[20]

Over the past decade, and with government support, the amount of renewable capacity connected to the grid has increased from 8GW in 2009 to 48GW at the end of June this year, an increase of 500 per cent.[21] The share of low-carbon electricity generation has risen to 54 per cent in 2019, with renewables at a record 37 per cent.[22]

Through a mix of early policy action, increased competition, innovation, and growth in deployment, our sustained support for clean electricity has helped secure dramatic falls in the costs of some renewables and provided developers and private investors with long term certainty.

The cost of offshore wind projects contracted in 2019 fell by 30 per cent for example, relative to those contracted in 2018.[23] There are even early signs of some renewable technologies deploying without direct policy support.[24]

But there is still much more to do. Our energy system is dominated by the use of fossil fuels and will need to change dramatically by 2050 if we are to achieve net zero emissions (see figure 1.4).

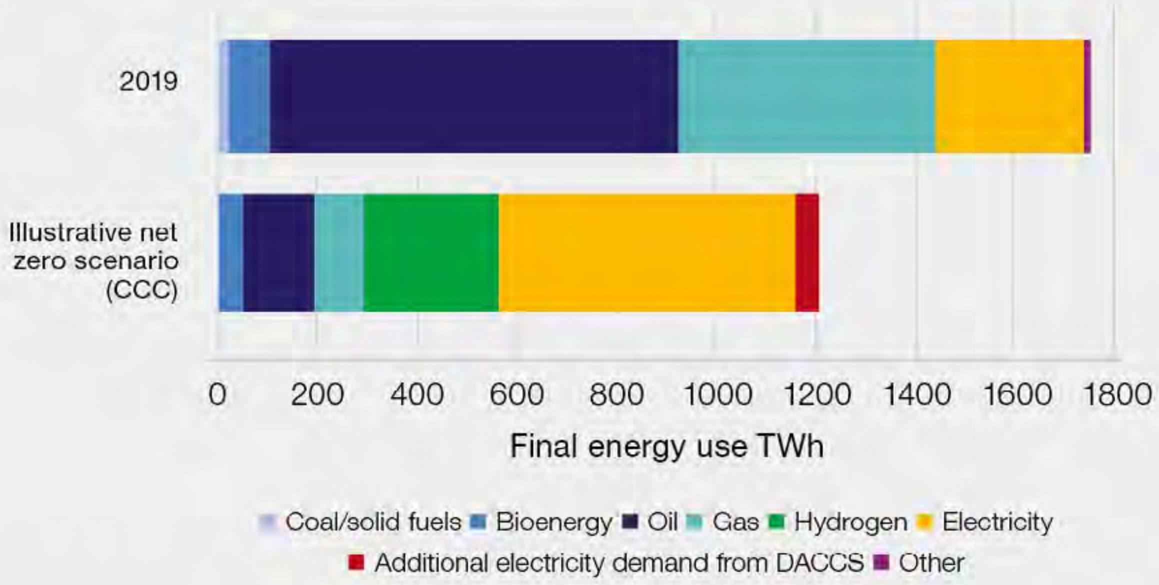
Decarbonising the energy system over the next thirty years means replacing - as far as it is possible to do so - fossil fuels with clean energy technologies such as renewables, nuclear and hydrogen.

30 **years of successfully reducing UK emissions** while simultaneously growing our economy

500% **increase in the amount of renewable capacity** connected to the grid from 2009 to 2020

72% **reduction in greenhouse gas emissions** from electricity generation between 1990-2019

FIGURE 1.4 – ILLUSTRATIVE UK FINAL ENERGY USE IN 2050



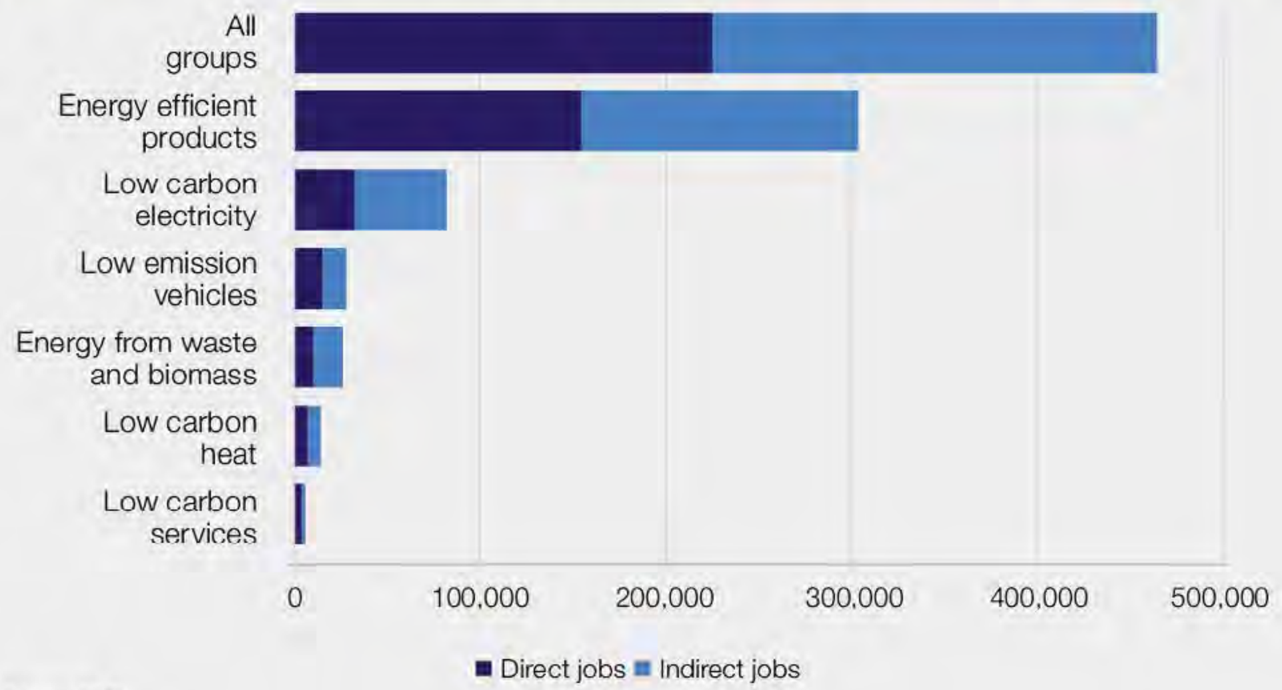
Source: Energy Trends table 1.2; CCC Net Zero Report

This is a significant and historic undertaking. It means ending our dependency on oil to power nearly half of our economy. It means largely eliminating the use of natural gas to heat our homes, and make them considerably more efficient – but as 20 per cent of homes currently overheat even in cool summers we will need to ensure that our homes are not just efficient, but adapted to the future climate.[25] This will apply throughout the system.

Clean electricity will become the predominant form of energy, entailing a potential doubling of electricity demand and consequently a fourfold increase in low-carbon electricity generation. We must secure this transition while retaining the essential reliability, resilience and affordability of our energy, as the bedrock of a modern, productive economy driving almost every facet of our home and working lives.

Delivering this transition will require billions of pounds of investment in clean energy infrastructure or new low-carbon technologies, and a major shift away from spending in fossil fuels. As set out in the National Infrastructure Strategy,[26] delivering this volume of private investment will require multiple policy levers and the right market frameworks to encourage competition and drive down costs. This challenge is set against the backdrop of an economy which has been hit by the largest recession in 300 years as a result of the COVID-19 pandemic. Our commitments to new and improved buildings, infrastructure and energy sources will support near-term investment and jobs in the UK. It will also establish world-leading capabilities in the new technologies which will be needed globally to tackle climate change, growing our capability to trade UK expertise around the world.

FIGURE 1.5 – LOW CARBON & RENEWABLE ENERGY EMPLOYMENT



Source: ONS

Across the UK almost half a million people are already employed in the low-carbon economy and its supply chains (Figure 1.5).[27] These jobs are frequently outside the South East of England, including electric vehicle manufacturing in the Midlands and North East, and reconditioning and recycling in the North East and West Midlands. The offshore wind sector supports an estimated 7,200 direct jobs as a whole, with a burgeoning industry on the north east coast of England, centred around the Humber and the Tees.

But this is just the beginning. In November 2020, the Prime Minister announced his Ten Point Plan to lay the foundations for a Green Industrial Revolution. We will start by supporting 90,000 jobs across the UK in this Parliament, and up to 250,000 by 2030. The response to the pandemic has been a reminder of the excellence of British science, a research and development (R&D) capability which engineers, fitters, construction workers and many others will harness to develop the clean energy technologies of the future and forge new industries to service new markets at home and abroad.

We will generate new clean power with offshore wind farms, nuclear plants and by investing in new hydrogen technologies. We will use this energy to carry on living our lives, running our cars, buses, trucks and trains, ships and planes, and heating our homes while keeping bills low. And to the extent that we still emit carbon, we will pioneer a new British industry dedicated to its capture and return to under the North Sea. Together these measures will reinvigorate our industrial heartlands, creating jobs and growth, and pioneering world-leading SuperPlaces that unite clean industry with transport and power.

THE PRIME MINISTER’S TEN POINT PLAN

GREEN PUBLIC TRANSPORT, CYCLING AND WALKING

We will accelerate the transition to more active and sustainable transport by investing in rail and bus services, and in measures to help pedestrians and cyclists. We will fund thousands of zero-emission buses and give our towns and cities cycle lanes worthy of Holland.

HYDROGEN

Working with industry the UK is aiming for 5GW of low-carbon hydrogen production capacity by 2030. We are also pioneering hydrogen heating trials, starting with a Hydrogen Neighbourhood and scaling up to a potential Hydrogen Town before the end of this decade.

NUCLEAR POWER

Nuclear power provides a reliable source of low-carbon electricity. We are pursuing large-scale nuclear, whilst also looking to the future of nuclear power in the UK through further investment in Small Modular Reactors and Advanced Modular Reactors.

OFFSHORE WIND

By 2030 we plan to quadruple our offshore wind capacity so as to generate more power than all our homes use today, backing new innovations to make the most of this proven technology and investing to bring new jobs and growth to our ports and coastal regions.

JET ZERO AND GREEN SHIPS

By taking immediate steps to drive the uptake of sustainable aviation fuels, investments in R&D to develop zero-emission aircraft and developing the infrastructure of the future at our airports and seaports, we will make the UK the home of green ships and planes.

GREENER BUILDINGS

Making our buildings more energy efficient and moving away from fossil fuel boilers will help make people’s homes warm and comfortable, whilst keeping bills low. We will go with the grain of behaviour, and set a clear path that sees the gradual move away from fossil fuel boilers over the next fifteen years as individuals replace their appliances and are offered a lower carbon, more efficient alternative, supporting 50,000 jobs.

CARBON CAPTURE, USAGE & STORAGE (CCUS)

Our ambition is to capture 10Mt of carbon dioxide a year by 2030 - the equivalent of four million cars’ worth of annual emissions. We will invest up to £1 billion to support the establishment of CCUS in four industrial clusters, creating ‘SuperPlaces’ in areas such as the North East, the Humber, North West, Scotland and Wales. We will bring forward details in 2021 of a revenue mechanism to bring through private sector investment into industrial carbon capture and hydrogen projects via our new business models to support these projects.

PROTECTING OUR NATURAL ENVIRONMENT

We will safeguard our cherished landscapes, restore habitats for wildlife in order to combat biodiversity loss and adapt to climate change, all whilst creating green jobs.

ZERO EMISSION VEHICLES

From 2030 we will end the sale of new petrol and diesel cars and vans, 10 years earlier than planned, and provide a £2.8 billion package of measures to support industry and consumers to make the switch to cleaner vehicles.

GREEN FINANCE AND INNOVATION

We have committed to raising total R&D investment to 2.4 per cent of GDP by 2027 and in July 2020 published the UK Research and Development Roadmap. The next phase of green innovation will help bring down the cost of the net zero transition, nurture the development of better products and new business models, and influence consumer behaviour.

LEADING GLOBAL ACTION

The UK accounts for less than one per cent of annual global emissions.[28] We therefore need to help other nations reduce their emissions in line with the Paris Agreement.

Our leadership is based on taking practical domestic action, which in turn creates business opportunities for the UK to export clean technology, skills and know-how.

We use our international partnerships and work through multilateral fora to influence international agreements on climate change and clean energy issues which help reinforce our domestic and international priorities. The principal vehicle we work through is the United Nations Framework Convention on Climate Change (UNFCCC), which delivered the Paris Agreement.

We will continue to demonstrate international leadership by building on the policies set out in the UK's National Energy and Climate Plan (NECP) and a number of other publications. This white paper goes even further than the ambitions set out in the NECP for renewables and energy efficiency.

Our presidency of the UN Climate Change Conference of the Parties (COP26), which will meet in Glasgow in November 2021, provides the opportunity to drive further ambitious action on climate change and unite the world on a path to a net zero economy, including through our COP26 Energy Transition Campaign and co-leadership of the Powering Past Coal Alliance.

Around 120 countries are committed to, developing plans or advancing consultations on **long-term climate or carbon neutral targets**

We are already seeing encouraging signs. In March, the European Union (EU) Commission proposed the first European Climate Law, which would commit the EU to achieving net zero greenhouse gas (GHG) emissions by 2050. In September, China announced that it would achieve carbon neutrality by 2060 and enhance its 2030 Nationally Determined Contribution (NDC). In October, both Japan and South Korea committed to achieving net zero by 2050. And thanks to the efforts of the UK, the EU, and other nations, there are now around 120 countries that are committed to, are developing plans or advancing consultations on long-term climate or carbon neutral targets.[29]

The countries delivering on these commitments will need to radically change their energy, transport, buildings and land use sectors. By driving forward UK action now, we can build companies that can win the lion's share of these new global markets in the future.

WHAT THE WHITE PAPER DELIVERS – AND BEYOND

This white paper builds on the Prime Minister's Ten Point Plan to set the energy-related measures the Plan announced in a long-term strategic vision for our energy system, consistent with net zero emissions by 2050.

It establishes our goal of a decisive shift from fossil fuels to clean energy, in power, buildings and industry, while creating jobs and growing the economy and keeping energy bills affordable. It addresses how and why our energy system needs to evolve to deliver this goal. And it provides a foundation for the detailed actions we will take in this Parliament to realise our vision.

We estimate the measures in this paper could reduce emissions across power, industry and buildings by up to 230MtCO$_2$e in the period to 2032 and enable further savings in other sectors such as transport. In doing so, they will support up to 220,000 jobs per year by 2030. These figures include the energy measures from the Prime Minister's Ten Point Plan as well as additional measures provided in this white paper.[30]

We recognise that more will need to be done to meet key milestones on the journey to net zero, including our ambition for Carbon Budget 6, which we will set next year, taking into account the latest advice from the Climate Change Committee. In the run-up to COP26 we will bring forward a series of sectoral strategies, and our overarching Net Zero Strategy, which will set out more detail on how we will meet our net zero target and ambitious carbon budgets.

FIGURE 1.6 – ESTIMATED CUMULATIVE EMISSION SAVINGS TO 2032 FROM THE ENERGY WHITE PAPER

Source: BEIS analysis

Overview of key commitments

This white paper sets out the government's policies and commitments that will put us on course to net zero, levelling up the country and strengthening the union as we achieve this goal. We will:

TRANSFORM ENERGY

Building a cleaner, greener future for our country, our people and our planet, by measures including:

- **Targeting 40GW of offshore wind by 2030**, including 1GW floating wind, alongside the expansion of other low-cost renewables technologies.
- **Supporting the deployment of CCUS in four industrial clusters** including at least one power CCUS project, to be operational by 2030 and putting in place the commercial frameworks required to help stimulate the market to deliver a future pipeline of CCUS projects.
- **Establishing a new UK Emissions Trading System**, aligned to our net zero target, giving industry the certainty they need to invest in low-carbon technologies.
- **Aiming to bring at least one large-scale nuclear project to the point of Final Investment Decision** by the end of this Parliament, subject to clear value for money and all relevant approvals.
- **Consulting on whether it is appropriate to end gas grid connections to new homes being built from 2025**, in favour of clean energy alternatives.
- **Growing the installation of electric heat pumps**, from 30,000 per year to 600,000 per year by 2028.
- **Building world-leading digital infrastructure for our energy system** based on the vision set out by the independent Energy Data Taskforce, publishing the UK's first Energy Data Strategy in spring 2021, in partnership with Ofgem.

SUPPORT A GREEN RECOVERY FROM COVID-19

Growing our economy, supporting thousands of green jobs across the country in new green industries and creating new export opportunities, by measures including::

- **Increasing the ambition in our Industrial Clusters Mission four-fold**, aiming to deliver four low-carbon clusters by 2030 and at least one fully net zero cluster by 2040.

- **Investing £1 billion up to 2025 to facilitate the deployment of CCUS in two industrial clusters** by the mid-2020s, and a further two clusters by 2030, supporting our ambition to capture 10MtCO$_2$ per year by the end of the decade.
- Working with industry, **aiming to develop 5GW of low-carbon hydrogen production capacity by 2030**.

CREATING A FAIR DEAL FOR CONSUMERS

Protecting the fuel poor, providing opportunities to save money on bills, giving us warmer, more comfortable homes and balancing investment against bill impacts, by measures including:

- **Creating the framework to introduce opt-in switching**, consulting by March 2021 on how it should be designed, tested and incrementally scaled up.
- **Considering how the current auto-renewal and roll-over tariff arrangements could be reformed** to facilitate greater competition, consulting by March 2021 on how opt-out switching could be tested as part of any future reforms.
- **Assessing what market framework changes may be required to facilitate the development and uptake of innovative tariffs and products** that work for consumers and contribute to net zero, engaging with industry and consumer groups throughout 2021 before a formal consultation.
- **Ensuring the retail market regulatory framework adequately covers the wider market**, consulting by spring 2021 on regulating third parties such as energy brokers and price comparison websites.
- **Establishing the Future Homes Standard** which will ensure that all new-build homes are zero carbon ready.
- **Consulting on regulatory measures to improve the energy performance of homes**, and are consulting how on how mortgage lenders could support homeowners in making these improvements.
- **Requiring that all rented non-domestic buildings will be Energy Performance Certificate (EPC) Band B by 2030**, barring lawful exceptions.
- **Extending the Energy Company Obligation to 2026** and expanding the Warm Home Discount to £475 million per year from 2022 to 2025/2026.

In addressing these issues we respect the devolution settlements with Scotland, Wales and Northern Ireland. All proposals in this white paper which touch on devolved matters will be progressed in accordance with those settlements.

CHAPTER 01

Consumers

OUR GOAL

We are committed to making the right reforms that will protect the interests of consumers and create opportunities to reduce bills and carbon emissions.

In partnership with the Office of Gas and Electricity Markets (Ofgem), we will:

- Create a **fair deal for consumers**
- **Protect the fuel poor**
- Provide **opportunities to make savings** on energy bills

CONSUMERS

The strategic context

Energy is integral to everything we do, from work, to travel, to leisure, to just relaxing at home. Whether it be for heating and lighting our homes or powering appliances, we all rely on secure, affordable energy every day. But the way we use energy in the home is changing.

Smart technologies, enabled by our increasingly digital world, offer new products and services which help us to take control of our energy use and reduce bills. And, over the next 30 years, electricity will become a significant proportion of the energy we use at home, powering electric cars, replacing petrol and diesel, and enabling the installation of electric heat pumps which reduce the need for oil and gas to heat our homes.

Over the next 30 years, **electricity will become a significant proportion of the energy we use**

This transformation of energy in our homes will only accelerate over the coming decade. The government and Ofgem have an important role to play, making regulatory reforms which place fairness and affordability at the heart of our efforts to protect the interests of consumers and create opportunities to save money.

This means:

- **Creating a fair deal for consumers.** We will increase competition throughout the energy retail market to benefit consumers and, as we transition to net zero, we will make sure the costs of doing so are distributed fairly;
- **Protecting the fuel poor.** We will offer additional protections to the vulnerable and fuel poor, through our Energy Company Obligation (ECO) and expanded Warm Home Discount (WHD) schemes and the Green Homes Grant, providing financial support of at least £6.7 billion over the next six years (see 'Buildings' chapter);
- **Providing opportunities to make savings on energy bills.** We will create opportunities for consumers to reduce bills and carbon emissions by upgrading the energy performance of homes (see 'Buildings' chapter), switching to clean energy, or using energy when it is cheapest thanks to smart technology.

SMARTER, CLEANER ENERGY FOR ALL CONSUMERS

Traditionally, households have been passive consumers of energy from fossil fuels.

Smart technology is unlocking new opportunities to give consumers more control, choice and flexibility over their energy use. We are seeing retail offers that will help consumers engage in the market and save money in the process.

SMART METERS

Smart meters are replacing traditional gas and electricity meters in homes and small businesses across Great Britain as part of an essential infrastructure upgrade to make the energy system more efficient and flexible, helping to deliver net zero emissions cost-effectively.

Smart meters are also modernising energy services by ending manual meter readings, delivering accurate bills and enabling prepayment customers to conveniently track their usage and top-up credit without leaving home. The In-Home Display (IHD), which households are offered when they have smart meters installed, gives accurate information about energy consumption and costs so consumers can easily understand how to save money on their bills.

The real-time information about energy use, recorded by smart meters, ensures that consumers are accurately charged by their suppliers. Smart meters also enable consumers to access innovative solutions such as smart tariffs, including 'time of use' tariffs. These tariffs reward consumers financially for using less electricity at peak times of demand or using more when overall demand is low and there is surplus generation available, for example on a sunny or windy weekend. This can reduce the cost of using clean electricity to power homes, businesses and electric vehicles, making the system more efficient and saving consumers money.

SMART TARIFFS

Smart tariffs include: tariffs where costs vary by the time of use, based on the cost of electricity; export tariffs, for those with generation technology such as solar panels; load control tariffs that can manage when appliances are used to ensure consumers use the cheapest energy; and tariffs designed for consumers with low-carbon technology, for example, electric vehicles, to ensure they can charge at the cheapest times.

There are now new ways for households to find the best energy products and services to match their specific needs. This ensures consumers are getting the best deal available and can help them choose new ways to engage with the energy system.

Consumers can be rewarded for playing a bigger role in our energy system. There are plenty of ways to save money, from installing energy saving measures to making the most of new technologies, such as batteries, heating controls or smart washing machines and dishwashers. Consumers can also generate their own electricity through roof-top solar panels, store it in batteries, and even sell any excess power back to the grid to generate a profit at times of higher demand.

CASE STUDY: SMART TARIFF COMPARISON TOOL

Smarter Tariff – Smarter Comparison, Vital Energi

Vital Energi is leading a consortium of experts to develop a comparison tool that gives consumers an easy way to find the most suitable smart tariff. Smart tariffs are often not included on price comparison websites and consumers have little visibility of their benefits. For example, many electric vehicle owners are unaware that there are dozens of tariffs designed specifically for them.

Supported with government funding, the project is developing a tool which will help people find the best smart tariff to match their needs. Consumers can use their actual smart meter data as an input to get personalised, accurate comparisons and, after they switch, see if they have achieved the expected savings. It eliminates the need to manually provide estimated electricity bills and integrates time-of-use tariffs and use of low-carbon technologies in the tariff search. Consumer research indicates that many people would be more likely to use a smart comparison tool such as this.

At the end of the project in March 2021, the proof of concept will be free for anyone to reuse. This means that suppliers, comparison websites and others will be able to integrate it into their services or reuse it. The research findings will be made public so they can be used by innovators in the market.

CASE STUDY: SMART TARIFF

Agile Octopus Tariff, Octopus Energy

Agile Octopus is a 'time-of-use' tariff, which gives consumers access to half-hourly electricity prices, tied to wholesale prices, which are updated daily. So when energy prices drop, so could bills. Sometimes prices even go 'negative' - meaning that consumers can be paid to use energy during that period. Octopus also cap prices at 35p/kWh to protect consumers during price spikes.

Octopus calculate that, on this tariff, customers could save £120 a year by shifting electricity use outside of the 4pm to 7pm peak.[31] This is best suited for households with lots of electricity demand during those periods. For example, households with electric heating or electric vehicles.

CASE STUDY: CONNECTED HOME

Core4Grid, geo

Through the 'Core4Grid' trial, battery storage and smart meters have been installed in 24 houses that already had solar panels, electric heating or electric vehicle chargers. Using Core - its "energy brain" - the technologies have been integrated to run as a whole system within each home.

Core responds to signals from the electricity system to make decisions on when to use energy or charge the batteries, using either excess solar generated by the household's panels or grid electricity imported during cheaper periods.

The trial has been running since March, with participating homes sourcing over half of the energy they used from their solar and batteries. The houses have generated almost 30MWh of local generation (equivalent to ten times a typical dual fuel household's annual electricity use[32]) for the period.

Electric vehicles will accelerate this trend (see Transport breakout box). By using a smart charger when powering up their electric vehicle, consumers will play an essential role in helping manage electricity demand, avoiding the expensive peak periods. Increasingly, consumers will also be able to export energy from their electric vehicle back to the grid. In doing so, they could significantly reduce their energy costs and help maximise the amount of solar and wind energy used to charge their vehicle.

CASE STUDY: SMART ELECTRIC CAR CHARGING AND 'VEHICLE-TO-GRID' TRIAL

Project Sciurus, Kaluza, Ovo Energy

Project Sciurus is the largest domestic 'vehicle-to-grid' (V2G) demonstration in the world - with 323 V2G chargers supplying electricity to the grid at times of high energy demand. These operate on the 'Kaluza' platform, which receives live signals from the grid so that consumers can charge their vehicle when prices are low, and sell electricity back to the grid at times of peak demand.

The Sciurus project is part of a £30 million Innovate UK competition, with a diverse consortium of participants taking part. The majority of trial participants have found V2G capability to be valuable. Consumers have changed how and when they were charging their electric vehicles to help reduce costs for themselves and the grid, all while helping balance the energy system and saving money.

And some local communities are coming together to establish their own approach to managing energy demand in their areas. Smart local energy systems are community-based initiatives which bring together a range of energy issues, typically including heat, power and transport, to reduce emissions in an integrated way, while also promoting local jobs and businesses. Local Authorities are key to delivering these systems by combining energy into their wider statutory work on housing, transport, waste and planning, making delivery more cost-effective and preparing for a net zero future. Government provides funding for Local Authorities to deliver programmes that support decarbonisation and will continue to work with communities to enable projects to be tailored and delivered to meet local needs.

CASE STUDY: COMMUNITY ENERGY

Energy Local Clubs, Energy Local

Energy Local has designed a local energy market. Households and small renewable generators form a Local Energy Club, the first of which started in a small town called Bethesda, in North Wales back in 2016. Through this, households use their smart meters to show how much power they are using.

They agree a ‘match’ tariff with local generators that pays them a price for the power they produce when households are using it. This keeps more money local and offers consumers the chance to reduce household bills by using energy when it’s cheaper. They also partner with a supplier (Octopus Energy) to buy more power when there’s not enough locally.

It benefits suppliers, generators and communities, giving a fair price to renewable generators and developing a suitable package of improved energy controls in the home, particularly for those at risk of fuel poverty as the benefits of local generation can be shared with anyone who joins the Local Energy Club, without having to pay a high capital cost.

HOUSEHOLD ENERGY BILLS

The average household's dual fuel energy bill in 2019 was similar to 2010 (figure 2.1).

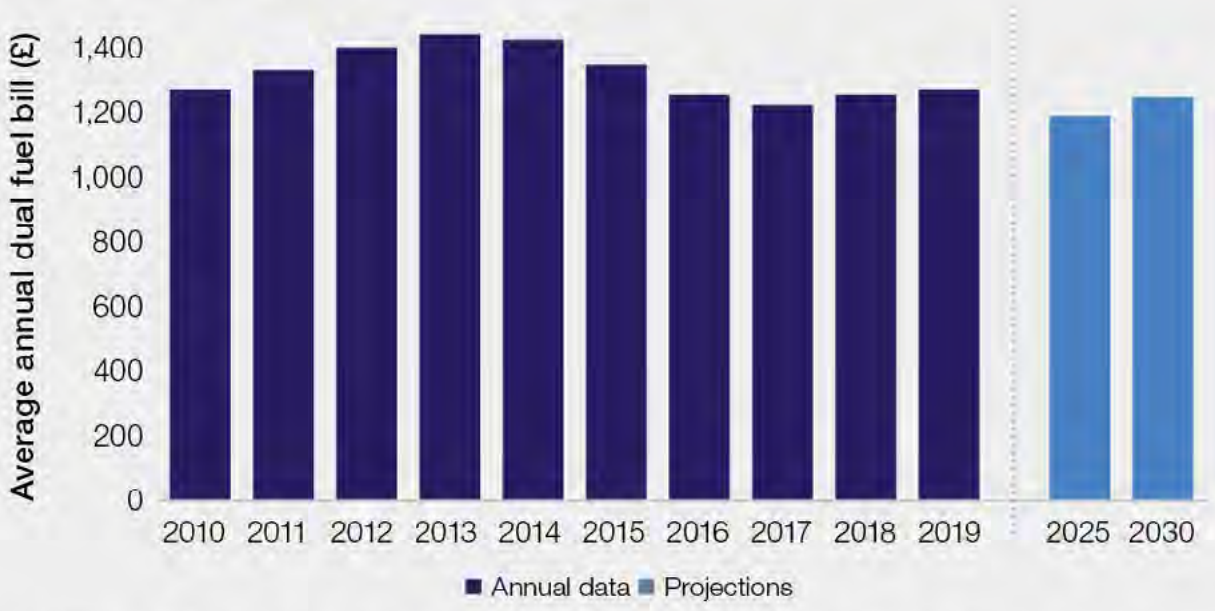
However, the underlying costs have changed. Over the past decade, electricity prices have gone up, because of rises in policy and network costs, while gas prices have fluctuated, reflecting movements in the wholesale gas price. However, consumers have used less energy, which has balanced out the cost increase.[34]

Overall, households who install energy saving measures will see significant savings and can offset the costs. Through targeting our energy saving schemes, such as extended ECO,[35] expanded WHD,[36] and the Green Homes Grant, many of the people making savings will be low-income or vulnerable households on benefits, whose homes currently have poor energy efficiency ratings. For such households, energy represents a significant share of their outgoings, so these savings can have a significant impact on their disposable income.

Our ECO and expanded WHD schemes will provide at least £4.7 billion of extra support to low-income and vulnerable households between 2022 and 2026. Under the Green Homes Grant, we expect £500 million to be spent on low-income households through Local Authority Delivery. In addition, £500 million of the £1.5 billion voucher scheme is also intended for low-income households.

FIGURE 2.1 – AVERAGE HOUSEHOLD DUAL FUEL BILL

2010 to 2030 (2020 prices)



Source: BEIS analysis. This graph is based on a limited set of assumptions and shows average net costs. The cost of policies still being developed, such as heat pump deployment, are not included. Individual bills will vary depending on consumer characteristics and behaviour. See references for more detail. [33]

For example, a household in receipt of Universal Credit and living in an old, inefficient home could enjoy bill savings worth over £400, making them warmer, healthier and reducing their carbon emissions.

Over the next ten years, increases in network costs, along with funding for clean energy and supporting vulnerable households could push gas and electricity prices up. Based on the policies in this white paper with agreed funding, we estimate that household dual fuel bills will be, on average, broadly similar in both 2025 and 2030 to 2019 (figure 2.1). These policies are estimated to amount to a net increase of around two per cent on average,[37] though households who take up measures stand to make material net savings. This depends on a range of uncertain and variable factors, including future fossil fuel prices and how consumers use energy. We have used a central set of assumptions for these drivers.

ENERGY BILL COMPONENTS

Wholesale costs:
The amount energy suppliers pay to buy gas and electricity.

Network costs:
The costs to build, maintain and operate the pipes, wires and cables that transport gas and electricity from producers to consumers.

Supplier costs and margins
The administrative costs of running the supply business, including customer service, marketing, metering, plus profits.

Policy costs:
Cost of programmes to save energy, reduce emissions, and provide financial support to the fuel poor.

ILLUSTRATIVE ANNUAL BILL SCENARIOS

Our assessment sets out the average picture. Underlying this, households could see net savings or costs depending on whether they take up measures. The graphic below sets out some illustrative case studies of how an individual household's bill may change because of the policies announced in this white paper.

FAMILY 1

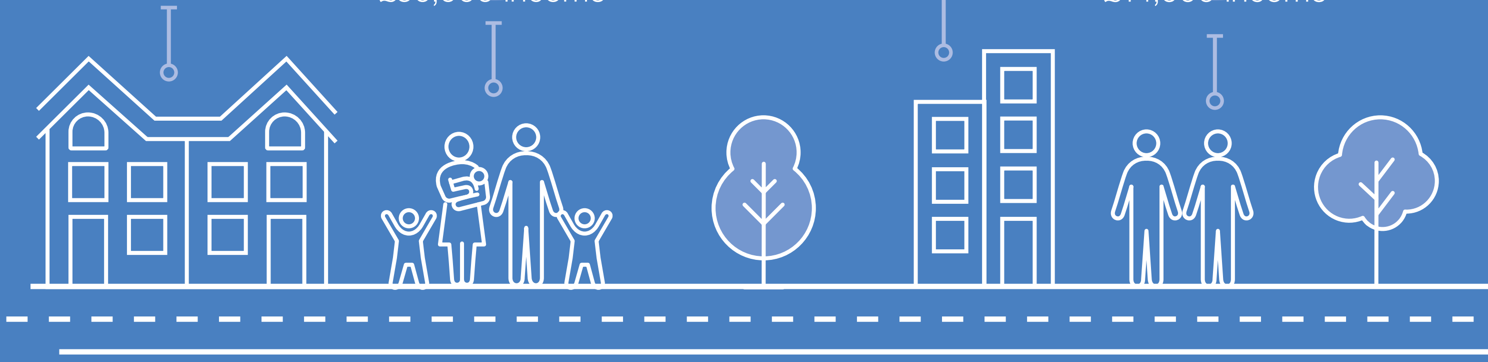
Semi-detached house
5 bedrooms
Owner-occupied
EPC C
Gas boiler

2 adults,
3 young children
Both parents
employed full-time,
£50,000 income

FAMILY 2

Purpose built flat
2 bedrooms
Owner-occupied
EPC D
Electric heater

2 adults
On state
pension with full
pension credit
£14,000 income



Illustrative measure

Green Home Grants

Floor insulation, delay start thermostat, time temperature zone control

Illustrative measure

Warm Home Discount

A rebate of £150 on the annual electricity bill

FAMILY 1 ANNUAL BILL	
Prior to white paper	£1,100
With white paper impacts before savings	£1,200
Potential energy bill savings	£110
WITH ENERGY BILL SAVINGS	**£1,090**

FAMILY 2 ANNUAL BILL	
Prior to white paper	£1,300
With white paper impacts before savings	£1,390
Potential energy bill savings	£150
WITH ENERGY BILL SAVINGS	**£1,240**

Details are provided on the household's characteristics and the composition of the household, including income. These are designed to be hypothetical households that can take advantage of certain policies (either Green Home Grants, ECO or WHD). They are not a complete list of qualifying criteria, and both a household's eligibility for certain policies and its potential savings will vary according to its characteristics, composition, and, in some cases, whether the household proactively chooses to apply for a measure.

Example bills are for the year 2025. The exact measures or level of rebate available under the future ECO and WHD schemes are subject to future consultation. For households who access schemes, there are opportunities for saving to significantly outweigh upward pressure on bills. Access to these opportunities depends on the policy. Schemes such as ECO are targeted at fuel poor households whereas the Green Home Grants is open to applications from a wider set of households.

FAMILY 3

Mid-terraced house
3 bedrooms
Private rented
EPC D
Gas boiler

1 adult, 2 young children
Unemployed, on Universal Credit
£11,000 income

FAMILY 4

Semi-detached house
3 bedrooms
Owner-occupied
EPC E
Gas boiler

1 adult, 2 young children
Employed part-time, on Universal Credit
£14,000 income

Illustrative measure

Warm Home Discount

A rebate of £150 on the annual electricity bill

Illustrative measure

Energy Company Obligation

External solid wall insulation, hot water tank insulation, delay start thermostat, time temperature zone control

FAMILY 3 ANNUAL BILL

Prior to white paper	£1,200
With white paper impacts before savings	£1,230
Potential energy bill savings	£150
WITH ENERGY BILL SAVINGS	**£1,080**

FAMILY 4 ANNUAL BILL

Prior to white paper	£1,200
With white paper impacts before savings	£1,280
Potential energy bill savings	£500
WITH ENERGY BILL SAVINGS	**£780**

Our key commitments

AFFORDABILITY AND FAIRNESS

It matters how much consumers pay for their energy, particularly when household budgets are tight.

The government will work with the regulator, Ofgem, to take the necessary steps to help households manage their bills. We have already introduced a price cap to ensure that the market does not excessively penalise consumers who do not frequently shop around for better deals.

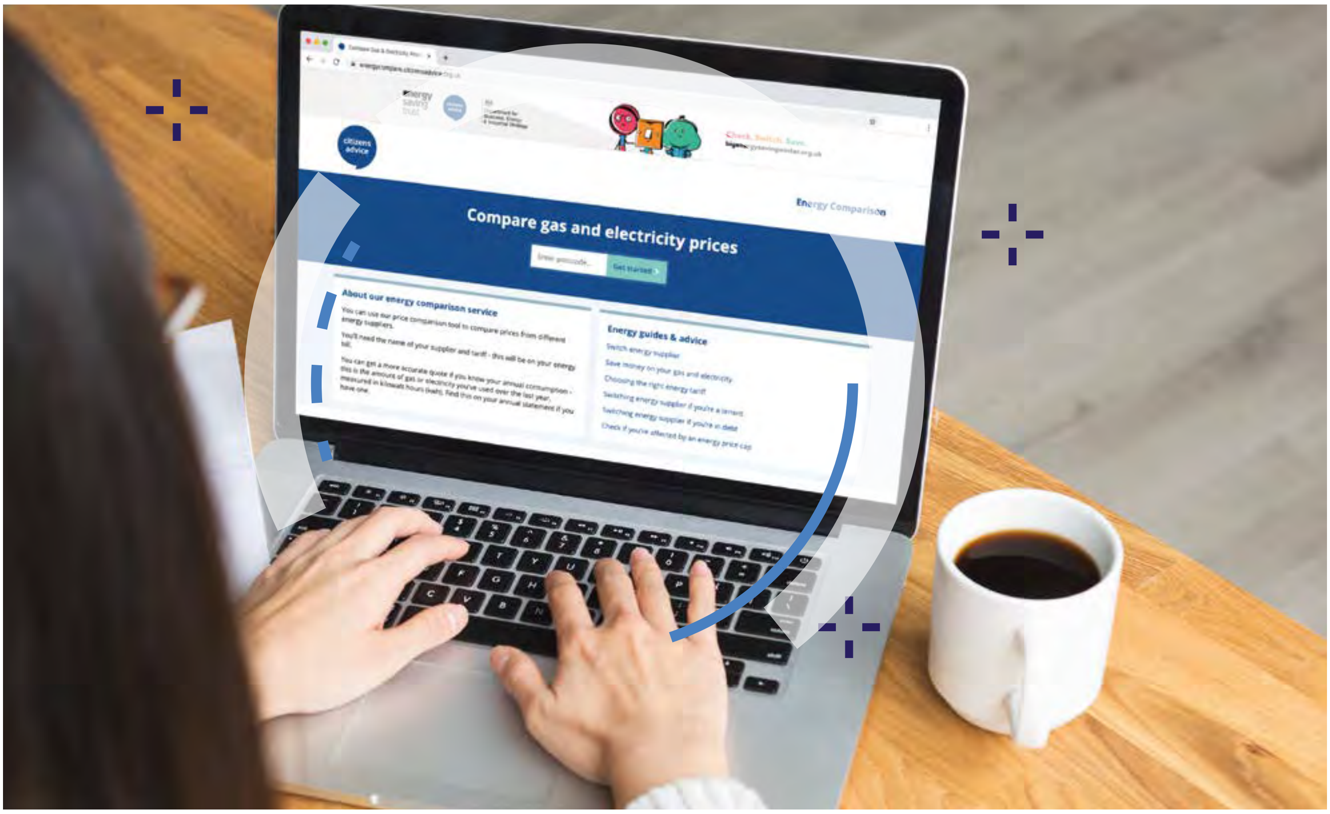
As we move to a clean energy system, fairness will be at the heart of our approach. Every household and business should be confident that everyone is paying their fair share of the costs of the transition. The members of the Climate Assembly UK identified "fairness within the UK, including for the most vulnerable" as one of the top two principles that should guide decisions around net zero.[38] We agree.

- **We will publish a call for evidence by April 2021 to begin a strategic dialogue between government, consumers and industry on affordability and fairness.**

We will work across the sector to identify existing distortions in the system and gain insights into the trade-offs involved in the distribution of energy costs. This will allow us to take decisions on how energy costs can be allocated in a way which is fair and incentivises cost-effective decarbonisation.

The nature of costs in a smart, clean energy system will be different. The largest part of our electricity bill is the cost to our energy supplier from buying power. This cost has traditionally been determined by the underlying price of gas or coal but this is changing. Gas will set the electricity price for some years to come but, over time, will do so less frequently, as more and more wind and solar connect to the electricity system. These are technologies which do not have a fuel cost. What we are paying for is the cost of building and operating the wind or solar farms, not the fuel cost. This trend fundamentally reshapes the costs of the system we must pay for. How consumers are charged will need to reflect this.

Ensuring that costs are fairly allocated between all consumers will be a central challenge for government. We need to strike the right balance between different households, between domestic consumers and businesses, including the big energy users in industry. The way that the costs are passed through to bills can incentivise or disincentivise certain types of consumer behaviour, including how the costs of decarbonising energy are apportioned between gas and electricity bills.



This can be a particular barrier to electrifying heat, which will be crucial for the transition to low-carbon buildings (see ‘Buildings’ chapter). It will be essential to ensure that price incentives are fair and help achieve our net zero target.

We are also mindful that, as we rightly encourage households to adopt new technologies such as roof-top solar and home energy storage, this change could affect how consumers pay for their energy in a way which is unfair to others. Households which self-generate electricity and store it, even sell it back to the grid, will be able to reduce how much they pay towards the fixed costs of the electricity system, while still relying on the system when they are not self-supplying. It could leave other consumers to pay a greater share, some of whom may not be able to take advantage of new technologies.

For all these reasons, the time is now right to reflect carefully on the nature of energy costs, who pays for them and how. HM Treasury has already launched a review of how the transition to net zero would be funded and where the costs would fall. An interim report will be published in December 2020, with a view to completing the review in spring 2021. This white paper sets out what we currently do to enshrine fairness in the way consumers are treated in the energy sector and puts forward new policy proposals to go even further. Building on this foundation, we will start a conversation with consumers and the energy industry about the fairness and affordability of the cost of moving to clean energy over the long-term. We are clear that the outcome of this work is a net zero world which continues to ensure a fair distribution of costs and maintains support in society and business for our climate goals.

ROLLING OUT SMART METERS

It remains our ambition to achieve market-wide roll-out of smart meters as soon as practicable, enabling homes and small businesses to access digital energy services that put them in charge of their energy use.

Second generation smart meters – which are compatible with all energy suppliers from the point of install – are now being rolled out as standard across Great Britain, while the enrolment of first generation smart meters into the national communications system will ensure these stay smart when consumers switch energy supplier.

We have introduced a new smart meter obligation on suppliers, which will start in July 2021. This will drive consistent, long-term investment, by setting annual targets and providing regulatory certainty. We are committed to exploring ways to encourage consumer uptake.

We are working with industry and delivery partners to help energy suppliers develop successful strategies for consumer engagement which improve the installation and operational performance rates of new meters, while stimulating consumer demand.

To allow consumers to make the most of the data recorded by smart meters, it needs to be combined with half-hourly settlement for suppliers. This will allow households to access more real-time prices, should they wish. Most households are currently billed at a fixed price, based on an estimate of when they use electricity during the day. Half-hourly settlement provides the option for different prices in each 30-minute period of the day. Ofgem's analysis estimates that half-hourly settlement would bring net benefits for consumers of between £1.6 billion and £4.6 billion by 2045.[39] Ofgem intend to publish their final decision in spring 2021 on how and when to implement half-hourly settlement.

FACILITATING COMPETITION AND TACKLING THE LOYALTY PENALTY

We are already seeing the value of innovation in smart controls and tariffs, as well as household batteries and solar panels.

To ensure that the growth in technological innovation goes from strength to strength, we need to ensure markets provide consumers with access to the services they want and offer fair value to all consumers. This is especially pressing as the system becomes more complex. Vulnerable consumers may need additional protections appropriate to their circumstances.

Consumers who have been automatically rolled onto a default tariff when their introductory tariff ends, or who start off on an auto-roll-over tariff, such as when they move into a new house, often pay much more for their energy, even when significantly cheaper alternatives are available. Over 50 per cent of consumers remain on default tariffs, despite almost all consumers knowing they can switch.[40] Many remain in this position for a long time, paying a 'loyalty penalty',[41] while other suppliers struggle to compete to provide these consumers with a better deal.

The price cap currently limits the extent of the loyalty penalty, but we believe competition is the most effective and sustainable way to keep prices low for all consumers over the long-term. Where the market and policy conditions for effective competition are not yet in place, we are prepared to ensure that proportionate price protection remains.

We have set out options for long term measures to protect consumers from the loyalty penalty in the joint government and Ofgem consultation 'Flexible and responsive energy retail markets' of July 2019.[44] With the measures set out in this white paper, we aim to address barriers to consumer engagement and the current nature of default tariff arrangements, the two leading causes of the loyalty penalty.

OPT-IN SWITCHING

- **We will create the framework to introduce opt-in switching, consulting by March 2021 on how it should be designed, tested and incrementally scaled up.**

We know from today's energy market that, for some consumers, the existence of cheaper deals is not sufficient in itself to drive consumer behaviour. Ofgem has found in recent trials that opt-in switching and similar tools can facilitate greater consumer engagement with the energy market.[45]

We will learn from these trials and create the framework to enable the introduction of opt-in switching by 2024. This will be implemented once we have reformed the exemption that smaller energy suppliers have from paying for energy efficiency measures (ECO) and from offering a discount for customers in fuel poverty (WHD).

OPT-IN SWITCHING TRIALS

Since 2017, Ofgem has run trials to develop and test new prompts to increase consumer engagement. Ofgem found that customers who have not switched energy tariff for many years can be prompted to do so following simple, well designed letters and emails. The trials included over 1.1 million customers and resulted in over 94,000 of them switching to new energy tariffs, with most of them making an active choice about their energy tariff for the first time in years. In total, these customers have saved around £21.3 million between them.[42]

The most successful trials were the opt-in collective switching trials.[43] These removed as many steps as possible from the switching process and provided additional reassurances, such as independent support. Between 19-30 per cent of consumers switched their tariff – five to ten times higher than the control group, which had rates of 2.6 - 4.5 per cent.

DEFAULT TARIFF ARRANGEMENTS AND OPT-OUT SWITCHING

- **We will consider how the current auto-renewal and roll-over tariff arrangements could be reformed to facilitate greater competition, consulting by March 2021 on how opt-out switching could be tested as part of any future reforms.**

Default or roll-over tariffs are important for ensuring continuous supply and service for consumers, even where they have not agreed a specific deal. However, these tariffs also enable passive engagement with the market, which limits competition and allows suppliers to charge such consumers excessive prices.

We want energy markets to be truly competitive. We do not think that energy suppliers should expect to roll over or continue contracts with customers indefinitely. Where consumers do not opt-out, reforms could move consumers on default tariffs to a new, cheaper contract through a competitive process. We will test how moving consumers to new contracts, with the option to opt-out, could work best for consumers, consulting by March 2021. We will engage closely with stakeholders to consider the design of the testing, including which consumers should be targeted, how the new tariff is determined and what safeguards should be in place to ensure beneficial outcomes.

REMOVING MARKET DISTORTIONS

We will work with industry to reduce the barriers to consumer engagement so that more households make informed choices about the products and services they receive.

TRANSPARENCY

- **We will ensure consumers are provided with more transparent and accurate information on carbon content when they are choosing their energy services and products, consulting on reforms in early 2021.**

Smart digital technology is not just giving consumers more control, choice and flexibility in their energy use. It allows consumers to make a personal contribution to delivering a clean energy system.

So, it is important that they have clear and easily accessible information on the options to do so. We will assess how effectively the market provides consumers with clear information on costs and clean energy choices.

This will be the key to helping consumers make informed decisions. We will consult in 2021 on how to ensure consumers receive transparent information when choosing an energy product, for example quantifying the additional environmental benefits of a tariff marketed as ‘green’.

POLICY OBLIGATIONS

We will consult on how:

- **The energy supplier thresholds of ECO can be removed without incurring disproportionate costs on suppliers, including potentially introducing a buy-out mechanism as part of reforms to the scheme beyond 2022.**
- **The energy supplier thresholds of WHD can be removed as part of reforms to the scheme beyond 2022 to ensure administrative simplicity and consistency.**

ECO and WHD are obligations on suppliers that tackle fuel poverty by providing targeted energy efficiency measures and discounts on bills (see 'Buildings' chapter for more detail).

Supplier thresholds for these schemes were introduced to avoid creating significant administrative barriers to market entry for new suppliers. The thresholds exempt suppliers with fewer customers from some of the costs to which their larger competitors are exposed. However, these thresholds may create market distortions as smaller suppliers are able to undercut other suppliers who still have to pay the costs.

For WHD, the threshold also creates barriers to switching for the fuel poor, as some suppliers are not required to offer the discount. We want to remove policy obligation thresholds but ensure that schemes can be extended, without creating significant administrative burdens for small suppliers. This will mean that fuel poor consumers who receive WHD can have greater confidence that switching to a cheaper tariff with an alternative supplier.

RETAIL REGULATORY FRAMEWORK

- **We will assess what market framework changes may be required to facilitate the development and uptake of innovative tariffs and products that work for consumers and contribute to net zero, engaging with industry and consumer groups throughout 2021 before a formal consultation.**

Consumers can benefit and contribute more effectively to net zero through an energy retail regulatory framework that accommodates emerging and innovative business models. Consumers are best placed to decide which business models suit their needs through market participation, but they could include peer-to-peer trading; energy as a service, where customers buy an outcome for an agreed price, such as a guaranteed temperature at home or guaranteed level of heat pump performance, rather than paying for units of gas or electricity; or the bundling together of utilities, such as water and energy.

The market framework will need to enable innovation and competition, while protecting consumers. We will continue to review whether the current supply licence framework strikes this balance effectively. We will assess whether incremental changes, alongside wider sectoral initiatives, are sufficient or whether more fundamental changes are required.

PROTECTING CONSUMERS AS TECHNOLOGIES AND SERVICES EVOLVE

Consumers must be able to benefit from robust and consistent protection when engaging the energy market, no matter where they obtain their products and services.

THIRD PARTY ENERGY PRODUCTS AND SERVICES

- **We will ensure the retail market regulatory framework adequately covers the wider market, consulting by spring 2021 on regulating third parties such as energy brokers and price comparison websites.**

The energy market is evolving rapidly as technology advances and consumer behaviour changes. Consumers can engage in the market in new ways. When the current licensing framework was developed, the majority of consumers would engage directly with their new supplier when arranging a switch but this is less common now, as consumers increasingly use price comparison websites. Ofgem does not currently regulate third parties like energy brokers and price comparison websites and we need to ensure that consumers can be confident that they are protected when engaging with any energy product or service through these channels.

This principle of protection does not just apply to households. In its Microbusiness Strategic Review, Ofgem identified harms to microbusinesses from some brokers such as mis-selling and misrepresentation. Government and Ofgem will work together to ensure microbusinesses have appropriate protection from bad practices.

SMART APPLIANCES

- **We will take powers to regulate smart appliances based on principles including interoperability, data privacy and cyber security, legislating when Parliamentary time allows.**

The market for smart appliances, such as smart fridges, washing machines and heating systems, is just emerging. Regulation of these devices, in particular relating to interoperability, data privacy, and cyber security, is required to support its development and to ensure that appropriate consumer protection is in place ahead of time. Devices should be able to link with any service provider's systems so that consumers cannot be locked into a single provider. It is also important that devices are cyber secure, to ensure consumers' data remains private and the energy system as a whole is protected. Industry is developing standards for smart appliances in line with these principles, which will be published by summer 2021.

We will ensure that the approach adopted for regulating smart appliances is compatible with the Department for Digital, Culture, Media and Sport's existing commitment to take powers to regulate the cyber security of consumer smart devices.

Our key commitments

We will **publish a call for evidence by April 2021** to begin a strategic dialogue between government, consumers and industry on affordability and fairness.

We will **create the framework to introduce opt-in switching**, consulting by March 2021 on how it should be designed, tested and incrementally scaled up.

We will **consider how the current auto-renewal and roll-over tariff arrangements could be reformed** to facilitate greater competition, consulting by March 2021 on how opt-out switching could be tested as part of any future reforms.

We will **ensure consumers are provided with more transparent and accurate information on carbon content** when they are choosing their energy services and products, consulting on reforms in early 2021.

We will **consult on how the energy supplier thresholds of ECO can be removed** without incurring disproportionate costs on suppliers, including potentially introducing a buy-out mechanism as part of reforms to the scheme beyond 2022.

We will **consult on how the energy supplier thresholds of WHD can be removed** as part of reforms to the scheme beyond 2022 to ensure administrative simplicity and consistency.

We will **assess what market framework changes may be required to facilitate the development and uptake of innovative tariffs and products** that work for consumers and contribute to net zero, engaging with industry and consumer groups throughout 2021 before a formal consultation.

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We will **take powers to regulate smart appliances** based on principles including interoperability, data privacy and cyber security, legislating when Parliamentary time allows.

CHAPTER 02

Power

OUR GOAL

Electricity is a key enabler for the transition away from fossil fuels and decarbonising the economy cost-effectively by 2050.

We will:

- **Accelerate the deployment of clean electricity generation** through the 2020s
- **Invest £1 billion in UK's energy innovation programme** to develop the technologies of the future such as advanced nuclear and clean hydrogen
- Ensure that the transformation of the electricity system **supports UK jobs and new business opportunities, at home and abroad**

POWER

The strategic context

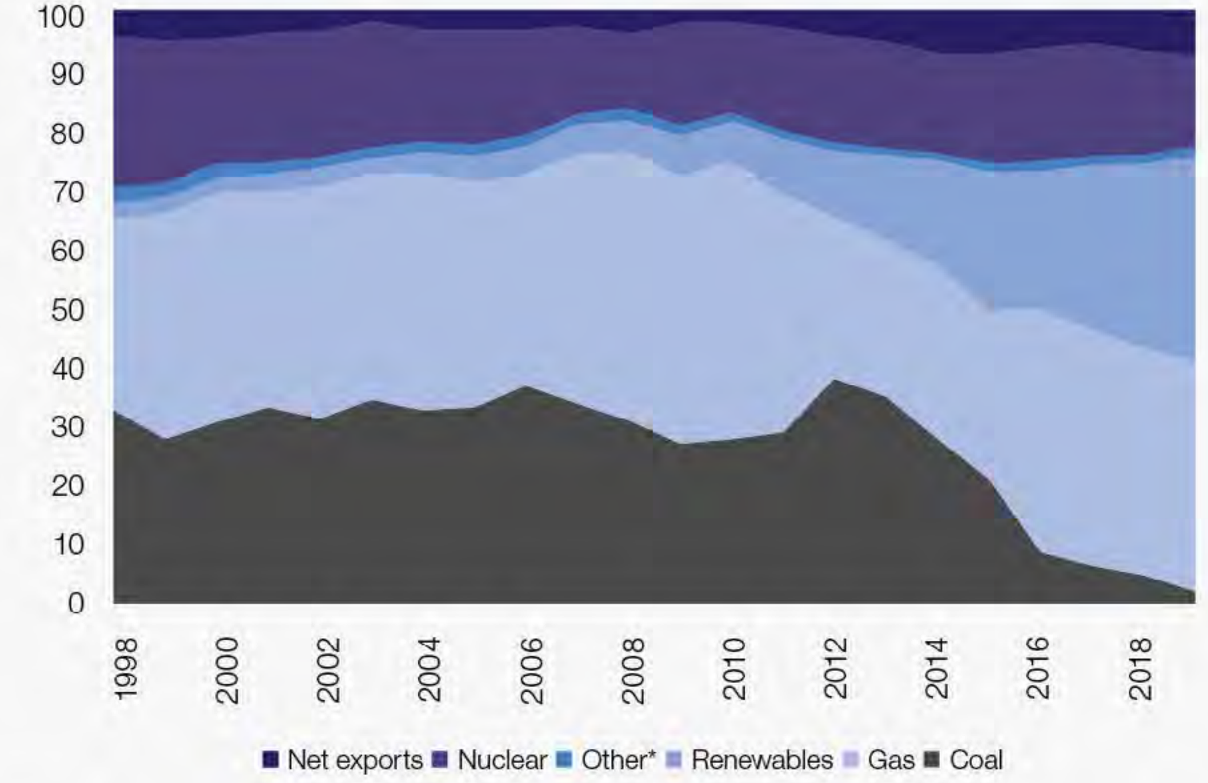
Decarbonising the power sector has led the UK's efforts to reduce greenhouse gas emissions.

In 1990, electricity generation accounted for 25 per cent of UK emissions. In 2018, it was only 15 per cent.[46] 30 years ago, fossil fuels provided nearly 80 per cent of electricity supply.[47] Today, the country gets over half of its power from low-carbon technologies.[48] The rapid growth of renewables has a been a critical feature of this transformation. Renewable capacity has grown fivefold since 2010, driven by the deployment of wind, solar and biomass. The UK had 10GW of operational offshore wind by 2019, up from just over 1GW in 2010.[49]

>50%	of the UK's power comes from **low-carbon technologies** today
5x	**renewables capacity has grown five-fold** since 2010
~9GW	**increase in operational offshore wind** since 2010

FIGURE 3.1 - CHANGE IN POWER SUPPLY

1998 - 2019



Source: Energy Trends, table 5.1. *Other includes oil, pumped storage, and other thermal generation.

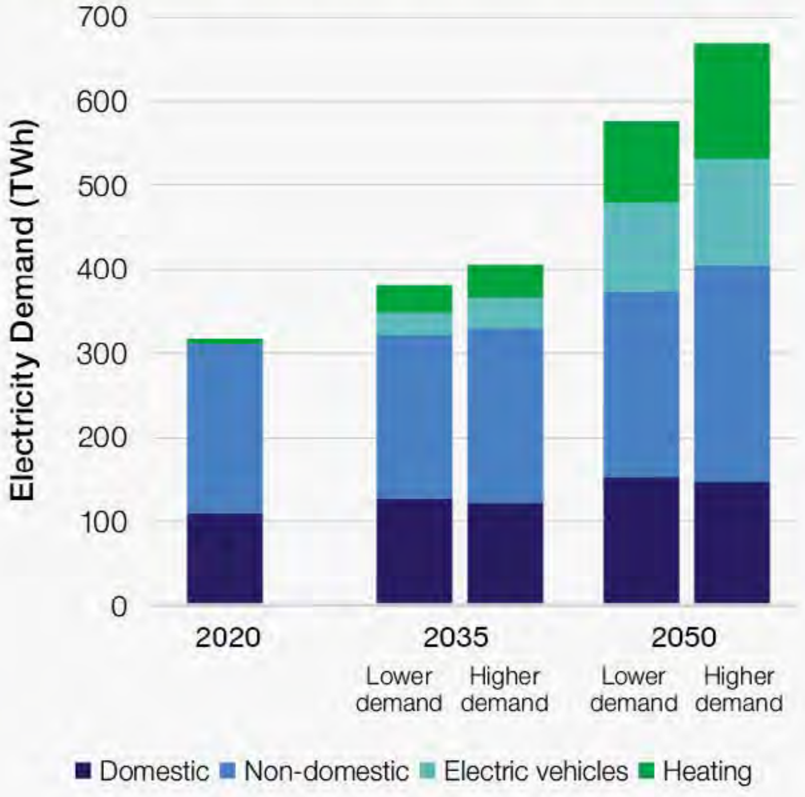
Renewables now account for over one third of electricity generation, up from seven per cent in 2010. Yet, this green revolution has been delivered without disruption to the reliability of our electricity supply and the scale of deployment has contributed to a significant reduction in the cost of renewables. Increasingly, green power is the cheapest power.[50]

Building on this foundation, we need to go further. With the exception of Sizewell B and Hinkley Point C, which is under construction, all of the existing nuclear power plants are due to have ceased generating by the end of 2030. We have already committed to ending coal in the electricity mix no later than 2025.

Today, as a signal of our further ambition and to encourage other countries along the path to phasing out coal, we are publishing a consultation over the option to bring forward our coal closure date to 2024.[51] Subject to this consultation, we will introduce legislation to give legal effect to the end date.

While retiring capacity will need to be replaced to keep pace with existing levels of demand, our modelling suggests that overall demand could double out to 2050. This is because of the electrification of cars and vans and the increased use of clean electricity replacing gas for heating. As a result, electricity could provide more than half of final energy demand in 2050, up from 17 per cent in 2019.[52]

FIGURE 3.2 - ELECTRICITY DEMAND, NET ZERO SCENARIOS



- BEIS analysis shows **electricity demand could double by 2050**
- **Power displaces petrol and diesel** in cars and, to some extent, gas for heating
- Difference in demand scenarios is **driven mostly by how much electricity replaces gas for heating or petrol and diesel in cars**

Source: BEIS analysis

This would require a four-fold increase in clean electricity generation with the decarbonisation of electricity increasingly underpinning the delivery of our net zero target.

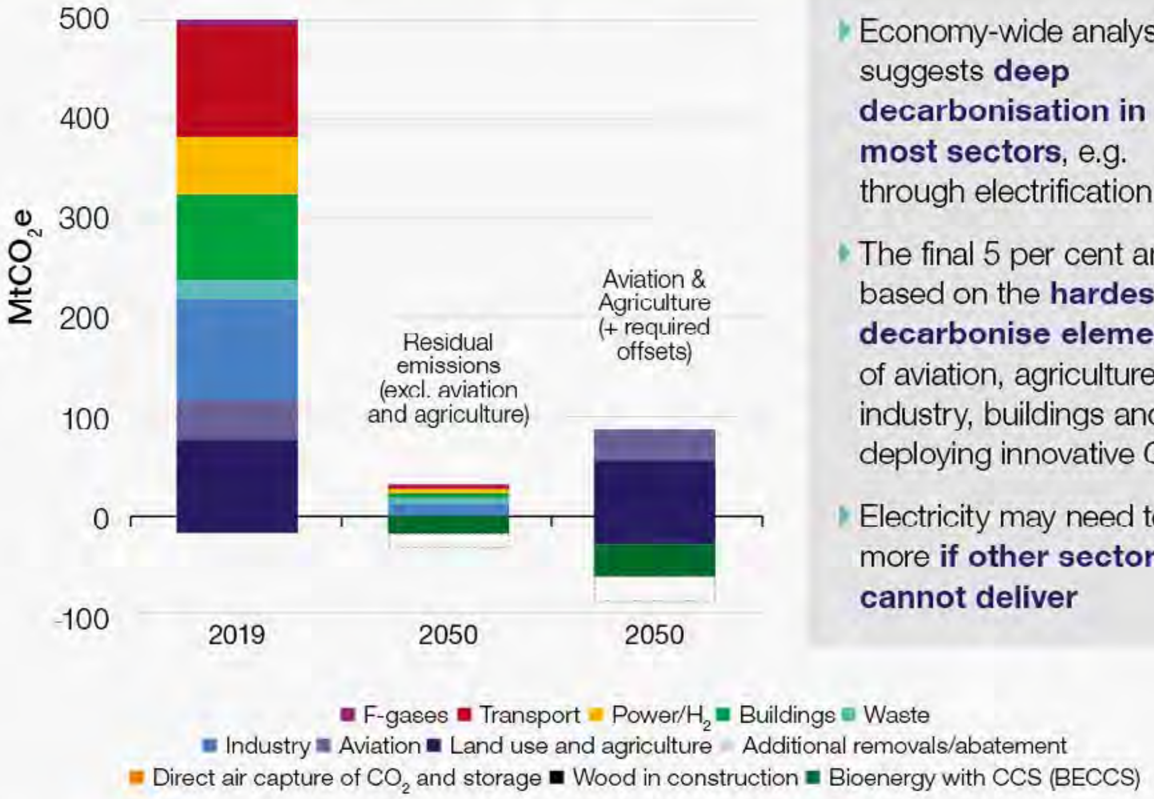
Given the pivotal role of electricity in delivering net zero emissions, we must aim for a fully decarbonised, reliable and low-cost power system by 2050. Low emissions in power does not necessarily mean higher costs. Carbon intensity, the amount of CO_2 emitted to generate 1kWh of electricity, can fall to very low levels without costs rising significantly. This will depend on the level of demand, and the cost and availability of other low-carbon technologies, particularly low-cost clean hydrogen.

Our understanding of what is required from the electricity sector to support the delivery of net zero emissions will change over time. Our views will be informed by what we learn about the costs of decarbonising other sectors of the economy and by the costs and availability of negative emissions technologies, such as Bioenergy with Carbon Capture and Storage (BECCS) or Direct Air Carbon Capture and Storage (DACCS).

We are not targeting a particular generation mix for 2050, nor would it be advisable to do so. We have already reduced power sector emissions 58 per cent between 2010 and 2018,[53] and to stay on a course for a fully decarbonised system we will continue that progress through the 2020s and have an overwhelmingly decarbonised power system in the 2030s.

The electricity market should determine the best solutions for very low emissions and reliable supply, at a low cost to consumers.

FIGURE 3.3 - UK EMISSIONS, NET ZERO SCENARIO



- Economy-wide analysis suggests **deep decarbonisation in most sectors**, e.g. through electrification
- The final 5 per cent are based on the **hardest to decarbonise elements** of aviation, agriculture, industry, buildings and deploying innovative GGRs
- Electricity may need to do more **if other sectors cannot deliver**

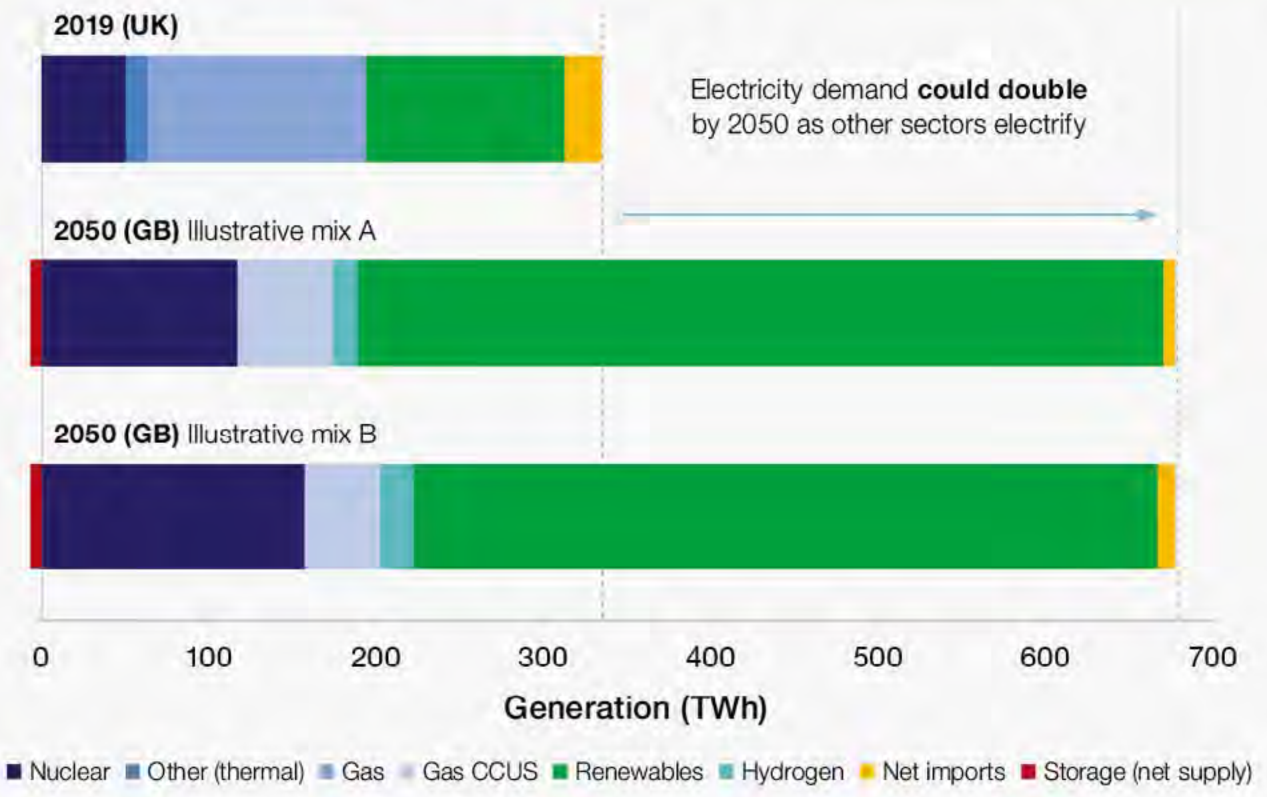
Source: CCC 2020 Progress Report

Competition should be a spur to greater investment in technologies which are cheaper and more efficient; or to the innovation which will reduce the costs of existing options. We have seen very rapid falls in the costs of renewables over the last five years and want to maintain the market conditions which stimulate these cost reductions. The government's role is to ensure a market framework which promotes effective competition and delivers an affordable, secure and reliable system, consistent with net zero emissions by 2050. This market framework should enable the deployment of the most efficient, low-cost technologies and mitigate delivery risk associated with a particular technology. We will intervene to address any potential market failures, as government did through the introduction of the Capacity Market, to ensure enough supply at periods of peak demand.

We will continue to invest in innovation which helps commercialise new technologies and reduce overall technology costs.

While we are not planning for any specific technology solution, we can discern some key characteristics of the future generation mix. A low-cost, net zero consistent system is likely to be composed predominantly of wind and solar. But ensuring the system is also reliable, means intermittent renewables need to be complemented by technologies which provide power, or reduce demand, when the wind is not blowing, or the sun does not shine. Today this includes nuclear, gas with carbon capture and storage and flexibility provided by batteries, demand side response, interconnectors (see 'Energy system' chapter) and short-term dispatchable generation providing peaking capacity, which can be flexed as required.

FIGURE 3.4 - ELECTRICITY MIX TODAY & ILLUSTRATIVE 2050 MIXES



Source: Energy Trends, table 5.1 and 6.1; BEIS analysis.

By 2050, we expect low-carbon options, such as clean hydrogen and long-duration storage, to satisfy the need for peaking capacity and ensure security of supply at low cost, likely eliminating the reliance on generation from unabated gas.

Figure 3.4 illustrates how the system could meet a doubling of demand, while reducing emissions. It shows just two of many scenarios which decarbonises electricity to very low levels of emissions at low cost. It serves to emphasise how much additional generation capacity we will need to build and how much electricity it produces to satisfy high levels of demand. Very different mixes can also provide low-cost solutions for the same demand scenario.

We are publishing the details of our electricity system analysis alongside this white paper.[54] We have modelled almost 7,000 different electricity mixes in 2050, for two different levels of demand and flexibility, and 27 different technology cost combinations. It has produced a dataset comprising of over 700,000 unique scenarios, allowing us to identify common features of a low emissions, low-cost electricity system.

The analysis allows us to better prepare for an electricity system which is consistent with net zero emissions, even if we do not know the precise generation mix in 2050. It informs the actions we need to take to support the deployment of clean electricity technologies, including how we can direct our innovation support most effectively. We can target the technologies which have a key role in the system of the future, such as low-carbon peaking capacity and long-duration storage, which enable us to integrate high volumes of low-cost intermittent generation.

Our key commitments

AFFORDABLE CLEAN ELECTRICITY

This white paper sets out the actions which we are taking to put the country on the path to a low-cost, clean electricity system by 2050.

It will comprise the technologies which allow us to drive deep reductions in carbon emissions at a low cost, while maintaining the reliability and resilience of the system. Our actions are a strong signal to project developers and the wider investor community about the government's commitment to delivering clean electricity. This should stimulate the continued deployment of key low-carbon technologies in the near term, while encouraging innovation in the technologies of the future which offer the greatest potential to reduce costs.

RENEWABLES

- **We will target 40GW of offshore wind by 2030, including 1GW floating offshore wind, alongside the expansion of other low-cost renewable technologies.**

A highly competitive Contracts for Difference (CfD) allocation round in 2019 led to the procurement of 5.5GW of offshore wind and 275MW of remote island wind, at strike prices around £40/MWh (2012 prices) for projects expected to start generating electricity by 2024.[55] This contrasts with prices for offshore wind of £150/MWh for projects which became operational in 2017.[56]

Our ambition is to have **40GW offshore wind by 2030,** a fourfold increase on today's installed capacity

As announced in the Prime Minister's Ten Point Plan for a Green Industrial Revolution, we will continue to hold regular CfD auction rounds every two years to bring forward a range of low-cost renewable technologies. The next auction in late 2021 will be open to onshore wind, solar photovoltaics and other established technologies, as well as offshore wind. Subject to sufficient projects coming through the planning pipeline to maintain competitive tension, we plan to double the capacity awarded in the last round with the aim to deploy around 12GW of low-cost renewable generation. Onshore wind and solar will be key building blocks of the future generation mix, along with offshore wind. We will need sustained growth in the capacity of these sectors in the next decade to ensure that we are on a pathway that allows us to meet net zero emissions in all demand scenarios.

Following our recent Call for Evidence on the potential of marine energy projects, we have set an ambition of deploying 1GW of floating offshore wind by 2030, supported by CfDs and innovation funding. Acting now will drive higher volumes of deployment in the 2030s and beyond, subject to cost reductions. We will work closely with the devolved administrations, the Crown Estate and Crown Estate Scotland to address issues such as seabed leasing and protecting the marine environment and to ensure the UK captures the economic benefits of deploying the technology. This will provide the foundation for a sustainable, competitive supply chain and enable floating offshore wind projects to scale up and accelerate cost reduction. We will consider the role of wave and tidal energy, following further evaluation of the commercial and technical evidence. We will also identify and utilise synergies between hydrogen and the deployment of offshore wind.

It is vital that CfDs offer value for money to consumers and continue to deliver low prices. We will structure the 2021 and future auctions to keep the CfD allocation process highly competitive, supported by a number of technical changes to the auction. Alongside this white paper, we are issuing a new Call for Evidence seeking views on how the CfD scheme could evolve beyond the 2021 auction, including how longer-term changes to the CfD or wider electricity market design can enable the effective integration of increasing renewables capacity.[57]

We want to understand how generators can best be exposed to market signals which stimulate innovation and incentivise generators to minimise the overall system costs of large amounts of renewables. We will also be asking about the broader evolution of the electricity market (see 'Energy system' chapter). We will seek a balance between options for further reform of the market with maintaining the success of the CfD in deploying low-cost renewables at scale.

We will establish a Ministerial Delivery Group, which brings together the relevant government departments to oversee the expansion of renewable power in the UK. This group will provide the cross-government coordination and collaboration necessary to achieve our ambition for renewable electricity. It will tackle barriers such as the impact of wind turbines on radar systems, maintaining a flourishing and biologically diverse marine environment and the development of appropriate network infrastructure to support future renewables deployment. We will also work to reduce consenting delays and ensure that planning guidelines and environmental regulations are fit for purpose. The Ministerial Delivery Group will make use of existing cross-government mechanisms, such as the Offshore Wind Enabling Actions programme, a £4.3 million initiative to be run jointly by Defra and BEIS and funded by HM Treasury (HMT).

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POWER CCUS

- **We will support the deployment of at least one power CCUS project, to be operational by 2030, and put in place the commercial framework required to help stimulate the market to deliver a future pipeline of power CCUS projects.**

In the power sector, gas-fired generation with CCUS can provide flexible, low-carbon capacity to complement high levels of renewables. These characteristics mean that deployment of power CCUS projects will play a key role in the decarbonisation of the electricity system at low cost.

We will support at least one power CCUS plant to come forward and be operational by 2030 and will put in place a commercial framework which will enable developers to finance the construction and operation of a power CCUS plant and stimulate a pipeline of projects. This will enable at least one power CCUS project to be developed in one of the four industrial clusters as part of our mission to decarbonise them (See 'Industrial energy' chapter). Following the publication of the government response to our CCUS business models consultation in August 2020,[58] we will introduce a business model based on the existing CfD framework, adapted so that price signals incentivise power CCUS to play a role in the system, which complements renewables. We set out our plans for the deployment of transport and storage infrastructure in the 'Industrial energy' chapter.

- **We will consult on steps to ensure that new thermal plants can convert to low-carbon alternatives.**

Since 2009, our Carbon Capture and Readiness requirements have ensured that planning consent is only granted to thermal plants for which it will be technically and economically feasible to retrofit CCUS. However, we believe the current 300MW minimum threshold creates a costly market distortion, by disincentivising the deployment of gas plants larger than 300MW, which tend to be more efficient. The threshold also means that the requirements only apply to a small proportion of new build thermal plants. Furthermore, the requirements do not reflect recent technological advances, including alternative options for decarbonising gas plants, such as conversion to firing clean hydrogen. Therefore, we intend to consult in early 2021 over proposals to update the requirements to reflect technological advances and apply them more broadly, by removing the 300MW threshold.

NUCLEAR

- **We will aim to bring at least one large-scale nuclear project to the point of Final Investment Decision (FID) by the end of this Parliament, subject to clear value for money and all relevant approvals.**

Nuclear power continues to be an important source of reliable clean electricity, currently supplying around 16 per cent of our needs.[59] It is an energy-dense technology which provides large volumes of power from very little land area and can reduce system costs at low levels of emissions. In 2016, the government agreed contracts related to the first new nuclear power station in a generation.

~7% of the country's current electricity needs will be **delivered by Hinkley Point C**

10,000 **jobs could be supported** during construction of a large-scale nuclear power plant

30% expected **reduction in the cost of nuclear new build projects** by 2030

Hinkley Point C is due to commission in the mid-2020s and will deliver around seven per cent of the country's current electricity needs - enough to power the equivalent of around six million homes.[60] But, with the existing nuclear fleet largely retiring over the next decade, we propose to go further. Our analysis suggests additional nuclear beyond Hinkley Point C will be needed in a low-cost 2050 electricity system of very low emissions. We must be ready for this.

We aim to bring at least one further large-scale nuclear project to the point of FID by the end of this Parliament, subject to clear value for money for both consumers and taxpayers and all relevant approvals.

As noted in the Ten Point Plan, a large-scale nuclear power plant could support a peak of around 10,000 jobs during construction.[61] We will remain open to further projects later if the nuclear industry demonstrates that it is able to reduce costs and deliver to time and budget.

We expect the sector to deliver the goal it set for itself in our Nuclear Sector Deal, published in 2018,[62] to reduce the cost of nuclear new build projects by 30 per cent by 2030.

Last year, we consulted on a Regulated Asset Base (RAB) model for private investment in new nuclear generation.[63] Today we are publishing a summary of the responses which have indicated that a RAB model remains credible for funding large-scale nuclear projects.[64]

The government will continue to explore this, alongside a range of financing options, with the developer of the next large-scale project in the pipeline and other relevant stakeholders, including other nuclear developers. Raising enough private capital to finance a nuclear power station is challenging given the significant investment needed for a developer to reach a point of FID. In considering the financing options, we will examine the potential role of government finance during construction, provided there is clear value for money for consumers and taxpayers.

ADVANCED NUCLEAR INNOVATION

- **We will provide up to £385 million in an Advanced Nuclear Fund for the next generation of nuclear technology aiming, by the early 2030s, to develop a Small Modular Reactor (SMR) design and to build an Advanced Modular Reactor (AMR) demonstrator.**

The UK continues to be a leader in the development of nuclear technologies.

SMRs have the potential to provide cost-competitive nuclear power as early as the 2030s. Pending regulatory approval, innovative manufacturing techniques and modular construction could mean that SMRs are faster to build than large-scale nuclear plants and are potentially suitable for deployment in a wider number of sites across the country.

SMALL MODULAR REACTOR

Small Modular Reactors (SMRs) are usually based on proven water-cooled reactors similar to current nuclear power station reactors, but on a smaller scale. They use nuclear fission to generate low-carbon electricity. SMRs are called modular reactors as their components can be manufactured in factories using innovative techniques and then transported to site to be assembled.

£385m **Advanced Nuclear Fund** created

£400bn **estimated worth of SMRs and AMRs** by 2035

Subject to future HMT Spending Reviews, we have provided a £385 million in an Advanced Nuclear Fund with up to £215 million investment to develop a domestic SMR design that could potentially be built in factories and then assembled on site. It is expected to unlock up to £300 million private sector match-funding.

To help bring advanced nuclear technologies to the market, we will also invest an additional £40 million in developing the regulatory frameworks and supporting UK's supply chain. As the first major commitment of the programme, in 2021 we will open the Generic Design Assessment to SMR technologies, the regulatory process through which developers can obtain approval for their proposed design approach.

Supporting the development of our supply chain now will increase our chances of having indigenous expertise capable of leading the world in developing the nuclear technologies of the future - SMRs and AMRs - a global market estimated by some to be worth approximately £250 billion to £400 billion by 2035.[65]

ADVANCED MODULAR REACTOR

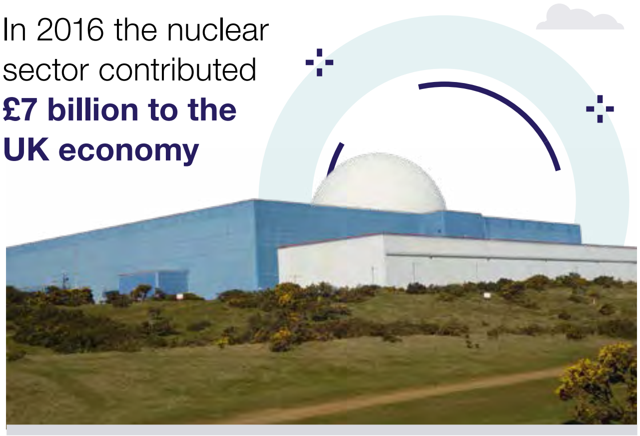
Advanced Nuclear Reactors (AMRs) are reactors which use novel cooling systems or fuels and may offer new functionalities (such as industrial process heat). These reactors could operate at over 800°C and the high-grade heat could unlock efficient production of hydrogen and synthetic fuels.

We are also committing up to £170 million of the Advanced Nuclear Fund to a R&D programme on AMRs – the next generation of nuclear technologies. Our aim is to build a demonstrator by the early 2030s at the latest to prove the potential of this technology and put the UK at the cutting edge against international competitors.

- **We aim to build a commercially viable fusion power plant by 2040.**

Fusion energy would offer low-carbon, continuous, and effectively unlimited power generation. The basic science and engineering involved in the production of fusion energy is now well advanced and fusion energy is expected to play an important role over the longer term to decarbonise global energy production.

In 2016 the nuclear sector contributed **£7 billion to the UK economy**



The UK is a world leader in the most promising fusion technologies with research capabilities across the technical challenges of fusion. This means that the UK is uniquely well-placed to lead the future commercialisation of this technology. The government has already committed over £400 million towards new UK fusion programmes. The aims are to develop a concept design for the Spherical Tokamak for Energy Production (STEP) – expected to be the world's first compact fusion power plant, to be built in the UK by 2040 – and to invest in facilities and infrastructure to make the UK a global fusion industry hub. In December 2020, the STEP programme published an open call for communities across the UK to apply to be the host site for STEP.[66]

NET ZERO INNOVATION PORTFOLIO

The Ten Point Plan announced a new £1 billion Net Zero Innovation Portfolio that will help bring down the cost of the net zero transition, nurture the development of better products and new business models, and influence consumer behaviour.

A £1 billion Net Zero Innovation Portfolio aims to accelerate the commercialisation of innovative low-carbon technologies, systems and processes in power, buildings and industry to set the UK on the path to net zero and create world-leading industries and new jobs. The portfolio will focus on ten priority areas to decrease the costs of decarbonisation and underpin innovation across the whole energy system.

As well as accelerating the commercialisation of novel clean energy technologies, innovation also plays an important role in driving economic growth, anchoring new technology to the UK, delivering levelling-up across the country and reducing our significant exposure to the risks of climate change.

An ambitious and well-designed energy innovation strategy could, by 2050, annually generate £54 billion of business opportunities for the UK.[67]

The current BEIS £505 million Energy Innovation Programme is delivering some of the UK's most significant advances in low-carbon technologies, leveraging £200 million industry investment:

- **The UK's first CCUS plant** at Tata Chemicals, Cheshire (£17 million total investment)
- **The world's largest "Cryogenic" energy storage plant** at Manchester (over £70 million total investment)
- **The UK's largest innovative heat pump trial** (750 homes, over £15 million total investment)
- **The UK's first Venture Capital fund solely focussed on Cleantech** (over £40 million total investment).

NET ZERO INNOVATION PORTFOLIO - PRIORITY AREAS

Advanced Modular Reactors
Floating offshore wind
Hydrogen
Bioenergy
Industrial fuel switching
Advanced CCUS
Homes
Disruptive technologies
Direct air capture
Energy storage and flexibility

BIOENERGY INNOVATION

- **By 2022, we will establish the role which BECCS can play in reducing carbon emissions across the economy and, as part of a wider biomass strategy, set out how the technology could be deployed.**

Biomass is unique amongst renewable technologies in the wide array of applications in which it can be used as a substitute for fossil-fuel based products and activities, from power generation to hydrogen production and even new forms of plastics. Along with its ability to deliver negative emissions, this makes biomass one of our most valuable tools for reaching net zero emissions.

BIOMASS

Biomass refers to any material of biological origin (including wastes) which is used as a fuel for bioenergy (conventional combustion, gasification, energy from waste and low-carbon fuels like hydrogen) or in products (such as chemicals, bio-plastics and timber for construction).

In the government's response to Climate Change Committee's (CCC) latest annual progress report to Parliament, we announced that we will publish a new Biomass Strategy in 2022. As part of this strategy, we will set out the results of a review of the amount of sustainable biomass available to the UK, and how this resource could be best utilised across the economy to help achieve our net zero greenhouse gas emissions target by 2050.

Our review will assess the UK's current biomass sustainability standards, which are already some of the world's most stringent, to see where and how we can improve them even further. Our review will also consider the role biomass can play in delivering our wider environmental targets, including on air quality.

We will shortly issue a call for evidence: 'Biomass for net zero', to inform the development of our strategy. We will issue a preliminary position paper by summer 2021, once the evidence has been reviewed.

Critical to our consideration will be the role of BECCS in our energy system. BECCS plants could deliver negative emissions, by capturing the carbon released during biomass combustion, gasification and other processes, provided supply chain emissions are sufficiently low. There are a number of applications for BECCS across the economy, including clean hydrogen production, power generation, waste management and in heat for industrial processes and we need to ensure that it is deployed where it has the greatest value in reducing emissions.

For example, current support for electricity generation, which converted from coal to using biomass as a fuel source, expires in 2027. BECCS could provide a long-term future for this capacity.

THE POTENTIAL OF GREENHOUSE GAS REMOVAL (GGR) TECHNOLOGIES

Greenhouse gas removal technologies actively remove greenhouse gases from the atmosphere and are diverse, ranging from engineered to nature-based solutions. The CCC has been clear that, in order to achieve net zero by 2050, GGRs will be necessary to balance residual emissions from some of the most difficult to decarbonise sectors, such as parts of the agriculture and aviation sectors. The CCC has estimated 75MtCO_2 of negative emissions could be required annually in order to reach net zero greenhouse gas emissions by 2050.[68]

The government is already taking steps to accelerate the development and deployment of GGRs in the UK. In June 2020, we announced up to £100 million of funding for research and development of DACCS and other GGR methods.[69] This funding seeks to demonstrate feasible GGR approaches at scale, as well as better our understanding of governance and ethics of GGRs. We have also published a call for evidence earlier in December,[70] which seeks views on mechanisms and governance principles to help bring GGR technologies like DACCS to deployment in the UK. Alongside this, both BEIS and the National Infrastructure Commission will conduct research projects to develop the evidence based on GGRs in order to support future policy in this area.

A PLANNING FRAMEWORK FOR ENERGY INFRASTRUCTURE

- **We will complete a review of the existing energy National Policy Statements (NPS), with the aim of designating updated NPS by the end of 2021.**

The suite of energy NPS establish the need for new energy infrastructure and set out a framework for the consideration of applications for development consent. We have decided that it is appropriate to review the NPS, to ensure that they reflect the policies set out in this white paper and that we continue to have a planning policy framework which can deliver the investment required to build the infrastructure needed for the transition to net zero. Work on this review will start immediately, with the aim of designating updated NPS by the end of 2021.

This white paper shows that the need for the energy infrastructure set out in energy NPS remains, except in the case of coal-fired generation. While the review is undertaken, the current suite of NPS remain relevant government policy and have effect for the purposes of the Planning Act 2008. They will, therefore, continue to provide a proper basis on which the Planning Inspectorate can examine, and the Secretary of State can make decisions on, applications for development consent. Nothing in this white paper should be construed as setting a limit on the number of development consent orders which may be granted for any type of generating infrastructure set out in the energy NPS. Other restrictions outside the planning regime (in particular the Emissions Performance Standard) mean that no new coal infrastructure projects can come forward.

THE ECONOMIC BENEFITS OF CLEAN ELECTRICITY

The UK should harness more of the economic benefit from the accelerated deployment of renewable technologies. This will help position the whole of the UK to reap economic benefits.

- **We will support the delivery of the industry's target of 60 per cent UK content in offshore wind projects by 2030, through more stringent requirements for the CfD supply chain plan process.**

We will invest in the growth of the UK's offshore wind manufacturing infrastructure to create jobs and opportunity in the UK supply chain. We will use our Offshore Wind Sector Deal with the renewables sector to ensure that domestic deployment creates jobs and raises skills levels across the country, and to support overseas trade and investment opportunities for UK-based companies. We will require developers who are awarded a CfD, to honour their supply chain plans.

- **We have announced a £160 million scheme and launched a competitive process in early December to support the development of offshore wind manufacturing infrastructure.**

The £160 million funding announced in October 2020 and the competitive process launched in early December will support the development of major port-side infrastructure hubs, strengthening UK offshore wind manufacturing. This will have a major impact on our ability to develop a competitive UK supply chain for domestic and overseas markets.[71] It will help attract inward investment to manufacturing in the UK and increase our global competitiveness and expertise. The investment will support major new offshore wind manufacturing capacity which is needed to develop a competitive industrial base capable of servicing UK and international markets. Our Ten Point Plan set out how the investment alongside 40GW offshore wind will support the industry's target to achieve 60 per cent UK content by 2030.[72] And we will use it as the platform to target a five-fold increase in exports of offshore wind goods and services to at least £2.6 billion a year by 2030. The sector could bring £3 billion GVA a year by 2030, of which £1 billion is export related.[73]

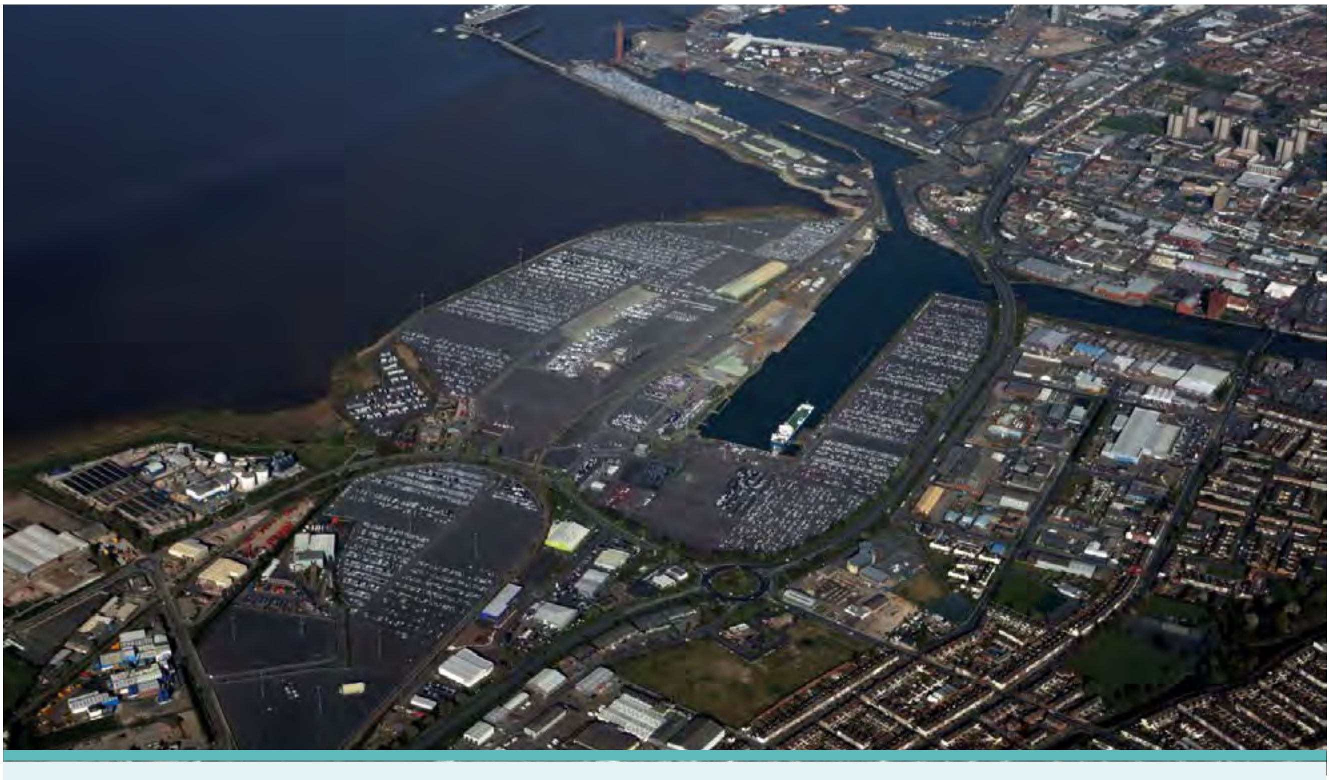
This new investment, could create around 2,000 construction jobs, representing high quality employment opportunities in many coastal regions around the country. This investment alongside other offshore wind commitments will enable the offshore wind sector to support up to 30,000 direct jobs and 30,000 indirect jobs in ports, factories and the supply chains by 2030.[74]

£2.6bn **target annual exports** of offshore wind goods and services by 2030

£7bn **contributed by the nuclear sector** to the UK economy in 2016

60,000 **direct and indirect jobs** could be supported by the offshore wind sector by 2030

The nuclear sector also makes a significant contribution to the UK economy - some £7 billion GVA in 2016.[75] The nuclear industry currently employs around 60,000 people.[76] Building, operating and decommissioning our nuclear assets takes place in some of the most remote areas of the UK. Developing the domestic supply chain for the sector has the potential to transform the prosperity of these regions. It provides high-value and skilled employment opportunities, unlocking investment to support infrastructure projects and growing manufacturing and industrial capability.



CASE STUDY: GRIMSBY PORT REVIVAL

North East Lincolnshire is home to the Port of Immingham which is the UK's largest port by tonnage - handling around 11 per cent of the UK's cargo.[77] It serves a diverse range of industries and is an international gateway.

Today Grimsby sits in the 10 per cent of England's most deprived regions,[78] however it has strong maritime history and the wider strengths in the energy sector. Its location close to the majority of the UK's offshore wind farm developments presents a major opportunity for the Port of Grimsby and the town with around £10 million being invested in the port and facilities.[79]

Since the first wind farms, notably Lincs and Lynn and Inner Dowling were built in 2009,[80] the Port of Grimsby has developed and is now recognised as the centre for operations and maintenance (O&M) services to the offshore wind farms. It is a major base for businesses such as Ørsted, E.ON, Innogy and GLID/Siemens These global leaders in offshore renewable energy offer many high skilled jobs for the area. The rapid growth of the renewable energy industry in the UK has presented new economic opportunities for Grimsby in the last decade. Ørsted recently opened its expanded O&M base, creating the world's largest O&M base, employing 350 people (83 per cent workers live within one hour's distance[81]), – with the port estimating that over 650 are employed on offshore wind O&M services.[82]

In addition, the Offshore Renewable Energy Catapult project, now based in Grimsby's Port Offices, plan to create a Centre of Excellence. This will serve as a leading testing facility for the development of next generation technologies benefiting the whole of the UK. Direct industry input into projects at the Operations and Maintenance Centre of Excellence is expected to be £90 million over the next 10 years.[83]

At Hinkley Point C, the developer expects that 64 per cent of the construction contracts, by value, will go to UK-based companies.[84] But the potential for the domestic supply chain beyond Hinkley Point C is greater than this, given the capability of UK companies across the nuclear lifecycle; from enrichment and fuel fabrication, through new-build construction, plant operation, world leading R&D, future nuclear technologies to waste management and decommissioning and final disposal.

In the Nuclear Sector Deal, we committed to help the UK supply chain become more productive and competitive.[85] This includes supporting established companies to strengthen their ability to compete for high-value work and we will reduce barriers to entry for innovative companies, especially Small and Medium-sized Enterprises. We are working with the sector to develop a national and regional supply chain productivity improvement programme to achieve these objectives and target at least £2 billion of domestic and export contracts for UK companies by 2030.

Our key commitments

We will **target 40GW of offshore wind by 2030**, including 1GW floating wind, alongside the expansion of other low-cost renewable technologies.

We will **support the deployment of at least one power CCUS project**, to be operational by 2030, and put in place the commercial frameworks required to help stimulate the market to deliver a future pipeline of power CCUS projects.

We will consult on steps to **ensure that new thermal plants can convert to low-carbon alternatives**.

We will **aim to bring at least one large-scale nuclear project to the point of FID** by the end of this Parliament, subject to clear value for money and all relevant approvals.

We will **provide up to £385 million in an Advanced Nuclear Fund** for the next generation of nuclear technology aiming, by the early 2030s, to develop a SMR design and to build an AMR demonstrator.

We aim to **build a commercially viable fusion power plant** by 2040.

By 2022, we will **establish the role which BECCS can play in reducing carbon emissions across the economy** and, as part of a wider biomass strategy, set out how the technology could be deployed.

We will **complete a review of the existing energy NPS** and designate updated NPS by the end of 2021.

We will **support the delivery of the sector's target of 60 per cent UK content in offshore wind projects by 2030**, through more stringent requirements for the CfD supply chain plan process.

We have announced a £160 million scheme and launched a competitive process in early December to **support the development of offshore wind manufacturing infrastructure**.

EXPLAINER

Modelling energy

SETTING THE SCENE

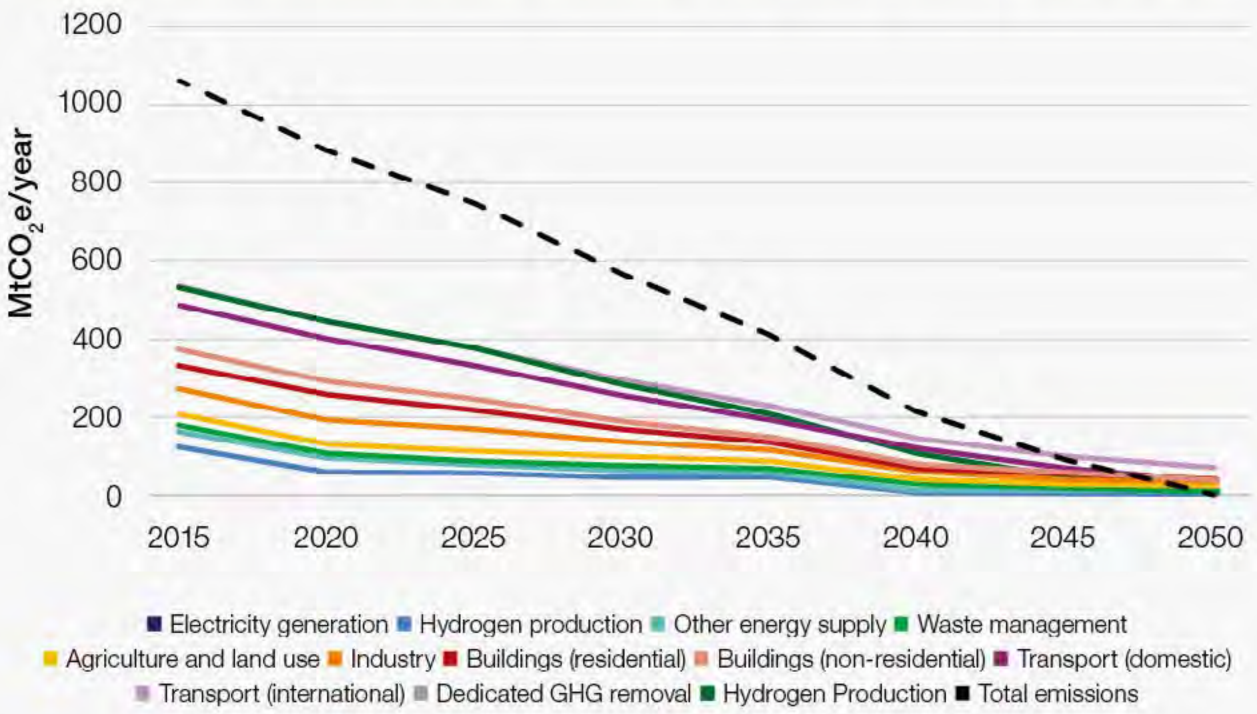
Developing the policies we need to achieve net zero is challenging. We need to manage uncertainties ranging from the cost of fuel, when and whether certain technologies will be available, and how people will behave when they are asked to use new ways of heating their homes.

To help us do so, we can use models of the economy and the energy system. These digital tools help us understand the linkages and interdependencies between different parts of the system and how our policies impact consumers.

The models we use perform functions ranging from strategic analysis of long-term decarbonisation to improving our understanding of how proposed policies will work in practice. For example, our Mackay Carbon Calculator provides illustrative pathways to reaching net zero by 2050 (figure 4.1).[86]

It is important that the results from models are understood and used correctly. This means reflecting uncertainties, being clear on assumptions and combining modelling evidence with, and testing it against, other forms of evidence.

FIGURE 4.1 – ILLUSTRATIVE PATHWAY TO NET ZERO EMISSIONS



Source: Mackay Carbon Calculator

Many of our models have been developed in-house and in close collaboration with academia. We now want to increase our ability to access the best modelling expertise available. We will implement a new modelling strategy that will increase transparency and collaboration. This will improve our insights and increase confidence in policy. We will build on the recommendations of the Energy Data Taskforce,[87] and have published the Mackay Carbon Calculator and the National Household Model.[88]

OUR LAST MODELLING STRATEGY

- **Consolidated and simplified** the "modelling landscape" by developing models that can support more than one policy;
- **Built collaboration** by
  - Developing academic links for long term energy modelling;
  - Publishing our 2050 Calculator & National Household Model;
- **Improved how we treat the many inputs** to our models; and,
- **Implemented standard quality assurance processes.**[89]

TRANSFORMING OUR MODELLING

Our modelling strategy will ensure our suite of models, data, assumptions and management processes are:

- **Effective** in supporting evidence-based policy making;
- **Accessible** for policy teams, open to all and trusted by the department and wider stakeholders;
- **Coherent** and coordinated;
- **Consistent** and / or transparent in the use of assumptions;
- **Efficient** in the use of resources; and
- **Robust** - capable of being maintained and meeting quality standards.

THE NEXT PHASE

The next phase of our modelling strategy will improve our approach to modelling:

- **Transparency:** We will set up and test a protocol for publishing our models. There will be specified exemptions such as models in development or models including with sensitive commercial or security information commercially.
- **Intra-energy system modelling:** We will review and update our long term, whole energy system models and their inter-operation with sector specific models, taking in the latest ideas from Digital Twins.[90]
- **Infrastructure:** We will develop and implement our IT strategy to make it easier for analysts, contractors and collaborators to develop and maintain models by harmonising development languages and providing a development environment for our partners.

THIS APPROACH WILL:

- Increase the **agility** of government decision and ensure policies to reflect the **best evidence** by:
  - Collaborating with a range of stakeholders on our modelling approaches and
  - Ensuring our models and their inputs adapt to a fast-changing market.
- Ensure our we **use the latest methodologies, software and technology** by continuing to invest in partnering to develop models of our energy systems.
- Stimulate **innovation**.

TO EXECUTE OUR STRATEGY:

- **We will improve and test the proposition of open sourcing models** by:
  - Developing a protocol for releasing our models
  - Developing an Open Modelling Environment to share modelling capability in a trusted space;

- Investigating providing an open access data source for the National Household Model;
- Opening access to a new version our long term energy systems model; developed in collaboration with University College London, and;
- Running modelling improvement competitions to leverage 3rd party knowledge - initially running a competition to improve econometric equations at the heart of BEIS Energy Demand Model – used to produce our Energy and Emissions Projections.[91]

- **We will establish a protocol for regular publication of quasi-statistical publications** such as Energy and Emissions Projections using voluntary application of the Code of Practice for Statistics.[92]
- **We have published an updated energy calculator.** The new calculator is named in honour of the late David Mackay. The Calculator was his brainchild. One important new feature will be the ability to alter start and finish dates for each lever. This is an important contribution for the global calculator community.

CHAPTER 03

Energy system

OUR GOAL

To deliver energy reliably, while ensuring fair and affordable costs and accelerating our transition to clean energy, we need to create investment opportunities across the UK to enable a smarter, more flexible energy system, which harnesses the power of competition and innovation to the full.

In partnership with the Office of Gas and Electricity Markets (Ofgem), we will:

- **Work to minimise the costs to consumers** of getting energy to homes and businesses, by promoting more innovation and competition in networks and in national and local energy markets
- **Ensure electricity networks are able to integrate increasing renewable generation** and more electric vehicles (EVs), while controlling system costs
- **Make sure that energy system information about supply and demand is used to drive greater efficiency and lower costs**, as well as promote more innovation and new services for consumers
- **Ensure that the system's rules and governing institutions support the transition away from fossil fuels** to clean energy

ENERGY SYSTEM

The strategic context

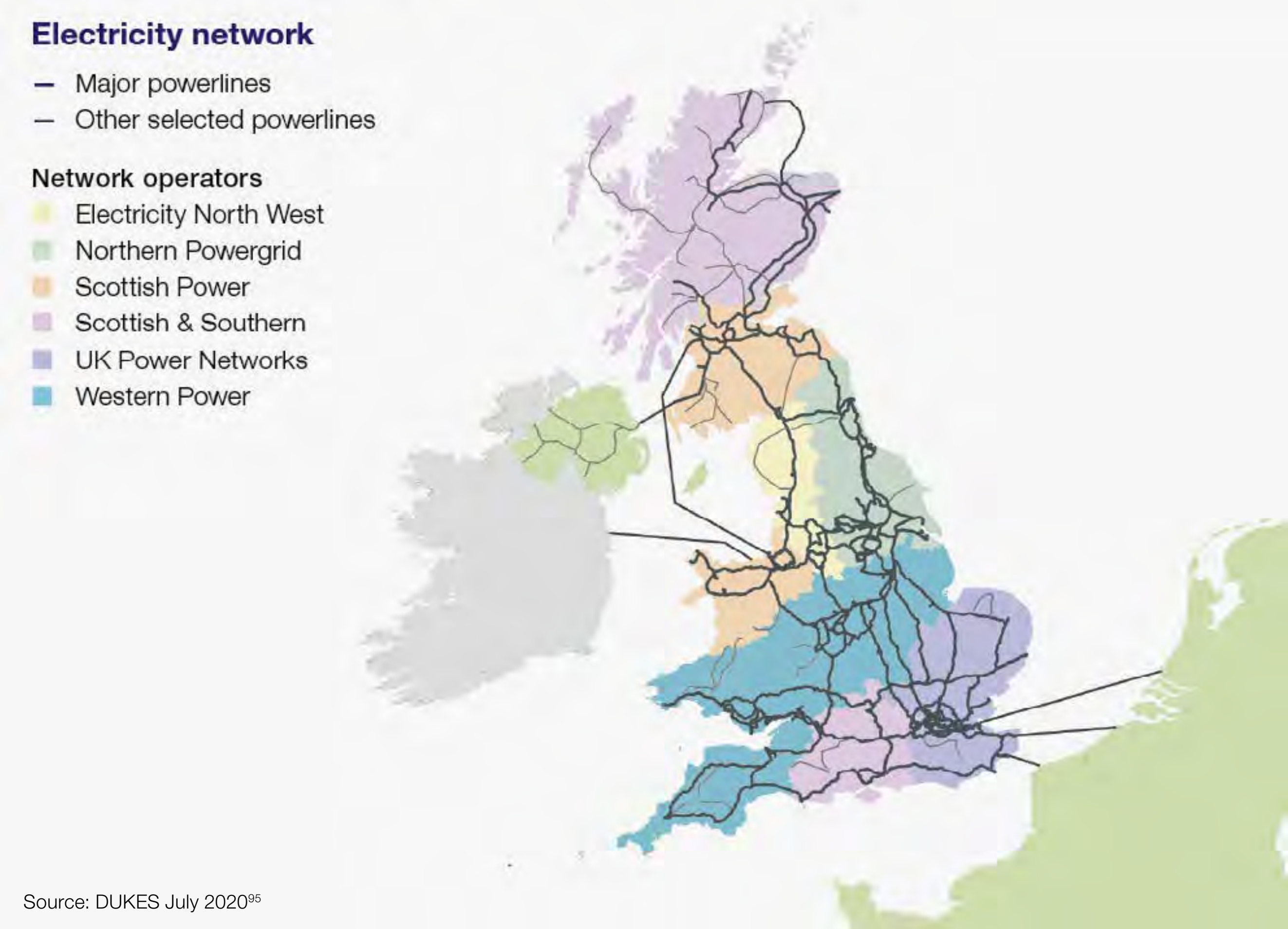
The UK's energy system is one of the most developed and successful anywhere in the world.

It was designed and built for the age of fossil fuels which, even today, are predominant in final energy use. Though they are now at record low levels, fossil fuels, primarily petroleum products and natural gas, still accounted for just over 79 per cent of energy supply in 2019, with electricity representing only 17 per cent of final energy use by consumers.[93]

This dependency on fossil fuels will change dramatically over the next 30 years. By 2050, electricity could provide over half of final energy demand, as it displaces petrol and diesel in cars and light vehicles and, to some degree, gas for heat in homes. As we set out in the 'Power' chapter, this could mean that electricity demand doubles from today's 345TWh.[94]

This change necessitates a very different approach, and not just because the energy system must support the deployment of clean energy technologies. It will also have to adapt to a world in which energy is far more decentralised.

FIGURE 5.1 - UK ELECTRICITY NETWORKS AND DISTRIBUTION AREAS



Source: DUKES July 2020[95]

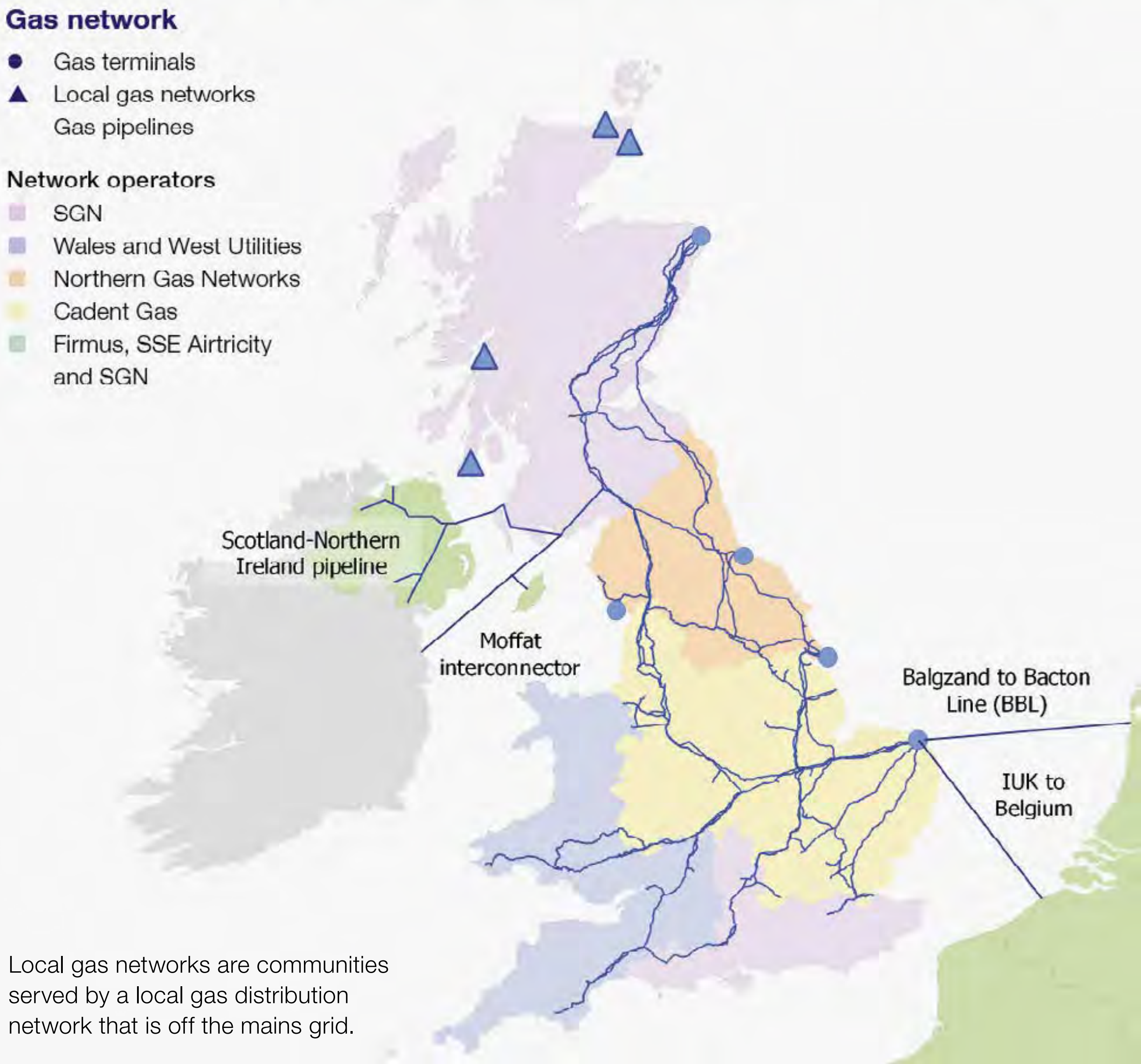
ELECTRICITY DISTRIBUTION NETWORKS

Smaller regional networks that transport electricity from the transmission lines and small-scale generators, into our homes and businesses – the ‘A and B roads’ of our energy network. There are 14 licenced distribution network operators (DNOs), owned by six different groups.

ELECTRICITY TRANSMISSION NETWORKS

The high-voltage networks that transport electricity across Britain and nearby offshore waters – the ‘motorways’ of our energy network. Owned and maintained by three different Transmission Owners (TOs) for England and Wales; southern Scotland; and northern Scotland and the Scottish islands groups, and by individual Offshore Transmission Owners (OFTOs) for the connections between offshore windfarms and the onshore grid.

FIGURE 5.2 - UK GAS NETWORKS AND DISTRIBUTION AREAS



Local gas networks are communities served by a local gas distribution network that is off the mains grid.

GAS DISTRIBUTION NETWORKS

Smaller regional networks that transport gas from the transmission pipes, into our homes and businesses. There are eight licenced gas distribution networks (GDNs), owned by four different groups.

GAS TRANSMISSION NETWORK

The high-pressure pipes that transport gas to smaller networks, or directly to gas power stations and large industrial consumers. Owned and operated by National Grid Gas plc (NGG).

Gas currently represents almost **30 per cent of final energy consumption** and 40 per cent of electricity generation

Demand will be satisfied as much by local solutions as by a nationally organised and operated system. Smart technologies, enabled by pervasive digitalisation, are already opening new possibilities, facilitating a transformation to faster and more efficient solutions which will only accelerate over the coming decade.

The switch to clean electricity has particularly profound implications. Separate networks for electricity, gas for heating and petrol or diesel for cars and vans, which today run independently of each other, will increasingly merge into one system, as electricity becomes the common energy currency. It puts new demands on electricity, to reflect how we use heat and power our cars and will require a new approach to how the system is managed. And the energy system will have to adapt further, to accommodate the production and use of clean hydrogen or the transport and storage of carbon dioxide from industry or power generation.

The costs of transporting energy and managing the balance between supply and demand make up around 25 per cent of an average household's energy bill currently.[96] As we move to clean energy, the system will comprise a more complex series of functions which it will need to discharge while keeping costs affordable.

79% of **energy supply** in 2019 came from **fossil fuels**

17% of consumers **final energy use was electricity**

>50% of final energy demand could be **provided by electricity** by 2050

The prize is an energy system which is not only cleaner but also smarter; one that gives customers more control, delivering the energy we need efficiently, and at a fair cost.

Securing this outcome requires a comprehensive approach, with evolution across all elements of the energy system so that it is fit for the future. It is not just about ensuring a cost-effective and resilient network of pipes and wires, critical though this is. It means exploiting a new digital infrastructure which will complement the system's physical infrastructure to liberate the potential of smart, flexible technologies.

THE SMART ELECTRICITY SYSTEM

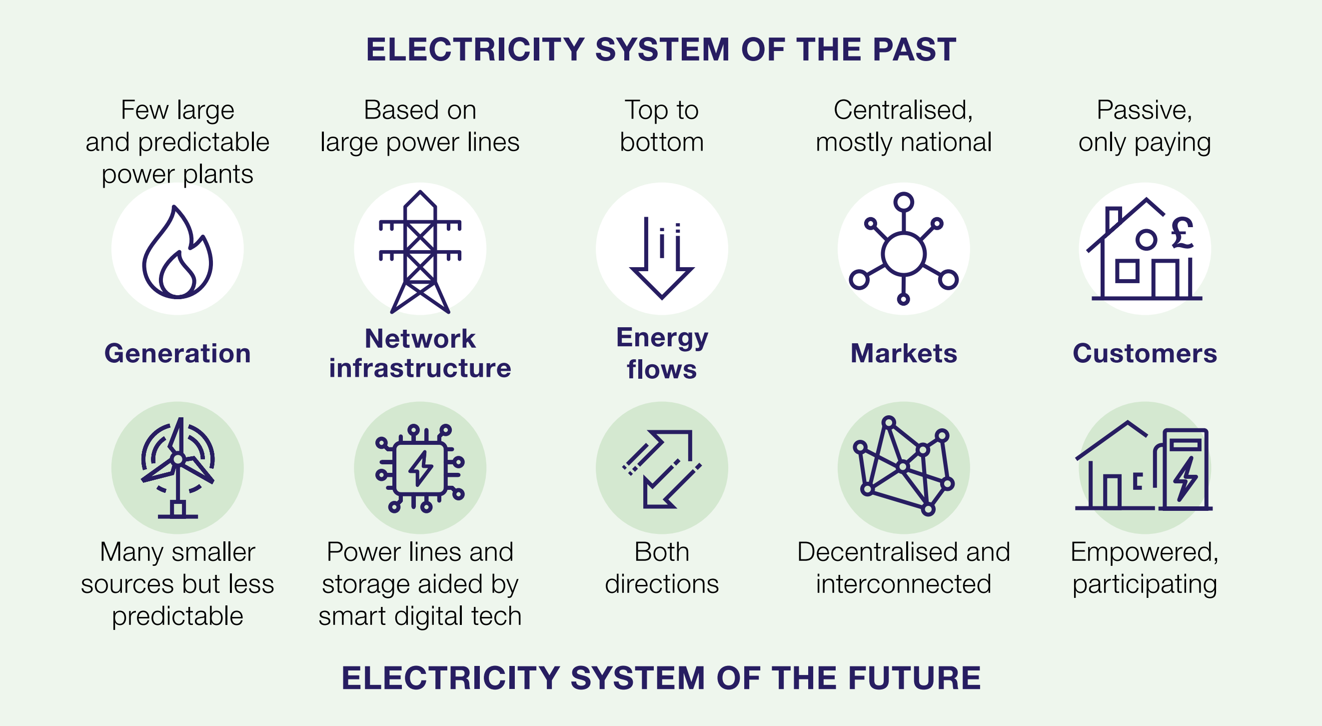
The electricity network is now becoming more decentralised.

This means there will be more numerous and smaller sites of generation across the country, not just the large, centralised power stations with which we are familiar. There will be new sources of demand, as millions of EVs and heat pumps connect to the system. A previously one-directional system is transforming into something more dynamic.

But it is not a matter of adding ever more generating capacity and cables. The transformation of the electricity system is an opportunity to exploit new forms of system flexibility in how energy is generated and consumed. This flexibility allows supply and demand to be shifted in time or location, so they are matched in the most efficient way – keeping costs down for consumers. For example, smart technology and time-of-use tariffs can help consumers charge EVs during off-peak periods – when energy is cheaper and cleaner.

Our analysis suggests that a smarter, more flexible system could unlock savings of up to £12 billion per year by 2050 (2012 prices), compared to a system with low levels of flexibility[97] – primarily because being able to respond more quickly and shift electricity around more easily means less generation and network needs to be built. This will lower costs for the customer of the future.

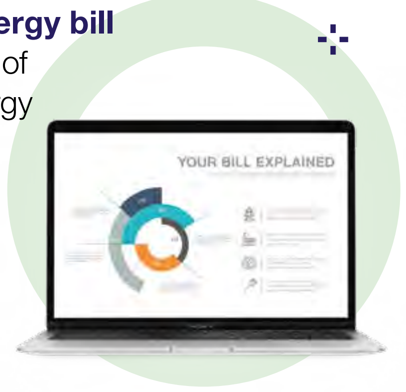
By 2050, the domestic market for smart systems and flexibility solutions, including EV smart chargers and smart network equipment, could contribute almost £1.3 billion to the nation's economy, with exports of these products and services adding a further £2.7 billion (2020 prices). The domestic market for smart systems equipment and related services could support 10,000 jobs by 2050, with a further 14,000 jobs supported by export markets.[98]



ELECTRICITY SYSTEM OF THE PAST		ELECTRICITY SYSTEM OF THE FUTURE
Few large and predictable power plants	**Generation**	Many smaller sources but less predictable
Based on large power lines	**Network infrastructure**	Power lines and storage aided by smart digital tech
Top to bottom	**Energy flows**	Both directions
Centralised, mostly national	**Markets**	Decentralised and interconnected
Passive, only paying	**Customers**	Empowered, participating

We have to instil competition deep into the operation of our energy markets to drive cost reductions and open the system to innovative new services for the benefit of consumers, while also incentivising the significant private sector investment that will make it possible to update our energy system. And we need an approach to managing the operation of the system which is flexible and responsive, and aligned to the demands of a net zero future.

Around 25% of the average consumer's energy bill is from the costs of transporting energy and balancing supply and demand



Our key commitments

EFFICIENT ELECTRICITY MARKETS

Electricity markets need to adapt as the deployment of renewable generation increases.

Balancing supply and demand becomes more complex because most renewables are, by their nature, intermittent and generate electricity only when the wind blows or the sun shines.

Gas-fired power stations have traditionally provided the flexibility needed to match supply to demand at peak hours, or when renewables output is low. Increasingly, flexibility will come from new, cleaner sources, such as energy storage in batteries, increased interconnected capacity from neighbouring electricity markets, or from consumers using smart technologies to reduce how much energy they use or shift when they use the energy to different times in the day. New forms of flexibility could lower future costs for consumers, by minimising expensive network reinforcement or reducing the need for additional generation, especially peaking capacity which needs to be deployed quickly to meet spikes in demand.

ELECTRICITY SYSTEM OPERATOR

The whole transmission system is operated by a single Electricity System Operator (ESO), who is responsible for keeping it stable and secure. National Grid ESO perform this function.

- **We will publish a new Smart Systems Plan in spring 2021, jointly with Ofgem, and define electricity storage in law, legislating when Parliamentary time allows.**

We need open, competitive markets which harness the full value of flexibility. In 2017, the government and Ofgem published the first Smart Systems and Flexibility Plan.[99] We have implemented two-thirds of the policies in the plan and are on track to deliver it in full by 2022, removing barriers to energy storage, enabling smart homes and businesses and properly rewarding providers of flexibility services. But we are now ready to take the next step in driving flexibility deep into the energy system.

In partnership with Ofgem, we will publish a new Smart Systems Plan in spring 2021, which will include a new framework for monitoring flexibility across electricity markets. We will legislate when Parliamentary time allows to define electricity storage in law, removing another barrier to flexibility.

- **Through the Net Zero Innovation Portfolio, we will launch a major competition to accelerate the commercialisation of first-of-a-kind longer duration energy storage, as part of our £100 million investment in storage and flexibility innovation, with delivery from spring 2021.**

Storing excess low-carbon generation over longer periods of time could enable us to decarbonise the energy system more deeply at lower costs.

Novel energy storage technologies show promising cost reductions[100] but some have yet to be demonstrated at scale. First-of-a-kind demonstrations are required to enable cost reduction and de-risk private investment. The Prime Minister's Ten Point Plan announced a further £100 million to address energy storage and flexibility innovation challenges, one of the key priority areas in the over £1 billion Net Zero Innovation Portfolio.

To promote energy storage innovation, we will further accelerate the commercialisation of innovative technologies, excluding proven technologies such as lithium ion and pumped hydro storage. Our support will build on the success of previous funding under the current Energy Innovation Programme.

It will focus on long-duration storage technologies that could be deployed at large scale and provide novel services or system benefits. The first competition to address energy storage and flexibility innovation challenges will be launched in spring 2021 with stakeholder engagement and information days.

Some flexibility solutions could be better delivered through local markets, in which organisations with a more in-depth knowledge of their communities can provide solutions to local need more quickly than responses at the national level. But local and national actions need to complement one another. We will work towards a market framework which ensures that national and local electricity markets are fully co-ordinated and satisfy the full suite of system requirements. We look to the Electricity System Operator (ESO), Distribution Network Operators (DNOs) and market participants to work closely together to facilitate this enhanced co-ordination, and government will keep progress on this under review to ensure the system enables optimal levels of flexibility.

DNOs, the companies which own the regional electricity networks, are already creating local flexibility markets. In 2020, they awarded contracts for around 1.2GW of flexibility services, including the first contracts to provide local services which pay households for using the aggregated electricity capacity from a collection of domestic batteries.[101] We will encourage more local solutions and open up as many services as possible to competition. We expect network operators to go much further, fully opening their networks to flexibility technologies while mitigating real or perceived conflicts of interest.

CASE STUDY

Creating New Marketplaces

Piclo Flex is an independent flexibility marketplace which allows DNOs and flexibility providers to find and contract with each other. It enables distributed resources such as electric vehicles or battery energy storage to identify where flexibility is needed via a dashboard, receive notification of relevant auctions, and bid for DNO payments. Overall, the platform helps to identify flexibility market opportunities and lowers barriers for entry for flexibility providers.

As part of the £505 million BEIS-funded Energy Innovation Programme, Piclo is now expanding its platform to support trading with the ESO, as well as trading between flexibility providers. Another competition winner, Electron, are also creating innovative digital solutions for flexibility trading.

Actions should include steps to implement standardised flexibility products as soon as possible and ensure that distributed flexibility is able to participate in all markets. We will keep open the option of legislating in support of local flexibility markets, should DNOs fail to make sufficient progress.

Due to the unique characteristics of electricity, there is a need to match supply and demand on a second-by-second basis. The government works in partnership with the ESO and Ofgem to ensure the reliable operation of the system and the security of electricity supplies. Security of supply will always be a priority, but our approach must also adapt to reduce carbon emission and costs.

Our markets should also incentivise the integration of the different types of energy assets which are now connecting to the energy system. We expect Ofgem and the ESO to ensure existing balancing services are fully transparent and competitively procured, while enabling new markets to emerge. We support the steps which they are taking to facilitate wider access to balancing services and embed more efficient processes into the operation of balancing markets, including establishing closer-to-real time markets and enabling greater automation.

As well as making sure the system is stable on a day-to-day basis, we need the assurance over the course of each year that there is enough generation capacity to satisfy even exceptional periods of demand or to back-up renewables when the wind does not blow, or the sun is not shining. The Capacity Market (CM) is our primary policy mechanism for delivering this security of electricity supply. It provides generators and flexibility providers with a payment for reliable capacity to ensure they deliver more electricity, or reduce demand, when required.

To date, the CM has supported investment in over 10GW of new capacity, including smart technologies such as battery storage and demand-side response.[102] We have made a number of reforms since its introduction in 2014, such as allowing certain renewables to participate and implementing carbon emissions limits in future auctions. In our five-year review, published in 2019, we committed to retaining the CM as a guarantee of system reliability and to making further incremental improvements to its design.[103] The next review will take place by 2024. We will ensure that the mechanism acts in concert with other markets to incentivise investment in the right type of capacity, in the right place at the right time.

Over the longer term, as generation moves towards a predominantly renewables mix, we want electricity markets to incentivise the right behaviours from generators and offer value for money to consumers, while continuing to ensure low-carbon solutions can deploy at the scale needed for net zero emissions. Our current market framework emphasises the cost of fuels such as gas and coal, but renewable technologies, such as wind, do not use fuel at all. It is also poor at valuing some services which will become increasingly important to the system, such as local balancing.

Increasing levels of renewable generation are likely to impact wholesale market prices and the ways in which markets determine which assets can most efficiently dispatch power, or reduce use, to balance the system. We need markets to incentivise both significant levels of new investment and efficient operation, in a system which mixes existing generation with increasing levels of renewables and the flexible technologies which complement them. We will support the technologies required for this transition and look for ways to adapt our policies to reflect emerging market dynamics; for instance, through our call for evidence on the future of renewable support schemes, published alongside this white paper, and in our new Smart Systems Plan, to be published in spring 2021. Beyond this, we will consider how our policies should continue to evolve, developing our approach as required in consultation with industry and other stakeholders.

NETWORK INFRASTRUCTURE

Electricity and gas transmission networks transport energy large distances around the country, while regional distribution networks connect our homes and places of work to the grid.

The vast majority of households are connected to the electricity network. The relatively few homes that are off grid, have their own electricity generator and might self-generate, using solar photovoltaics for example. Britain's gas network is one of the most efficient, resilient and advanced operations in the world, connecting over 23 million users through 284,000 km of pipelines.[104] Around four million households live off the gas grid, many of them in remote locations and using stored oil or gas for heating and for hot water.[105]

Britain has been at the forefront of introducing competition to networks and regulating these natural monopolies. This approach has served consumers well, promoting innovation, and lowering costs. Since privatisation, our gas and electricity networks have become more resilient and delivered better value for customers. The cost of transporting a unit of electricity has fallen by 17 per cent since the mid-1990s, while investment has increased. Reliability and customer service have improved, and the number of power cuts has almost halved.[106]

The transformation of our energy system will require growing investment in physical infrastructure, to extend or reinforce the networks of pipes and wires which connect energy assets to the system and maintain essential resilience and reliability. As well as creating a low-carbon system we need enhanced preparedness for climate risks. Government is supporting the efforts of key stakeholders in this important endeavour.

Under the Climate Change Act's Adaptation Reporting Power over 90 organisations have committed to report on their preparatory actions by the end of 2021, including those responsible for electricity generation, and the transmission and distribution of gas and electricity.[107]

While the gas network will need continual updating, the electricity network faces a complete step-change in approach and scale. Working with Ofgem, we need to deliver investment in our existing electricity network at the lowest possible cost to consumers while ensuring the network can keep pace with burgeoning demand for power, for example, from the accelerated adoption of EVs and heat pumps.

- **We will legislate, when Parliamentary time allows, to enable competitive tendering in the building, ownership and operation of the onshore electricity network.**

We need market and regulatory frameworks which promote greater competition and more innovation in the construction and operation of energy networks. Competition in network assets is key to reducing network costs. Since 2009, awarding the ownership and operation of offshore wind network connections through a competitive tender process is estimated to have saved consumers in excess of £800 million.[108] We now need a similar competitive regime for onshore networks, where currently only incumbent network operators can build, own and operate network assets.

Britain's gas network connects 23 million users through 284,000 km of pipelines

Allowing other parties to compete for onshore network projects will deepen the pool of capital available for the significant amount of investment needed in our networks as we transition to clean energy. Competitive pressure in these networks will improve efficiency, saving consumers more money, and encourage further innovations in system design and operation. It will also provide Ofgem with better price information, which it can utilise in setting its periodic price control mechanism.

We therefore intend to introduce legislation, when Parliamentary time allows, to enable competitive tendering for building, owning and operating onshore electricity network assets. We intend the legislation to allow the Secretary of State to appoint an appropriate party to run the tender processes. We propose that competitive tendering could be opened up at the distribution network level, as well as in the transmission network, should evidence suggest that this will secure value for consumers. This competitive regime will extend widely, addressing network constraints across Wales, Scotland and England. We also intend to open network innovation funding to third parties and encourage more whole-system innovation in gas and electricity networks. We will consider amending legislation to achieve this, should it be necessary.

- **We will support the rollout of charging and associated grid infrastructure along the strategic road network, to support drivers to make the switch to EVs ahead of the phase out of the sale of new petrol and diesel cars and vans by 2030, and hybrids with significant zero emission capability by 2035.**

Following extensive consultation with car manufacturers and dealers, the Prime Minister has confirmed that the UK will end the sale of new petrol and diesel cars and vans by 2030, ten years earlier than planned. The sale of hybrid cars and vans that can drive a significant distance with no carbon emissions will continue until 2035.

This accelerated transition requires scaling-up the rollout of EV chargepoints and, in turn, an associated expansion in electricity generation and network capacity, to meet the increase in demand for power. With the necessary investment in new infrastructure and the adoption of smart charging, we are confident that the system will cope with the transition.

As part of a £2.8 billion package announced in the Prime Minister's Ten Point Plan, the government will provide funding of £1.3 billion to accelerate the rollout of chargepoints for EVs in homes, workplaces, streets and on motorways across England, so people can more easily and conveniently charge their cars. We will invest £950 million of this funding in future proofing grid capacity along the strategic road network, to prepare ahead of need for 100 per cent take-up of zero emissions cars and vans.

CASE STUDY

EV Charging on the Strategic Road Network

Over 95 per cent of people in England use the Strategic Road Network at least once a year.[109] We will support the roll out of charging infrastructure along England's Strategic Road Network by investing £950 million in future proofing grid capacity at motorway and major A road service areas. This will ensure the private sector can continue to expand the charging network at pace in the 2020s.

By 2030, we expect the network to be extensive and ready for more people to benefit from the switch to electric cars. We are planning for there to be around 2,500 high powered chargepoints across England's motorways and major A roads. By 2035 we expect around 6,000 high powered chargepoints across England's motorways and major A roads.[110] This will be a vital investment for our future, and key to reducing consumer anxiety about long-distance journeys.

We expect the mass uptake of EVs to create significant new demand for power, but it also represents an opportunity for enhanced system flexibility. Smart charging can help mitigate peak demand; for example, charging overnight rather than in the early evening when an EV owner might plug in their vehicle after returning home from work but also the time when electricity demand tends to peak. Vehicle-to-grid technology can then utilise the electricity stored in car batteries to supply power or services to the grid during periods of high demand. To capture these system benefits, the deployment of charging infrastructure needs to run ahead of the uptake of EVs. Only then will consumers have the confidence that they can charge their vehicles conveniently and cost-effectively.

The Prime Minister's Ten Point Plan also set an ambition to reach 600,000 electric heat pump installations per year by 2028, as one option to accelerate the decarbonisation of heating. Along with the rollout of EVs, the electrification of heat will further drive the need for anticipatory investment in the network but equally create opportunities to exploit system flexibility. Deployed in conjunction with storage and smart meters, heat pumps are able to avoid periods of high demand, benefitting the grid, and reducing running costs.

We are working closely with Ofgem to ensure that the regulator's network price control mechanism enables the investment needed in EV charging infrastructure, heat pumps and other low-carbon technologies. Price control must be as agile as possible in approving future network upgrade projects when the need becomes clear, while keeping costs down, now and in the future.

Given the key role of electricity distribution networks in being able to accommodate low-carbon technologies such as EVs and heat pumps, the government wrote to Ofgem in October 2020 to outline relevant policy in advance of Ofgem setting its final methodology for the next distribution price control, which covers the period 2023 to 2028.[111] Our letter highlighted the importance of appropriate investment to enable timely connection of new low-carbon technologies, and gathering and sharing the data needed to optimise the use of networks. We are also working with Ofgem, and partners across the energy and transport systems to address barriers which can prevent the efficient connection of chargepoints to the electricity grid. This will include ensuring there is easily accessible and accurate information for commercial customers on the costs and opportunities of rolling out chargepoints in different locations, to give them confidence to make informed choices around the switch to EVs.

Interconnection increases the ability of the GB electricity market to trade with other markets, enhances the flexibility of our energy system and has been shown to have clear benefits for decarbonisation. Alongside this white paper, we are publishing a report into the impact of interconnectors on decarbonisation, which demonstrates how a higher level of interconnector capacity could decrease cumulative emissions in Great Britain by up to 199MtCO_2e by 2050, as well as reducing total system costs.[112]

We will work with Ofgem, developers and our European partners to realise at least 18GW of interconnector capacity by 2030. This represents a three-fold increase from current levels and will position us as a potential net exporter of excess green energy, helping to keep wind turbines generating even when GB electricity demand has been met.

- **To minimise the impact on local communities, we will implement a more efficient approach to connecting offshore generation to the mainland grid.**

The current regime for connecting offshore wind farms to the onshore grid has encouraged single point-to-point connections. Each project has a separate cable route and associated onshore infrastructure. We recognise the impact this is having on the coastal communities which host this infrastructure and will act quickly to take the necessary steps to address the situation, particularly given our ambition to have 40GW offshore wind by 2030. We have launched the Offshore Transmission Network Review to improve the delivery of transmission connections for offshore wind generation.[113] This will consider the full impacts on affected communities, particularly on the east coast of England, while making sure the whole of the UK benefits from a more strategic approach.

The review will seek the appropriate balance between environmental, social and economic costs. It will also consider the potential of hybrid, multi-purpose interconnectors, which are already being explored by developers in the UK and the Netherlands, to get the most from our offshore wind and transmission assets. These hybrid projects could integrate the transmission links we need to connect offshore wind to our grid with interconnectors to neighbouring markets.

40GW **offshore wind by 2030** is our ambition

£6bn **in consumer savings** could be delivered by 2050

These projects would allow us to sell excess green power in other markets, or, when our wind output is low, import electricity through cross-border trade.

Initial outputs from the ESO, delivered as part of the review, have shown that taking a more coordinated approach could deliver up to £6 billion in consumer savings by 2050, significantly reducing environmental and social impacts on coastal communities.[114] This analysis showed benefits not just for the east of England, but also Scotland and Wales. We are working closely with the Scottish and Welsh Devolved Administrations through the review.

In order to start delivering these benefits, we will encourage projects already in development, where early opportunities for coordination exist, to consider becoming pathfinder projects. This will help inform the design of the enduring regime. We will consider changes to the current regulatory framework which enable developers to implement innovative approaches, including on anticipatory investment. For the 2030s and beyond, we will redesign the current regime to incentivise more extensive coordination and minimise environmental, social and economic costs.

DIGITAL INFRASTRUCTURE

We need a modern digital infrastructure to underpin markets and optimise physical networks. This requires new ways of creating, collecting, analysing and sharing energy data from different sources.

- **We will build world-leading digital infrastructure for our energy system, based on the vision set out by the independent Energy Data Taskforce, publishing the UK's first Energy Data Strategy in spring 2021, in partnership with Ofgem.**

Data will help us to discover cheaper ways of delivering the energy we need by making information available to those who can provide solutions to reduce costs and improve services to consumers. For example, better data can help local authorities make the best decisions about where to install chargepoints for EVs.

Open and secure data is also essential to the efficient integration of low-carbon technologies, such as solar panels, heat pumps and batteries, into our electricity networks. Information about the scale and nature of demand, the capability of networks, or the location and size of generation and storage capacity will enable markets to optimise the use of assets across the system. This information can be combined with data from transport, homes and commercial buildings to enable whole-system strategic planning and investment decisions. Smart meter data can help DNOs to identify system constraints and enable them to direct investment more efficiently, including where network reinforcement is required to support an increase in heat pumps or EVs.

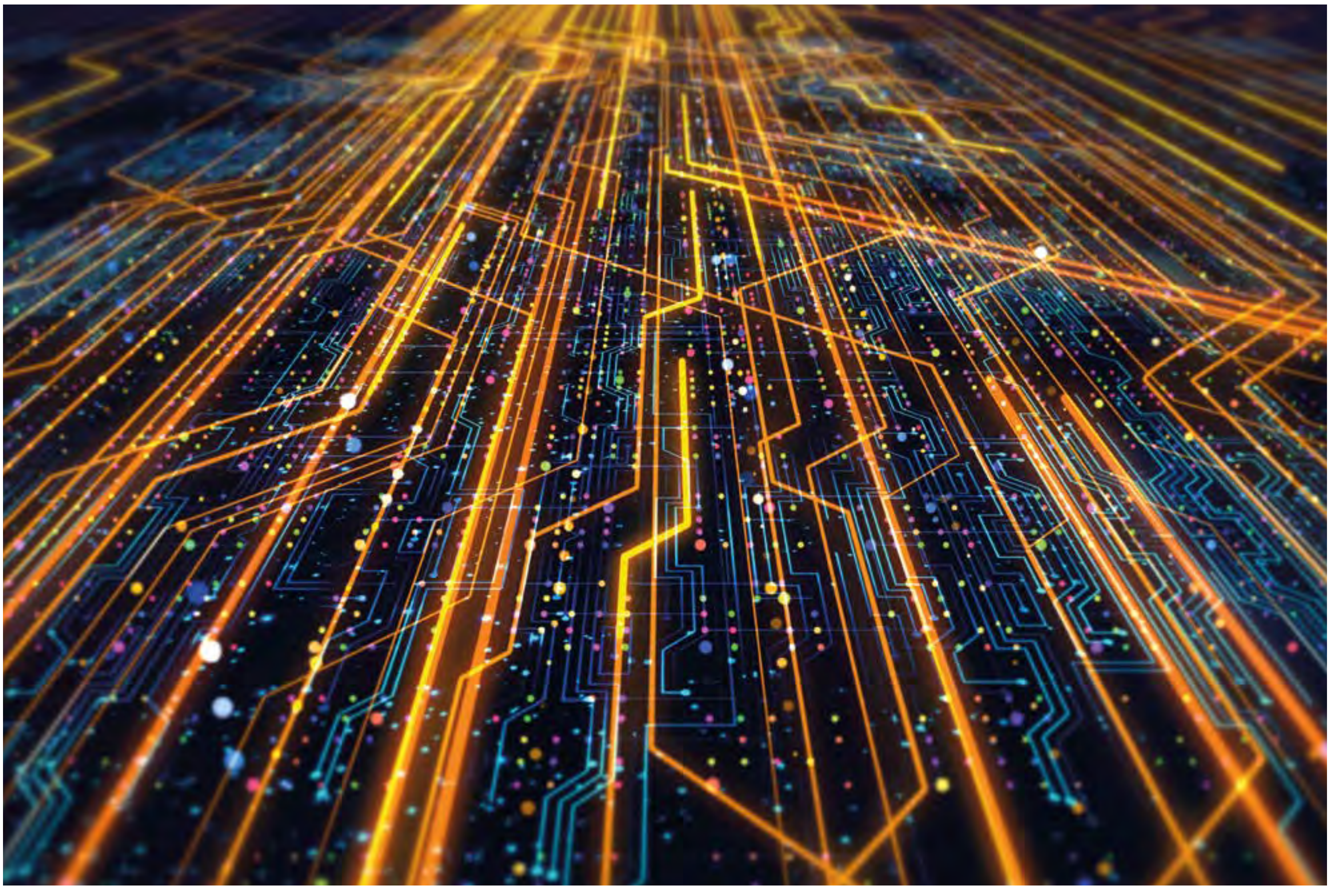
In all such activities, we will ensure that new technologies are introduced in a way that empowers consumers and protects their data at all times.

CASE STUDY

Batteries and Machine Learning

Habitat Energy are using artificial intelligence and machine learning to provide optimisation and trading services to owners of battery storage and other flexible energy assets. Habitat uses algorithms to process data from individual assets and trading platforms to optimise the batteries across multiple markets.

This data-driven approach maximises the revenue that can be achieved while also carefully managing the degradation of the battery to preserve asset life. Improved co-ordination between markets and better quality data about network condition and performance enable innovators like Habitat to optimise assets to meet system needs, thereby reducing costs for consumers.



In 2018, the government and Ofgem launched the independent Energy Data Taskforce. The Taskforce's final report in 2019 highlighted how the move towards a modern, digital energy system is being hindered by poor quality or missing data, while data which is valuable can be hard to find or subject to restricted access.[115] The report set out a strategy to fill data gaps, improve the quality of data and make data more open.

We are implementing all of the Taskforce's recommendations through 'Modernising Energy Data', a joint programme with Ofgem and Innovate UK. We will publish an energy data and digitalisation strategy jointly with Ofgem in spring 2021. The strategy will set out the progress that we have made against specific recommendations and show how better use of data is realising our objective of a fully digital and clean energy system.

Our approach will be aligned with the overarching principles set out in the National Data Strategy and aims to help establish the energy sector's role in growing the UK's data economy.[116]

The Taskforce showed that a lack of access to energy data creates a barrier to innovation in the new technologies and services required to achieve net zero emissions. We are therefore creating a national energy data catalogue to make data more visible and reduce the costs of accessing this information. A prototype of the service will be launched by summer 2021. Market participants will be able to use this data to identify opportunities for creative new solutions, such as supplying more efficiently groups of customers who have similar needs.

Data owners often default to not sharing the information they create. We will develop a 'data triage' process which provides practical support to energy companies for making data more readily available, while ensuring cyber-security and data privacy. It will represent a clear guide for market participants on how to share data appropriately. Ofgem will consult on this guidance and associated licence conditions by summer 2021. It will complement the digitalisation strategies of the network companies which have recently been published to set out operators' plans for improving the use of data.

We will also develop the tools and processes which allow innovators to make full use of the data once they have access to it. The Modernising Energy Data innovation competitions will enable providers of new services to link energy data with information from other sectors such as transport, heat and buildings, integrating the UK's different infrastructure.[117]

For example, the £2 million Modernising Energy Data Access competition will help develop the digital structures needed for innovators to build new apps and products that are compatible across different systems and sectors. The early outputs from these competitions are expected to be available by autumn 2021.

As the energy system becomes increasingly reliant on digital technologies, cyber security will be ever more important for the stability and security of the energy system. Our smart metering system has already been developed with security experts from government and industry and we will continue to ensure cyber security plays a key role in the actions we are taking to facilitate a smart, digital and secure energy system.

OUR COMMITMENTS TO MODERNISE ENERGY SYSTEM DATA

Getting data into the open

A clear new process to guide industry

Making sure data is easy to find

Open-access Energy Data Catalogue

Fully harnessing the value of data

Government-funded Modernising Energy Data innovation competitions

UK's first Energy Data and Digitalisation Strategy

THE ROLE OF NATURAL GAS

Gas currently represents almost 30 per cent of final energy consumption and 40 per cent of electricity generation.[118]

We will continue to rely on natural gas for some years, even as we work to largely eliminate carbon emissions from the entire energy system including those from gas.

- **We will consult on updates to the Gas Act to ensure we decarbonise gas supplies while continuing to provide the right price signals to market participants.**

We will therefore make sure the natural gas markets and networks evolve in a way which enables continued investment and ensure secure supplies but also promotes the use of low-carbon options, wherever possible. This will reduce emissions now and help build the networks of the future which will need to accommodate technologies such as hydrogen and Carbon Capture, Usage and Storage. We will need investment in the gas network to support the ambition set out in the Prime Minister's Ten Point Plan for a potential Hydrogen Town before the end of the decade.

But while natural gas continues to play a role in powering and heating our homes, we will need to maintain security of supply and ensure network operators have the right market and regulatory signals to ensure the necessary levels of investment in resilient, efficient infrastructure.

GAS SYSTEM OPERATOR

The whole transmission system is operated by a single Gas System Operator (GSO), who is responsible for keeping it stable and secure. National Grid Gas Transmission (NGGT) perform this function.

Our gas markets operate effectively but it is important they continue to provide the right incentives consistent with our overall strategic goals. We will therefore review the overarching market framework set out in the Gas Act to ensure the appropriate powers and responsibilities are in place to facilitate a decarbonised gas future. This will include a review of gas quality standards to enable the widest range of gasses to be used to decarbonise energy. We will work with Ofgem to remove distortions within the gas market, such as reviewing the Domestic Load Connection Allowance which acts as a subsidy for extensions to the gas grid rather than allowing competition with other lower carbon options. These changes are important to make sure the right price signals are in place to maintain security of supply while also enabling the decarbonisation of gas.

Starting in 2021, through a series of workshops and consultation, we will work with network operators, suppliers and consumer groups on the future of gas as we transition to a clean energy system. Our dialogue with stakeholders will also consider the implications for networks, gas wholesale and retail markets and for final energy use by consumers.

ENERGY SYSTEM INSTITUTIONS AND GOVERNANCE

The markets and networks that deliver our energy are governed by a series of standards and rules.

Our current standards are geared to the safety of our energy system and the rules we have in place protect customers and ensure fair competition. This process is overseen by institutions including Ofgem, and the system operators who keep supply and demand in balance.

- **We will ensure that the institutional arrangements governing the energy system are fit for purpose for the long term, consulting in 2021 over organisational functions, including system operation and energy code governance.**

Our approach to system governance needs to evolve. The roles of Ofgem, the electricity and gas system operators and the transmission and distribution network operators still largely reflect the model from 30 years ago and need to be updated. As we decarbonise the energy system, the regulator, networks, industry and government will need to work together to consider the potential solutions.

Interactions within the energy system are becoming more complex. The system operators need to take on new responsibilities and the regional network owners need to play a more proactive role in delivering an open, flexible and efficient system.

We need the operation of national and local energy markets to be managed impartially, without conflict of interest, ensuring they are fully open to competition. We need a robust process for setting and enforcing system rules, an approach which ensures that the rules promote competition and innovation, not act as a barrier to change. There is also a need for a greater co-ordination to drive collaboration between different parts of the energy system which are currently too siloed.

We need to consider, at both the transmission and distribution level, whether the roles which discharge these functions are undertaken by government, Ofgem, industry parties such as the system operator, or by an entirely new body. We will review the right long-term role and organisational structure for the ESO, in light of the reforms to the system operator instituted in April 2019. It is possible that there will need to be greater independence from the current ownership structure, should it be appropriate to confer additional roles on the system operator.

These new roles should help the system achieve our net zero ambitions and meet consumers' needs. Without them, we risk having an energy system which makes less effective investment and operational decisions, resulting in excessive costs for consumers or a failure to reduce emissions in line with our net zero target.

The detailed technical and commercial rules of the energy system, established in a collection of codes and engineering standards, also need an overhaul to ensure that they are fit for purpose as we transition to a clean energy system. Many rules have only seen minimal change since the 1950s.

We will consider the best future framework for energy codes and consult on options for reform in 2021, building on the government and Ofgem's joint review of code governance[119] and the work of the independent panel on engineering standards.[120]

Ofgem is clear that helping to deliver a clean energy system consistent with net zero emissions protects consumers' interests, which is Ofgem's principal statutory objective. However, as the pace of this transformation accelerates, it will be important that Ofgem has clear sight of the government's policy priorities for the decarbonisation of energy, including how we approach the electrification of road transport and heat.

- **We will set out our vision for energy as a guide to Ofgem, by consulting in 2021 on a Strategy and Policy Statement for the regulator.**

The Strategy and Policy Statement will set out the strategic priorities of our energy policy, the outcomes we seek to achieve and the roles of government, Ofgem and other parties which are collectively responsible for delivering these goals. Subject to Parliamentary approval, the Strategy and Policy Statement will require the Secretary of State and Ofgem to carry out their regulatory functions in a manner which is consistent with securing the government's policy outcomes, including delivering a net zero energy system while ensuring secure supplies at lowest cost for consumers. This will enable not just Ofgem, but energy consumers and industry as well, to better understand the government's ambitions for the energy sector.

Our key commitments

We will **publish a new Smart Systems Plan in spring 2021**, jointly with Ofgem, and define electricity storage in law, legislating when Parliamentary time allows.

Through the Net Zero Innovation Portfolio, we will **launch a major competition to accelerate the commercialisation of first-of-a-kind longer duration energy storage**, as part of our £100 million investment in storage and flexibility innovation, with delivery from spring 2021.

We will legislate, when Parliamentary time allows, **to enable competitive tendering** in the building, ownership and operation of the onshore electricity network.

We will **support the roll out of charging and associated grid infrastructure along the strategic road network**, to support drivers to make the switch to EVs ahead of the phase out of the sale of new petrol and diesel cars by 2030, and hybrids by 2035.

To minimise the impact on local communities, we will **implement a more efficient approach to connecting offshore generation to the mainland grid**.

We will **build world-leading digital infrastructure for our energy system**, based on the vision set out by the independent Energy Data Taskforce, publishing the UK's first Energy Data Strategy in spring 2021, in partnership with Ofgem.

We will **consult on updates to the Gas Act**, ensuring we decarbonise gas supplies while continuing to provide the right price signals to market participants.

We will **ensure that the institutional arrangements governing the energy system are fit for purpose for the long term**, consulting in 2021 over organisational functions, including system operation and energy code governance.

We will **set out our vision for energy as a guide to Ofgem**, by consulting in 2021 on a Strategy and Policy Statement for the regulator.

EXPLAINER

Transport

SETTING THE SCENE

Transport is an important aspect of our everyday lives and fundamental in connecting us together.

Our cars, buses, trains and planes allow us to travel long distances to meet with our families, friends and colleagues; and our lorries, vans, and ships ensure our goods and mail are delivered safely to our businesses and homes.

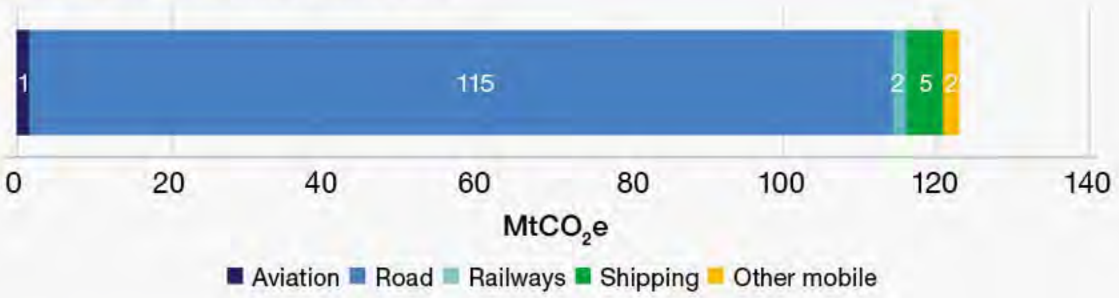
Yet while transport helps to connect people and places, boosting economic growth and opportunity, it now contributes over a quarter (28 per cent) of UK domestic greenhouse gas (GHG) emissions.[121]

Over 90 per cent of these emissions come from our roads, with passenger cars, heavy goods vehicles and light duty vehicles contributing the most. Despite dramatic progress to improve fuel efficiency of new passenger cars, emissions reductions have been largely offset by their increased use.[122]

The Department for Transport will publish its plan to decarbonise the UK's entire transport system in spring 2021, putting us on a pathway to reach net zero. The Transport Decarbonisation Plan is focused on six strategic priorities.

FIGURE 6.1 - DOMESTIC AND ROAD TRANSPORT EMISSIONS

Domestic transport emissions 2018



Road transport emissions 2018

Source: BEIS Analysis

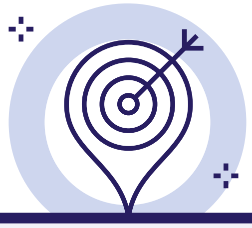
SIX STRATEGIC PRIORITIES FOR THE TRANSPORT DECARBONISATION PLAN, TO DELIVER A NET ZERO TRANSPORT SYSTEM

ACCELERATING MODAL SHIFT TO PUBLIC AND ACTIVE TRANSPORT

- Help make **public transport and active travel** the natural first choice for daily activities
- **Support fewer car trips** through a coherent, convenient and cost-effective public network; and explore how we might use cars differently in future
- **Encourage cycling and walking** for short journeys
- Explore how to best **support the behaviour change** required

DECARBONISING HOW WE GET OUR GOODS

- **Consider future demand** and changing consumer behaviour for goods
- **Transform ‘last-mile’ deliveries** - developing an integrated, clean and sustainable delivery system
- **Optimise logistics efficiency** and explore innovative digitally-enabled solutions, data sharing and collaborative platforms



PLACE-BASED SOLUTIONS

- **Consider where, how and why emissions occur** in specific locations
- Acknowledge a single solution will **not be appropriate for every location**
- **Address emissions at a local level** through local management of transport solutions
- **Target support for local areas**, considering regional diversity and different solutions

DECARBONISATION OF VEHICLES

- **Support the transition to zero emission road vehicles** through:
  - Regulatory framework
  - Strong consumer base
  - Market conditions
  - Vehicle supply
  - Refuelling and recharging infrastructure
  - Energy system readiness
- **Maximise benefits** through investment in innovative technology development and development of sustainable supply chains

UK AS A HUB FOR GREEN TRANSPORT TECHNOLOGY AND INNOVATION

- Utilise the UK's world-leading scientists, business leaders and innovators to position the UK as an internationally recognised leader of environmentally sustainable technology and innovation in transport
- Build on expertise in the UK for technology development and capitalise on near market quick wins

REDUCING CARBON IN A GLOBAL ECONOMY

- Lead international efforts in transport emissions reduction
- Recognise aviation and maritime are international by nature and require international solutions
- Harness the UK as a global centre of expertise, driving low-carbon innovation and global leadership, boosting the UK economy

THE ELECTRIC VEHICLE REVOLUTION IS ALREADY UNDERWAY

The emissions from passenger cars and light goods vehicles make up over two thirds of all transport emissions, so decarbonising those forms of transport is a priority.

Following extensive consultation with car manufacturers and sellers, the Prime Minister has confirmed that the UK will end the sale of new petrol and diesel cars and vans by 2030, ten years earlier than planned. From 2035, all new cars and vans must be zero emissions at the tailpipe. Between 2030 and 2035, any new cars and vans sold that emit from the tailpipe must have significant zero emission capability, for example plug in and full hybrids. The meaning of 'significant zero emission capability' will be defined by consultation in 2021. The government has also committed to providing a delivery plan in 2021 to realise these new ambitious phase out dates. The delivery plan will provide key milestones, and government will work with stakeholders to ensure these phase out dates can be met.

The UK car industry already manufactures a significant proportion of Europe's electric vehicles (EVs), including one of the most popular models in the world.

To support this acceleration, the Prime Minister has announced:

- **£1.3 billion to accelerate the rollout of chargepoints for EVs** in homes, workplaces, streets and on motorways across England, so people can more easily and conveniently charge their cars.
- **£582 million in grants for those buying zero or ultra-low emission vehicles** to make them cheaper to buy and incentivise more people to make the transition.
- **Nearly half a billion to be spent in the next four years for the development and mass-scale production of electric vehicle batteries** (gigafactories) and other strategic technologies, as part of our commitment to provide up to £1 billion to support development of the electric vehicle supply chain, boosting investment in the automotive sector, including existing clusters of activity in the Midlands and North East.

In 2019, the UK was the third largest market for ultra-low emission vehicles (ULEVs) in Europe and is a global leader in their development and manufacture.[123] Nearly 10 per cent of zero emission cars bought in Europe in 2019 were built in the UK.[124] As at 30 June 2020, there were nearly 320,000 ULEV vehicles registered in the UK, up from just over 140,000 at the end of 2017. The vast majority of those ULEVs are cars, accounting for nearly 300,000 vehicles.[125]

EVs will create significant new demand for electricity, and we are already taking action to ensure the energy system now, and in the future, is ready for this shift. The transition to mass uptake of EVs will also have a big impact on how households consume energy. This is why the government has established the Electric Vehicles Energy Taskforce, to ensure consumers are placed at the heart of this journey.

We expect the mass uptake of EVs to create significant new demand for power but also offer opportunities for enhanced system flexibility. As discussed further in the 'Energy system' chapter smart charging and vehicle-to-grid technology can provide benefits for the consumer and the grid.

320,000 **ultra low emission vehicles registered in the UK** as of June 2020

#3 In 2019 the **UK was the third largest market for ULEVs** in Europe

Under the Automated and Electric Vehicles Act 2018 government have the powers to mandate all smart functionality for chargepoints, enabling consumers to drive home from work, plug their car in, and automatically charge when electricity is cheaper, or greener, rather than in the evening, when it is more expensive. We intend to bring forward regulations in 2021 to mandate that private EV chargepoints must be smart, and in the 'Buildings' chapter we discuss the ongoing work to introduce chargepoints into all new homes and non-residential buildings. Consumers will need to access accurate, trusted information to enable them to make an informed decision about electric vehicle charging. Government wants consumers to have confidence that they will be offered choice, convenience, and appropriate protections.

Information from these chargepoints will inform planning and operation of electricity systems, and help customers save money. Government is working to ensure security and privacy measures are in place to protect chargepoint users.

As well as building new network infrastructure where needed, it is important that we use the existing network to enable the deployment of chargepoints at the lowest cost to the consumer. The 'Energy system' chapter sets out how we will further support the roll out of charging infrastructure along the strategic road network.

CASE STUDY

Bus2Grid

In January 2018, the Office for Low Emission Vehicles and the Department for Business, Energy and Industrial Strategy awarded almost £30 million, through an Innovate UK vehicle-to-grid programme, where EVs can supply electricity to the grid at times of high energy demand.

Bus2Grid is part of this programme and is exploring the commercial value and social benefits to the energy and passenger transportation systems. The project will develop services to support National Grid, local Distribution Network Operators (DNOs), bus operators and transport authorities and at the same time will consider bus fleet consumer engagement approaches necessary for its commercial implementation. Bus2Grid claims to be developing the "world's largest bus to grid site" and is bolstered by a diverse project consortium, including: SSE Enterprise, automotive manufacturer Build Your Dreams (BYD), the Distribution Network Operator UK Power Networks (UKPN) and the University of Leeds.

The project is a first of a kind large scale, multi-megawatt, demonstration of vehicle-to-grid technology in electric bus depots located in London. This process is managed by an aggregation platform that enables the 28 e-bus batteries to interact with the energy system by charging or exporting energy to support the grid in times of high energy demand.[126]

ALTERNATIVES FOR HEAVY DUTY VEHICLES

After passenger cars, heavy goods vehicles (HGVs) are the biggest contributor to domestic transport emissions in the UK, and zero emissions solutions for HGVs, particularly the heaviest vehicles, are much less developed by comparison.

The Prime Minister's 'Ten Point Plan for a Green Industrial Revolution' announced that we will consult on a date for phasing out the sale of new diesel HGVs.

Battery Electric Vehicles (BEVs) are well place to deliver the bulk of decarbonisation for cars and vans and now also smaller HGVs in short distance and medium weight applications, such as urban distribution. However, the solution for larger, long-haul, road freight vehicles is not yet clear and so we will invest £20 million next year in freight trials to pioneer hydrogen and other zero emission truck technologies to support industry to develop cost-effective, zero emission HGVs in the UK.

In our 'Oil and gas' chapter we mention the work being undertaken in the downstream oil and gas sector on low-carbon fuels, and we are continuing to explore alternatives, including through a £40 million innovation programme looking at the best fuel/vehicle combinations to decarbonise construction, mining and other off-road heavy vehicles by 2030.

We are also supporting the decarbonisation of buses. Early next year, the Department for Transport will publish a National Bus Strategy, which will set out ambitious plans to transform the sector, including delivering higher frequency of service, simpler fares, improved routes and more green buses.

As set out in the Ten Point Plan and the Spending Review 2020, the government will invest £120 million in 2021/22 to start the delivery of the 4,000 zero emission buses announced by the Prime Minister in February. Government will support both battery electric buses and hydrogen buses where the market favours their use.

RAIL DECARBONISATION

For areas of the rail network with significant freight flows or long-distance high-speed services, electrification is a proven technology that is able to support these service types.

Analysis suggests that electrification may also be the best whole-life cost solution for more intensively used areas of the network. Away from these areas of operation the deployment of emerging technologies such as battery traction and hydrogen rolling stock on both an interim and permanent basis may offer alternative solutions to help in achieving decarbonisation of rail at a lower cost.

AVIATION AND MARITIME

We are making the UK the home of green ships and planes.

We have established the Jet Zero Council to accelerate the development and adoption of new technologies to help develop our strategy to reach net zero aviation, along with investing £15 million into FlyZero as well as running a £15 million competition to support the production of sustainable aviation fuels in the UK.

As we are preparing the Transport Decarbonisation Plan, which will also include actions to get the maritime sector on track to net zero, we continue to implement the commitments in Clean Maritime Plan, building on the government's ambitious vision for the future of UK zero emission shipping. This includes the launch of a £20 million Clean Maritime Demonstration Competition, which will support the UK design and development of clean maritime technology, including hydrogen, and will lay the foundation for a network of real-world projects.

On 16 November, the Department for Transport published the Union connectivity review: call for evidence.[127] The review, led by Sir Peter Hendy, will look at how the quality and availability of transport infrastructure can support quality of life in communities across the UK while also aiding economic recovery and will consider the environmental impact of current and future infrastructure. Sir Peter is expected to publish his final recommendations in summer 2021.

£20m competition to support the design and development of **clean maritime technology**

£15m competition to support the production of **sustainable aviation fuels in the UK**

40,000 **new jobs supported** by accelerating the shift to zero emission vehicles

As we decarbonise across transport, energy requirements will change in many sectors, from trains, to boats and planes. This will create new demands on our energy systems. Accelerating the shift to zero emission vehicles could support around 40,000 new jobs by 2030. More details on ensuring all modes of transport are on a pathway to net zero will be set out in the forthcoming Transport Decarbonisation Plan.

CHAPTER 04

Buildings

OUR GOAL

Delivering our net zero target means largely eliminating emissions from domestic and commercial buildings by 2050.

We will:

- **Drive greatly improved energy performance** in both existing and new buildings to reduce consumption and help keep bills affordable
- **Support the transformation of heating for homes and workplaces** from oil and gas to clean energy sources
- **Use the switch to clean energy to support up to 50,000 jobs** across the UK by 2030

BUILDINGS

The strategic context

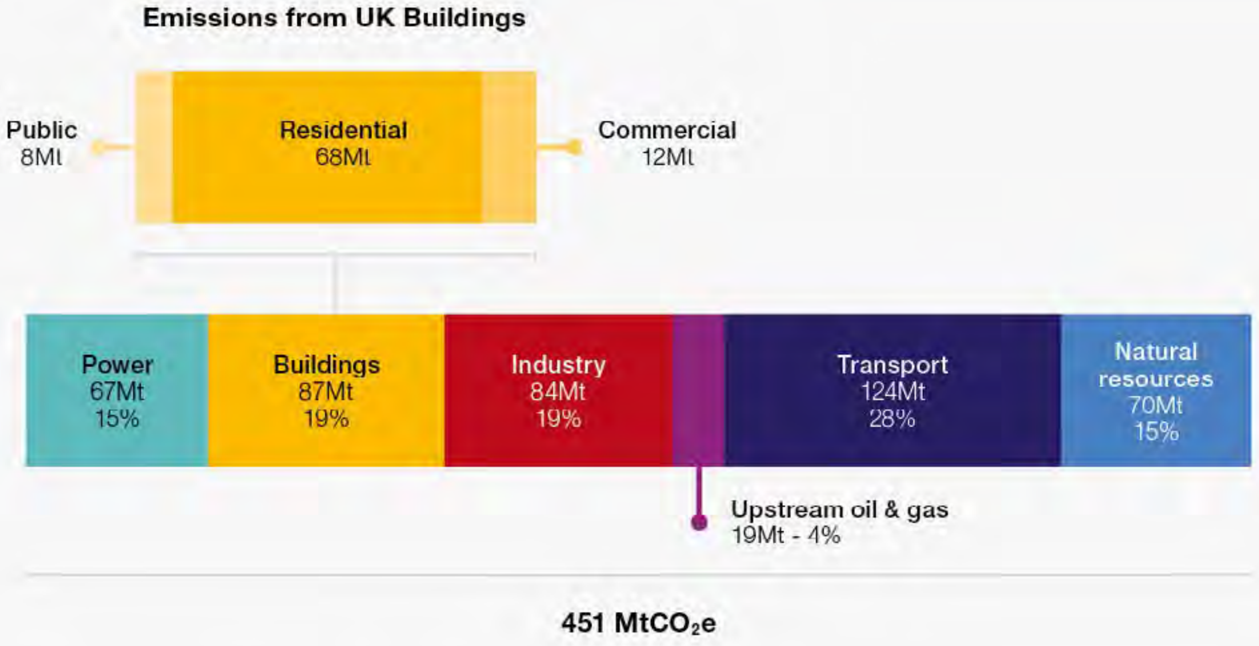
We need the energy we use to heat or cool our homes and workplaces to be reliable and affordable, and support comfortable, healthy surroundings in which to live and work.

But emissions from homes and from commercial and public sector buildings account for 19 per cent of total UK greenhouse gas emissions.[128] It makes buildings the second largest source of emissions after transport. Buildings also indirectly contribute to power sector emissions through electricity-using products in our homes.

#2	buildings are the **second largest source of emissions in the UK**
90%	**of homes in England currently use fossil fuels** for heating, cooking and hot water
66%	of homes are at **Energy Performance Certificate D or worse**

FIGURE 7.1 - UK TERRITORIAL EMISSIONS [129]

2018



Source: BEIS Analysis of 'Final UK GHG emissions national statistics' and NAEI

Our challenge is to transform how buildings use energy in line with our net zero target. We need to minimise the disruption to consumers as we go through this change and keep bills affordable, while safeguarding the quality of the environment in our building stock.

Almost 90 per cent of homes in England currently use fossil fuels, predominantly for heating but also for cooking and hot water.[130] The vast majority of these homes, some 85 per cent, are connected to the gas grid.[131] Those that are not connected use mostly oil, liquified propane gas or electricity, or are connected to a shared heat network. While proportions differ between Scotland, Northern Ireland, Wales and England, fossil fuels dominate heating across the UK.[132]

The installation of energy efficiency measures and tighter building regulations have improved the energy performance of buildings, lowering consumption and helping to reduce household dual fuel bills by an average of £30 to £40 per year over the last 10 years.[133] Emissions from buildings across the UK have fallen by 18MtCO$_2$e, 17 per cent, over the last 30 years.[134] But we need to go further and secure a reduction in emissions by 2050 five times greater than we have achieved over this period.

ENERGY PERFORMANCE CERTIFICATE

Energy Performance Certificates (EPCs) are required in the UK to provide a prospective owner or tenant with information on the energy performance of a building and recommendations for improvement. EPCs for homes use an A-G rating scale based on the modelled energy bill costs of running the building.

90% said it is important or very important that the UK makes a **full transition towards greener heating systems**

£9.2bn **commitment to invest in the energy efficiency** of homes, schools and hospitals

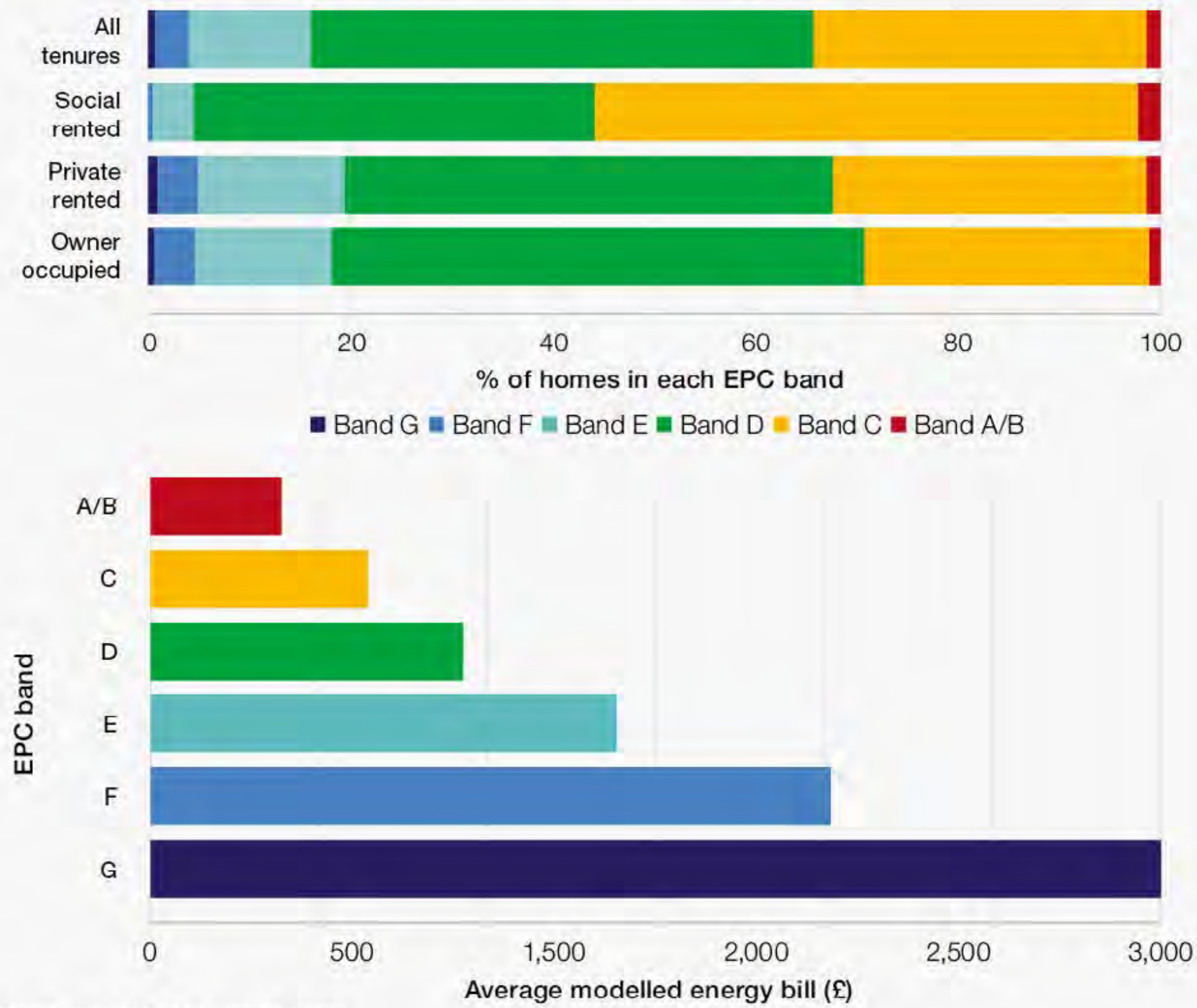
The energy performance of too many existing homes is not good enough. Around 16 million homes in England, 66 per cent of the total, are at Energy Performance Certificate D or worse.[135] In the private rental sector, existing legislation requires that all buildings have a minimum standard of energy performance only of Band E at the point of rental. The modelled annual energy cost of the average Band C rated home is around £750 less than the average Band E rated home, assuming both homes are being adequately heated (see figure 7.2).[136]

There are about 1.8 million non-domestic properties in England and Wales.[137] Buildings in the commercial and public sectors account for around a third of the total final energy consumed for buildings purposes (i.e. excluding industrial, agricultural or transport).[138] Large premises of 1,000 square meters or larger represent only 10 per cent of commercial and industrial buildings but emit over half of all the carbon from the building stock.[139]

Public awareness is low about the connection between climate change and how we heat homes and workplaces. Research by BEIS suggests that the majority of the population has not heard of low-carbon heating technologies.[140] Almost a third of gas-users stated they were on ‘environmentally-friendly heating’, suggesting a general under-appreciation of what the transition to low-carbon heating could mean in practice. Encouragingly, however, the survey shows that there is strong support for carbon reduction policies. Almost 90 per cent of respondents said it is important or very important that the UK makes a full transition towards greener heating systems.

Tackling emissions from buildings will take many years to deliver but it is a journey which must start now. The 2020s must be a decade of action to put the country on the path to net zero emissions by 2050. Depending on fossil fuels for heat or tolerating wasteful loss of energy in poorly insulated buildings is not sustainable. Action now will put us on a pathway to affordable, green and healthier buildings. Inaction will mean more disruption when we do eventually address the challenge, as well as higher bills and a lower quality of life in our homes and places of work.

FIGURE 7.2 - EPC RATING OF HOMES IN ENGLAND AND AVERAGE MODELLED ENERGY BILL BY EPC BAND



Source: 2018-19 English Housing Survey

This white paper builds on our Manifesto commitment to invest £9.2 billion in the energy efficiency of homes, schools and hospitals. It sets out concrete actions to reduce how much energy we use and to support the move to low-carbon heat. We will publish a dedicated Heat and Buildings Strategy in early 2021 which will set out our ambitious plans in further detail, including the suite of policy levers that we will use to encourage consumers and businesses to make the transition.

Offices, retail space, hospitality and industrial buildings account for **around 80 per cent of private sector buildings energy demand**

Our key commitments

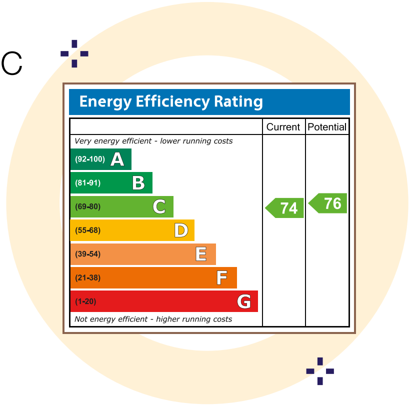
IMPROVED BUILDING ENERGY PERFORMANCE

Ensuring our homes and workplaces use energy efficiently makes good financial sense, as well as supporting better health and well-being.

Energy efficiency measures help bill payers to reduce consumption and keep bills affordable. The asset value of homes can increase based on improved energy performance. Conversely, poor energy performance means that too many bill payers pay more than they should to heat or cool their homes and workplaces comfortably.

In November 2020, the Prime Minister announced £1 billion of funding to continue our support for the decarbonisation of buildings through improved energy efficiency. This will be allocated across several existing government schemes, including the Green Homes Grant Voucher Scheme, the Public Sector Decarbonisation Scheme and Social Housing Decarbonisation Fund.

Upgrading all UK homes to EPC C could provide **annual energy bill savings of £7.5 billion**



NEW BUILDINGS

- **The Future Homes Standard will ensure that all new-build homes are zero carbon ready.**

The Future Homes Standard will require new-build homes to be fitted with low-carbon heating, and high levels of energy efficiency. Homes built to the Future Homes Standard will be zero carbon ready and have 75 to 80 per cent lower carbon emissions than those built to current standards. We will seek to implement the standard as soon as possible. As a stepping stone to the Future Homes Standard, we have consulted on an interim uplift in standards which would result in a 31 per cent reduction in carbon emissions from new homes compared to current standards.[141] We will publish the government response to the consultation and set out a roadmap to the Future Homes Standard, as soon as possible.

We have separately published guidance for drafting building specifications to support the installation of smart meters in new build homes to avoid the need for costly retrofitting. We will work with the industry to incorporate smart technologies, such as heating controls, into the methodology for assessing the energy performance of homes.

This will give occupants the ability to manage their energy consumption easily, reduce their energy bills and maximise the use of energy from renewable sources.

We have committed to consulting on mitigating overheating risk in new homes and a range of methods will be considered to demonstrate compliance with new requirements.

We will consult shortly on increased standards for non-domestic buildings so that new buildings have high levels of energy efficiency and low-carbon heating. We are also taking action on introducing new building regulations to require electric vehicle chargepoints in all new homes and in non-residential buildings.[142] We will respond to the consultation in early 2021.

EXISTING HOMES

- **We want as many existing homes as possible to hit EPC Band C by 2035, where practical, cost-effective and affordable.**

While we face the huge challenge of preparing almost 27 million existing homes for a clean energy future, we have already taken significant steps to reduce the carbon footprint of homes, in line with our Manifesto pledge. The Green Homes Grant Voucher and Local Authority Delivery schemes, together worth £2 billion, were launched in September 2020 and the Prime Minister's Ten Point Plan confirmed that the schemes will be extended for another year, helping to support the development of the supply chain and grow the market ahead of the introduction of regulatory measures later in the 2020s.

The £1.5 billion voucher element offers homeowners and landlords a voucher covering up to two thirds of the cost of upgrading energy performance, to a maximum of £5,000. A voucher of up to £10,000 is available for low-income households, with no contribution required. Low-income households can also benefit from the £500 million of the Green Homes Grant that has been ringfenced for Local Authority Delivery.[143]

The schemes could enable more than 600,000 homes in England to be more energy efficient, saving these households up to £600 year on their energy bills.[144] Vouchers can be spent on a range of measures from cavity wall and loft insulation and air-source heat pumps, to draught proofing and replacing single glazing with double or triple glazing.

We will also take action to improve the energy efficiency of homes in the private rental sector. In September 2020, we issued a consultation on proposals for an estimated 2.8 million privately rented homes to meet a minimum energy performance standard of EPC Band C by 2028, where practical, cost-effective and affordable.[145] These proposals could reduce energy bills by an average of £230 per property annually, cutting fuel poverty, saving 9.5MtCO$_2$e by 2032 and supporting 80,000 jobs in the energy sector annually between 2025 and 2028.[146]

44 per cent of all social rented homes in England, approximately 1.8 million, have an EPC Rating below C.[147] In our manifesto, we committed to invest in upgrading a significant number of these homes to at least EPC Band C. In July 2020, the government announced £50 million for 2020/21 to kickstart delivery of this ambition, piloting innovative retrofit projects across the UK and committed further funding in the Prime Minister's Ten Point Plan, announced in November.[148]

£50m to support delivery of **upgrading homes to meet EPC band C**

£2bn **Green Homes Grant voucher scheme**, plus further funding this year

- **We will consult on regulatory measures to improve the energy performance of owner occupied homes, and are consulting on how mortgage lenders could support homeowners in making these improvements**

Meeting our commitments to decarbonise and improve the energy performance in buildings will require the mobilisation of around £100 billion of capital across homes, businesses and the public sector over the 2020s alone.[149] It is investment that must come principally from businesses and homeowners, and from landlords of domestic and commercial premises. Growing the market for green finance products will be essential to leveraging this scale of private capital and demands a partnership between the financial services sector and suppliers, manufacturers and energy services companies. We are consulting on how mortgage lenders can help homeowners to improve the energy performance of their homes. The proposals are intended to kickstart the green home finance market and support homeowners to improve the energy efficiency of their homes as we move towards our target of reaching as many existing homes as possible at EPC Band C or above by 2035.[150]

CASE STUDY

Whole House Retrofit Grant

In summer 2019, the government launched the Whole House Retrofit Grant competition as part of the government's £505 million Energy Innovation Programme. The aim of the programme was to demonstrate the importance of taking a 'whole house retrofit' approach to improving the energy performance of the UK's buildings and in doing so, tackle one of the most challenging components of our decarbonisation agenda. The competition is based around an innovative 'fabric first' approach, while also introducing some low-carbon heating elements.

As an initial push towards achieving the government's Buildings Mission target of halving the cost of retrofits by 2030, the Whole House Retrofit programme also seeks to achieve cost reductions through process innovations and economies of scale and scope. Ultimately this will make it both cheaper and easier for all homeowners to improve the energy performance of their properties.

Retrofits should also deliver improvements in the health and well-being of occupants, including reduction of risk to summertime overheating and damp or mould growth.

The three projects selected are led by Local Authorities. More than 300 houses will be retrofitted in total, with a focus on socially rented properties across a range of housing archetypes. The projects are aiming to achieve retrofit cost reductions of between 5 and 20 per cent per property, making the properties not only warmer and more comfortable to live in, but less costly to run as well. The work will help pave the way for further cost reductions, and mass deployment of the whole-house approach as we head towards 2030.

At the same time as driving down install costs, a further objective of the competition is to increase expertise in the workforce and build capability of the supply chain, while ensuring resident health and comfort is placed at the centre of the whole house retrofit process.

Alongside a package of incentives, we can create a long-term regulatory framework to improve the energy performance of homes. We will seek primary powers to enable this. This will provide certainty to the market and clear signals to homeowners. We will consult in 2021 on options for these measures.

In September 2020, the government launched the Energy Performance Certificates Action Plan, which set out a pathway to improve the EPC system. The Action Plan will help to increase the energy efficiency of the building stock by exploring ways to increase the quality of EPCs, build consumer trust and increase engagement.

It will support policies which strengthen regulatory compliance and ensure that the data infrastructure underpinning EPCs is fit for the future. We anticipate that changes may be needed to the Energy Performance of Buildings (England and Wales) Regulations 2012 to deliver progress. We will need a new primary power to change the legislation after the Transition Period ends on 1 January 2021, which we will seek through an appropriate legislative vehicle in 2021, if Parliamentary time allows.

We also need to make energy-using products, such as household appliances, more efficient, helping to reduce bills and encourage innovation. Policies to increase the energy efficiency of products have been an effective lever and represent one of the most cost-effective ways to reduce energy bills and carbon emissions. The findings from our recent call for evidence will help to inform a best-in-class regulatory framework for energy-using products.

Our current estimates show that, taken together with related energy labelling requirements, ecodesign requirements will lead to emissions reductions of 8MtCO_2e to 2020.[151] Through our world-class energy-related products policy, to be launched in spring 2021, we will push for greater energy and carbon savings. This year the government published a Call for Evidence and Consultations for ecodesign and energy labelling regulations across a range of products. We are currently reviewing the scope of our powers for achieving our energy efficiency ambition and, if necessary, will look to take additional powers through legislation.

COMMERCIAL & INDUSTRIAL PROPERTIES

- **All rented non-domestic buildings will be EPC Band B by 2030, where cost-effective.**

Offices, retail space, hospitality and industrial buildings account for around 80 per cent of private sector buildings energy demand.[152] Around a half of all energy consumed in commercial and industrial buildings in England and Wales is in the rented sector, placing the onus on landlords to make energy efficiency and heating improvements.[153] We will therefore tighten minimum standards for this sector to reach EPC Band B by 2030 where cost-effective. We will consult shortly on improving the implementation and enforcement of this target. This will reduce carbon emissions, help make businesses more productive and grow the energy efficiency market.

We are proposing a performance-based rating scheme for large commercial and industrial buildings to provide businesses and their investors with more information on how to reduce energy consumption and lower both carbon emissions and energy bills. We will consult in early 2021 on how the scheme will work and plan to launch the first phase by 2022/23.

Improving energy efficiency is one of the most cost-effective mechanisms for businesses to reduce their energy bills, while reducing their carbon emissions. But a lack of information and the upfront capital costs of installation can deter investment by small businesses in measures such as insulation and energy management systems. We will continue to explore how we can stimulate a thriving market for business energy efficiency through the proposed new energy efficiency scheme focused on small businesses. As well as providing access to advice, the scheme will facilitate the installation of efficiency measures through either an auction process or an energy efficiency obligation so they can improve the energy performance of their premises. We will consult on our proposals in 2021.

The Energy Savings Opportunity Scheme aims to drive energy and carbon savings in businesses by improving the quality of the audits of the energy used by their buildings, industrial processes and transport. We will consult in 2021 on strengthening the scheme, taking forward options identified in the comprehensive scheme evaluation and Post Implementation Review published in February 2020.

PUBLIC SECTOR BUILDINGS

As announced in the Prime Minister's Ten Point Plan, we will extend the Public Sector Decarbonisation Scheme for a further year

Public sector buildings account for nine per cent of emissions from buildings.[154] There is a particular onus on the public sector to demonstrate leadership by improving the energy performance of its building stock. By doing so, it can support a growing private sector energy services sector, helping to support jobs and new business opportunities.

As part of our Manifesto commitment to reduce emissions from the public sector, the Chancellor has already committed the first £1 billion of our funding pledge to upgrade schools, hospitals and other buildings. The Public Sector Decarbonisation Scheme, which was launched at the end of September 2020, will help the public sector play its part in delivering net zero emissions, with improved energy efficiency and clean heat investment.[155]

The £1 billion first tranche of funding is expected to cut emissions by up to 1.3MtCO_2e by 2032, equivalent to taking nearly 45,000 cars off the road. In addition to catalysing green investment in the public sector, the scheme will support the supply chain, providing clean energy jobs in communities throughout UK.

A FAIR AND AFFORDABLE TRANSITION

The benefits of well-insulated homes, on health and well-being and on bills, should not be the preserve of households which can afford to pay for energy efficiency measures.

People in fuel poverty will not be left behind. Indeed, our support will mean that fuel poor homes will be amongst the first beneficiaries of the energy transition. In line with our net zero goal, we will reduce energy consumption and lower energy bills by upgrading homes, focusing on the least energy efficient housing stock first.

There is currently no minimum energy efficiency standard which applies in the social rented sector except the requirement in the Decent Homes Standard which stipulates that homes should provide a reasonable degree of thermal comfort and be free of excess cold. This expectation is broadly equivalent to EPC Band F. The government has committed to a review of the Decent Homes Standard to consider how it can better support the decarbonisation and energy performance of homes, particularly with regard to the ambition set out in the Clean Growth Strategy that all homes should meet EPC C by 2035, where practical, cost-effective and affordable. We will work closely with the housing sector to carry out this review.

The government has also committed to further funding for the Social Housing Decarbonisation Fund, which will upgrade a significant amount of the social housing currently below EPC Band C to at least that standard.

Details of our multi-billion-pound plan to transform the poorest quality housing will be set out in our updated Fuel Poverty Strategy for England, due to be published in early 2021.

FUEL POVERTY

The government definition of fuel poverty is where a household has fuel costs that are above average and, were they to pay that amount, would be left with a residual income below the official poverty line.

Building on 'Cutting the Cost of Keeping Warm', our 2015 strategy, this refreshed update will set out our approach to tackling fuel poverty in the context of net zero emissions and the nation's recovery from the COVID-19 pandemic. In addition to outlining our plan for reducing fuel bills through improved energy efficiency, the new strategy will set out how we will ensure the fuel poor benefit from a fair and functioning energy market. We will also provide details of our guiding principles for future fuel poverty policies.

ENERGY COMPANY OBLIGATION

- **We will extend the Energy Company Obligation from 2022 to 2026 to support fuel poor consumers.**

The current Energy Company Obligation (ECO) is an obligation on larger energy suppliers to provide energy efficiency and heating measures for fuel poor consumers across Great Britain. Since the programme began in 2013, nearly 2.9 million measures have been installed in over 2.1 million homes.[156] Eligible households can save up to £300 on their energy bills, compared to an identical household.[157] Households are eligible if they receive certain benefits or live in the least efficient social housing, or if they are referred by their local authority.

We will continue to prioritise low-income and vulnerable households and focus on those living in the least efficient homes to make their dwellings warmer and healthier. The next iteration of ECO will run from 2022 to 2026 and will focus primarily on improving the worst-quality homes across Great Britain, complementing the upcoming Home Upgrade Grant scheme in England and equivalent schemes in the Devolved Administrations. The Home Upgrade Grant scheme will upgrade the energy performance of the worst-quality off-gas grid homes in England by supporting the installation of energy efficiency measures and low-carbon heating. Both schemes will focus support on low-income households.

WARM HOME DISCOUNT

- **We will expand the Warm Home Discount to around three million low-income households until at least 2025/26 and will consult on reforms to the scheme to better target fuel poverty.**

It can be a challenge for fuel poor households simply to pay their bills. The Warm Home Discount, currently worth £350 million per year, is a key policy to alleviate fuel poverty. Now in its tenth year, the scheme continues to provide £140 off electricity bills to over two million low-income and vulnerable households each winter, when they need it the most. Over £2.7 billion of direct assistance has been provided by participating energy suppliers under the scheme.

Government recently concluded a consultation on extending the current scheme until March 2022. Further to this, we will extend the scheme from 2022 to 2025/26 and expand the total spending envelope from £350 million to £475 million[158] per annum to support around 750,000 additional households in or at risk of fuel poverty with paying their energy bills and almost three million households in total. This represents £1.9 billion of extra support for households in or at risk of fuel poverty.

We will also consult on reforms to improve fuel poverty targeting, such as using government data to provide automatic rebates to most recipients - making the scheme administratively simpler - and allowing smaller suppliers to participate at lower cost. Better targeting of Warm Home Discount will support a fair transition to a clean energy future for fuel poor households. It will contribute to our fuel poverty interim milestone for as many fuel poor households as reasonably practicable to achieve a minimum energy efficiency rating of Band D by 2025.

CLEAN HEAT TECHNOLOGIES

As well as tackling energy performance, we need to decrease the emissions from heating and cooling our buildings.

We stand on the verge of a major transformation as clean energy alternatives replace fossil fuels. We need to complete this transformation while ensuring households continue to enjoy a reliable heating system and a comfortable, healthy and affordable home environment.

To achieve net zero emissions, we will have to transition completely away from traditional natural gas boilers for heating homes on the gas grid. There are currently around 1.7 million fossil fuel boiler installations every year[159] but by the mid-2030s we expect all newly installed heating systems to be low-carbon or to be appliances that we are confident can be converted to a clean fuel supply. There is no single technology alternative to fossil fuels.

Electric heat pumps and hydrogen, green gas and shared heat networks all have their part to play. So, while we are clear on the eventual outcome, we will be flexible in how we achieve it, always looking for the most cost-effective, consumer-friendly approach and open to innovative solutions.

We want to give households, suppliers, installers and equipment manufacturers long lead times to prepare for this transition. We will target the point of least disruption to consumers and minimise the impact on the housing market and will therefore look to use natural trigger points, such as the replacement cycle for existing heating systems. And we need to ensure consumers are receiving fair value as they switch to clean heat, which means working with the market to reduce costs and addressing barriers to the deployment of new technologies.

- **We will consult on whether it is appropriate to end gas grid connections to new homes, in favour of clean energy alternatives.**

We need to ensure that the right legislation is in place to support the heating market through the transition to net zero. We will review the overarching regulatory framework set out in the Gas Act 1995 to ensure the appropriate powers and responsibilities are in place to facilitate a decarbonised gas future. In particular, to ensure the Gas Act is in line with the Future Homes Standard, we will seek views on the feasibility of ending the connection of new build homes to the natural gas grid.

ELECTRIFICATION

- **As announced in the Prime Minister's Ten Point Plan, we will grow the installation of electric heat pumps from 30,000 per year to 600,000 per year by 2028, supporting up to 20,000 jobs by 2030.**

Heat pumps are a proven and commercially viable way to transform heat in buildings, which is also available now. Currently, however, fewer than one per cent of homes in England use a heat pump.[160]

HEAT PUMP

A very efficient electrically-driven device that extracts heat from the air, ground or water and concentrates it to a higher temperature and delivers it elsewhere, for example to a central heating system. It can replace fossil fuel heating, such as a gas or oil boiler.

We want to open the market of homes not on the gas grid to heat pumps or other clean energy alternatives, representing some 50,000 to 70,000 installations a year.[161] We will therefore consult in early 2021 over new regulations to phase out fossil fuels in off-grid homes, businesses and public buildings, including a backstop date for the use of any remaining fossil fuel heating systems.

In setting a clear target for deploying the technology, there is an opportunity to expand the existing UK heat pump manufacturing base and exploit future export potential. The UK has a growing expertise in heat network design and is already home to several manufacturers of heat pumps. Annual global heat pump sales are expected to roughly double between 2019 and 2030 from 11.4 million to 20.8 million units.[162]

We need to take advantage of future export opportunities, particularly to markets in north-western Europe where high demand is expected.

But electrification is not just a solution for off-grid buildings. We believe that significantly increasing the deployment of heat pumps for on-gas grid homes through the 2020s, on a voluntary basis, will be beneficial, whatever the eventual mix of technologies for clean heat in 2050. We recognise that, to achieve this, we will have to increase business and public confidence in heat pump technology.

In April 2020, we launched our proposal for a Clean Heat Grant, due to launch in 2022, as a successor scheme to the domestic Renewable Heat Incentive. We will publish a government response in 2021. The Clean Heat Grant will be targeted at households and small, non-domestic buildings to support the installation of heat pumps and, in certain circumstances, biomass. The scheme will build upon the Green Homes Grant which provides support for heat pump deployment in the near-term.

Reducing emissions from buildings will require an annual market for heat pumps by 2028 at least 20 times the size of today's market, a scale which can help realise the economic benefits of a domestic supply chain. We will work with equipment manufacturers, wholesalers and installers to ramp up supply chain capacity and reduced technology and installation costs. In early 2021, we will consult on policy approaches to underpin the development of the UK heat pump market, including voluntary up-take by consumers in current on-gas-grid homes.

The electrification of heat has implications for the GB electricity system, given the increased demand for power and the prospect of different demand patterns which arise from using power for heat.

We need to electrify heat in buildings in a way which reduces the need for additional generation and network capacity. This could mean using thermal, hot water or battery storage, potentially in combination with a smart time of use tariff, enabled by smart metering, to shift heating demand away from more expensive peak periods. Managing this transition is a key priority for the development of our plans for low-carbon electricity generation, detailed in the 'Power' chapter, and a smart energy system, as set out in the 'Energy system' chapter.

We are also considering how to further reduce market barriers to the deployment of energy efficiency, and how demand reduction is rewarded for the benefits it provides to the energy system. We want permanent electricity demand reduction to be a viable alternative to simply building more generation or network capacity. We will explore options to achieve this goal, building on the response to our call for evidence on Facilitating Energy Efficiency in the Electricity System, launched in July 2019.

GREEN GAS

- **We will increase the proportion of biomethane in the gas grid.**

Biomethane is currently the only green gas commercially produced in the UK. It can be injected into the gas grid to accelerate the decarbonisation of gas supplies.

BIOMETHANE

A form of gas that is produced by processing biomass. It can be used for the same purposes as natural gas, like producing electricity or heat, and can use the same infrastructure for transmission and end-user equipment.

Budget 2020 confirmed that a green gas levy imposed on gas suppliers will fund a new support scheme to achieve this goal, the first of its kind applied to gas in Britain. The costs of the levy are expected to be passed onto gas bill payers. We are considering the responses to our consultation on the green gas levy design and intend to publish a government response in early 2021.

Subject to the outcome of the consultation, we expect the Green Gas Support Scheme (GGSS) to launch in autumn 2021 and run for four years. It will support continued deployment of anaerobic digestion biomethane plants in order to increase the proportion of green gas in the grid. We anticipate that the GGSS could deliver annual generation of 2.8TWh of renewable heat in 2030/31,[163] the equivalent of the gas requirements roughly 230,000 homes.[164] This scheme will be designed to minimise any associated negative environmental impacts from the anaerobic digestion process, such as ammonia emissions.

We believe that through these new measures, building on the success of existing government policies, we have the potential to treble the amount of biomethane in the grid between 2018 and 2030.

CLEAN HYDROGEN

- **As announced in the Prime Minister's Ten Point Plan, we will work in partnership with industry to evaluate hydrogen as an option for heating our homes and workplaces and develop plans for a possible pilot hydrogen town before the end of the decade.**

Clean hydrogen could potentially provide a way to decarbonise our gas supplies on a much larger scale than reliance on biomethane alone. This could offer consumers a future heating option which works for them in a very similar way to natural gas today, but no carbon emissions. However, unlike electric heat pumps and heat networks, the feasibility of using hydrogen for clean heat needs further testing and development. The practicalities and cost of safely converting or replacing existing networks and appliances to operate with pure hydrogen need to be fully evaluated.

The UK is already a world leader in investigating the use of hydrogen for heating. Both the government and the gas industry are currently running major studies and testing projects. We will increase the funding available for testing and trialling projects, working with the industry to ensure that the overall programme of work is comprehensive and fully coordinated. A range of further Research and Development (R&D) and testing projects are required, including an assessment of the options for major new hydrogen infrastructure, such as gas transmission networks and inter-seasonal storage.

Trials of hydrogen will also be key to evaluating the practicalities of converting existing boiler appliances and the way in which consumers experience hydrogen for heating in their own homes and workplaces. The Prime Minister's Ten Point Plan for a Green Industrial Revolution set out key milestones for a pioneering programme of trials. We will support industry to begin a Hydrogen Neighbourhood trial by 2023, and a large Hydrogen Village trial by 2025. The knowledge and experience gained in delivering trials in communities, together with the results of our wider R&D and testing programme, will enable a strategic decisions around the mid-2020s over the long-term role of hydrogen for heating and develop a plan for a potential Hydrogen Town before the end of the decade.

We will consult on the role of 'hydrogen ready' appliances in 2021.

In advance of strategic decisions on the role of hydrogen for heating, we will assess the case for encouraging, or requiring, new gas boilers to be readily convertible to hydrogen, so-called 'hydrogen-ready' boilers, in preparation for any future conversion of the gas network. We are already supporting the development of prototype 'hydrogen-ready' boilers, cookers and fires, through the Hy4Heat programme, which is due to conclude in summer 2021. Subject to the results of Hy4Heat, we plan to issue a call for evidence later in 2021 to seek views from stakeholders.

To facilitate the transition and development of the gas network, we will continue to work with the Health and Safety Executive to enable up to 20 per cent hydrogen blending on the network by 2023. This is subject to the success of testing and trials.

HEAT NETWORKS

We will use a new Heat Network Transformation Programme to co-ordinate our support for the roll out of district heating systems, including the switch to low or zero-carbon heat sources.

We are committing £122 million of funding towards a new Heat Network Transformation Programme and will implement local authority zoning by 2025.

HEAT NETWORK

A heat network, sometimes called district heating, is a system of insulated pipes that takes heat and cooling generated from a central source and distributes it to a number of domestic and non-domestic buildings.

Around half a million households in the UK take heat and hot water from shared heat networks.[165] These systems lend themselves particularly well to densely populated towns and cities. Networks with low-carbon heat sources, such as waste-heat recovery, large heat pumps, solar thermal or possibly hydrogen boilers, will reduce emissions from heating and can help consumers with lower energy bills. We are currently investing up to £320 million through the existing Heat Networks Investment Project (HNIP), using grants and loans to accelerate the growth of the market. This scheme will come to an end in 2022.

As part of our new Heat Network Transformation Programme, we are committed to funding the Green Heat Network Fund as the successor to HNIP. This will deliver additional low-carbon networks, particularly focusing on the recovery of waste heat and the use of heat pumps. We published a consultation on the design of the scheme in November 2020. In addition, we will fund a widespread improvement in the performance of legacy networks and boost supply chains and workforce skills, as the basis of a comprehensive transformation programme for heat networks.

We intend to legislate in this Parliament for the regulation of heat networks to protect consumers and reduce carbon emissions. We will take powers to reduce the 90 per cent reliance on natural gas in heat networks, as well as enable consumer protection for heat network customers.

CASE STUDY

Tolent Construction

The UK's first large scale mine energy district heating system is being developed at Seaham, County Durham by Tolent Construction, with the help of the North East Local Energy Hub and in partnership with Durham County Council and the Coal Authority. The project has secured investment of £175 million with construction starting in December 2020.

The government has provided financial support to the council to develop the heat scheme through £3.8 million of Heat Network Investment Programme funding, £150,000 Garden Village grant and technical support from the Coal Authority, stimulating over £170 million of private sector funding.

The project is set to create 960 new jobs. A training academy will be established on site and will give young people apprenticeship opportunities to develop their skills to become trades men and women, as well as other professions.

The district heating will be made up of 1,500 homes, a primary school, shops and an innovation centre all heated by mine water heating, pumped using solar photovoltaics for carbon free heat. One quarter of properties in the UK sit on the coalfields giving huge potential to mine water heating as a low-carbon sustainable heat source.

£320m invested to 2022 through the existing **Heat Networks Investment Project**

£270m further funding from 2022 through the **Green Heat Network Fund**

£122m allocated to the **Heat Network Transformation Project**

These powers will require heat networks to switch to low-carbon fuel sources as part of a natural replacement cycle, thereby minimising disruption to consumers connected to a network.

We will support Local Authorities to designate new heat network zones, no later than 2025. Zoning entails the identification of areas which can be readily connected to a low-carbon heat network and mandating connection unless it is not cost-effective to do so. The certainty of connection for projects, which zoning affords, will ensure that heat networks are better able to grow and deliver lower-cost, clean heat for consumers. We will consider how local heat network zoning can be most effectively integrated with wider local area planning for the environment, infrastructure and place. We will work with local authorities to optimise delivery of this and related interventions by working with local authorities and through our consultation due to be published in spring 2021.

THE ECONOMIC BENEFITS OF TRANSFORMING ENERGY IN BUILDINGS

Upgrading the energy performance of our building stock cuts energy bills and, for businesses, helps to reduce other day-to-day operating costs which they face.

The Energy Efficiency Infrastructure Group estimates that upgrading all UK homes to EPC C could provide annual energy bill savings of £7.5 billion.[166] Better energy efficiency can therefore support a persistent uplift in productivity and consumer spending to drive economic growth, particular as the country recovers from the COVID-19 pandemic.

And transforming the nation's homes with improved energy performance and new clean heat solutions will also grow the UK's manufacturing base and construction industry. It offers the prospect of hundreds of thousands of high-quality green jobs right across the UK. Building projects are typically labour intensive so scaling up delivery will support more jobs per pound spent than in most other areas of the transition to net zero emissions. The measures announced by the Chancellor in July 2020, worth £3.05 billion, will alone support up to 140,000 jobs over the next year.[167]

Improving the quality of our building stock will contribute substantially to our agenda to level up the country. Wales and, in England, the North East, the West Midlands, the North West and the Yorkshire and the Humber region have the highest per capita energy efficiency investment need across the UK.

- **We will develop a strategy for upskilling through the 'Green Jobs Taskforce' and a National Skills Fund, to be launched in 2021.**

Analysis by the London School of Economics estimates that over six million people have skills which will be affected by the transition to clean energy, representing 21 per cent of current jobs.[168] This is a major opportunity to develop new skills across a range of career pathways and ensure key sectors, such as construction, which employs around 2.2 million people, are fit for a clean energy future.[169] Principally, we will need more installers to retrofit existing buildings with energy efficiency and clean heat measures or ensure new-build homes are zero carbon ready. In September 2020, we launched the Green Homes Grant Skills Training Competition to provide £6.9 million funding to a range of energy efficiency and low-carbon heat skills providers and support delivery of the Green Homes Grant scheme.[170]

We are establishing a Green Jobs Taskforce with key industry bodies to produce an action plan for net zero skills across a range of sectors with the goal of two million net zero jobs by 2030. The taskforce will pinpoint the skills needed now and over long term. It will support high quality green jobs and a diverse workforce, and manage the transition for people working in high carbon industries. The action plan will be published in spring 2021.

Our key commitments

The Future Homes Standard will **ensure that all new-build homes are zero carbon ready**.

We want as many **existing homes as possible to hit EPC Band C by 2035**, where practical, cost-effective and affordable.

All rented non-domestic buildings will be EPC Band B by 2030, where cost-effective.

We will **consult on regulatory measures to improve the energy performance of homes**, and are consulting how on how mortgage lenders could support homeowners in making these improvements.

We will **extend the Public Sector Decarbonisation Scheme** for a further year.

We will **extend Energy Company Obligation from 2022 to 2026** to support fuel poor consumers.

We will **expand the Warm Home Discount to around three million low income households** until at least 2025/26 and will consult on reforms to the scheme to better target fuel poverty.

We will **consult on whether it is appropriate to end gas grid connections to new homes** being built from 2025, in favour of clean energy alternatives.

We will **grow the installation of electric heat pumps** from 30,000 per year to 600,000 per year by 2028, supporting up to 20,000 jobs by 2030.

We will **work in partnership with industry to evaluate hydrogen as an option for heating** our homes and workplaces and develop plans for a possible pilot hydrogen town before the end of the decade.

We will **increase the proportion of biomethane in the gas grid**.

We will **consult on the role of 'hydrogen ready' appliances** in 2021.

We are **committing £122 million of funding towards a new Heat Network Transformation Programme** and will implement local authority zoning by 2025.

We will **develop a strategy for upskilling through a 'Green Jobs Taskforce'** and a National Skills Fund, to be launched in 2021.

CHAPTER 05

Industrial energy

OUR GOAL

By 2050, emissions from industry will need to fall by around 90 per cent from today's levels.[171]

We will:

- **Create a sustainable future for UK manufacturing industry** through improved energy efficiency and the adoption of clean energy technologies
- **Establish the UK as a world leader in the deployment of CCUS and clean hydrogen**, supporting up to 60,000 jobs by 2030
- Ensure that the transformation of our industrial sectors **supports jobs, higher skills and new business opportunities** across the country
- **Introduce a UK Emissions Trading Scheme** which will be the world's first net zero emissions trading scheme, and will underpin the decarbonisation of energy in the UK

INDUSTRIAL ENERGY

The strategic context

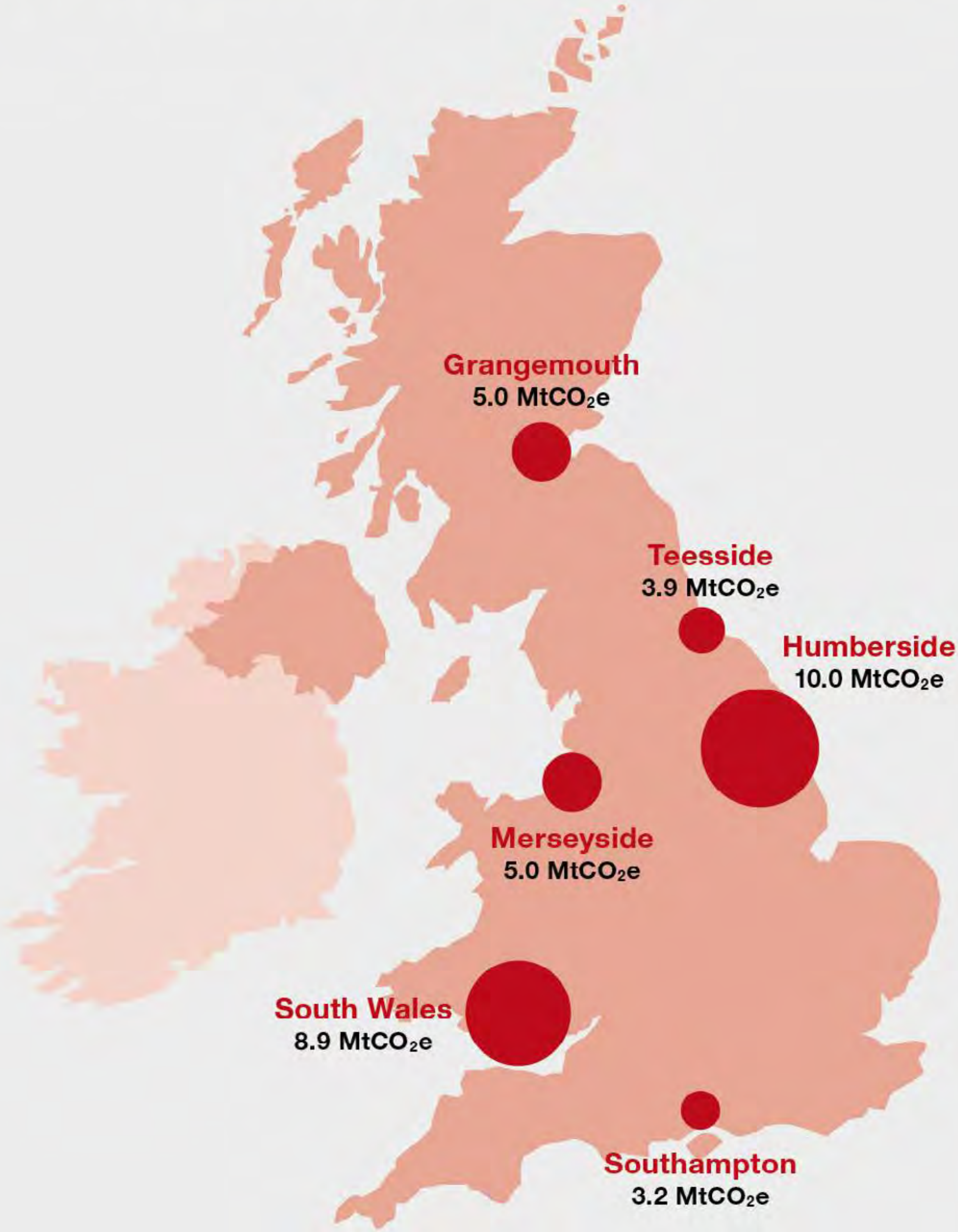
Manufacturing industry drives the UK economy. In 2018, the industrial sector contributed £170 billion to Gross Value Added (GVA), 42 per cent of British exports and employed 2.6 million people across the country.[172]

Almost all industry is located outside London and the South East and provides high value jobs across the four nations.[173] Investment in low-carbon technologies and renewing our industrial infrastructure will therefore help level up the UK and promote a green economic recovery.

Manufacturing and refineries, which form the bulk of industrial emissions, still account for around 16 per cent of the UK's greenhouse gas emissions.[174] Although emissions from industrial activity have fallen by half since 2000,[175] driven partially by greater energy efficiency in industrial processes, the sector will need to achieve significant decarbonisation over the next 30 years.

About half of emissions from manufacturing and refining are concentrated in the UK's major industrial clusters (see Figure 8.1).[176] These hubs are critical drivers of local and regional economic activity and a vital component of the UK's national economy.

FIGURE 8.1 - LOCATIONS OF CLUSTERS AND 2018 EMISSIONS



Source: NAEI Emissions from NAEI large point sources 2018. Clusters defined as all large emitters within 30km of a cluster centre

Improved efficiency in the energy performance of buildings and industrial processes will lay the groundwork for the transformation of industrial energy. But we cannot rely on energy efficiency alone to reduce emissions in line with our 2050 goal. Manufacturing industry will need to capture their carbon for onward storage and switch from using fossil fuels to low-carbon alternatives.

The successful decarbonisation of industry will mean overcoming a number of obstacles in manufacturing sectors which operate in highly competitive international markets and, in some cases, on tight profit margins. Lowering emissions and adopting clean energy technologies requires capital investment and could impact operating costs. It will be necessary to build additional infrastructure, such as the pipes and storage to transport captured carbon from industrial processes. Long lead-times to plan, design and install emissions-capture technologies, coupled with limited opportunities to undertake construction works, could present further barriers to businesses, even when they wish to act.

We will work with businesses to overcome these challenges and deliver the successful transformation of our vital industrial base. Markets are best placed over the long run to implement the most cost-effective solutions which deliver net zero industrial emissions, supported by a long term carbon price signal. But, for now, we cannot rely on market forces alone to see industry through the transition.

Manufacturing and refineries still account for around **16 per cent of the UK's greenhouse gas emissions**

The UK's industrial sectors need our continued support, particularly through the initial phase of decarbonisation, in which the risks and costs are highest. Our approach during the 2020s will be to stimulate action, investing in the critical infrastructure which enables the deployment of low-carbon technologies. We will support industry with the costs of improving energy performance and reducing emissions. We will maintain the ability of UK-based companies to compete and win in global markets and ultimately position them to capitalise on new commercial opportunities arising in a global net zero economy.

The cost of energy impacts the competitiveness of UK-based industry. We have taken steps to protect the manufacturing sectors which are most exposed to the impact of the UK's relatively higher electricity prices, compared to other major European markets. In 2019, we provided around £442 million to support qualifying energy intensive industries, including reductions in the policy costs of the transition to renewable electricity and compensation to partly offset the indirect impacts on electricity prices from the European Union Emissions Trading System (EU ETS) and the Carbon Price Support (CPS).

Our key commitments

A NEW STRATEGIC APPROACH TO CLEAN INDUSTRIAL ENERGY

In the 2030s, markets will be best placed to determine the most efficient approach to decarbonising industrial emissions. Our actions in the 2020s will create the right conditions to enable this transition.

- **We will publish an Industrial Decarbonisation Strategy in spring 2021 to set out the details of how the government will support the decarbonisation of manufacturing industry.**

Our strategy will set out a vision for a prosperous, low-carbon UK industrial sector in 2050. Working closely with our partners in the devolved administrations, we will establish how the transition to clean energy will support the UK's industrial competitiveness and a resilient, green economic recovery, including opportunities to exploit new markets at home and abroad.

A low-carbon and more resource efficient economy is not just about transforming existing industries and enabling a long-term sustainable future. It is the basis for new industrial sectors to flourish. It will catalyse innovation for new technologies, boost UK manufacturing and support thriving construction and operations sectors. It is a transformation which can help all the UK's manufacturing regions to become centres for the production of low-carbon goods. It will enhance long-term regional competitiveness, support a green recovery and insulate businesses from the impacts of a rising carbon price.

Domestic action is a platform for the UK's global leadership on climate change. With our leading role in industrial decarbonisation, we will be able to export technology, know-how and skills to the rest of the world. If global industry were to reduce emissions by around 70 per cent by 2050, relative to 2012 levels, UK exports of clean energy technologies in 2050 could support around £1.4 billion in annual GVA and support 18,000 jobs.[177]

In line with the increased ambition set out in the Ten Point Plan we will increase the Industrial Clusters Mission to support the delivery of four low-carbon clusters by 2030 and at least one fully net zero cluster by 2040.

We will start with a focus on the UK's industrial clusters – centres where related industries have congregated and can benefit from utilising shared clean energy infrastructure, such as carbon capture utilisation and storage (CCUS) and low-carbon hydrogen production and distribution. Decarbonisation in clusters will enable economies of scale, reducing the unit cost for each tonne of carbon abated. Clusters provide high quality jobs which tend to pay above the UK average wage.[178]

Transitioning to clean energy will bring opportunities to all four UK nations. Many clusters are located in regions in need of economic revitalisation and decarbonising those clusters can act as a driver of prosperity for the surrounding areas. Investments in key technologies like hydrogen and CCUS, together with broader interventions, such as through helping people to retrain, will be crucial to enhancing local economic growth and creating jobs. These actions will also deliver wider environmental benefits such as improved air quality. We will work with local government and businesses to consider how an integrated strategic approach can most effectively be developed to enable local places to capitalise on this opportunity to build back greener. Supporting the delivery of four low-carbon clusters will enable greater decarbonisation, leading the way for a more sustainable industry.

CARBON CAPTURE UTILISATION & STORAGE (CCUS)

The deployment of CCUS is fundamental to the decarbonisation of energy intensive industries such as steel, cement, oil refining and chemicals. CCUS can help secure the long-term future of these industries and enable production of clean hydrogen at scale.

- **We will invest £1 billion up to 2025 to facilitate the deployment of CCUS in two industrial clusters by the mid-2020s, and a further two clusters by 2030, supporting our ambition to capture 10MtCO$_2$ per year by the end of the decade.**

The UK is in a strong position to become a global technology leader in CCUS. We have the opportunity to develop a domestic supply chain by utilising the expertise of our existing oil and gas industry. Innovative start-up companies, spun out of the UK's world-class academic institutions, are focused on driving cost reductions and creating new UK-based innovative carbon capture technologies. With the potential to store more than 78 billion tonnes of carbon dioxide,[179] we can be a global leader in carbon storage services.

Deployment of CCUS could create new markets for UK businesses, at home and abroad, as other countries look to meet their emissions reduction commitments. Action now can harness the UK's strengths in engineering, procurement, construction, and management services, with export opportunities from CCUS estimated at £3.6 billion by 2030.[180]

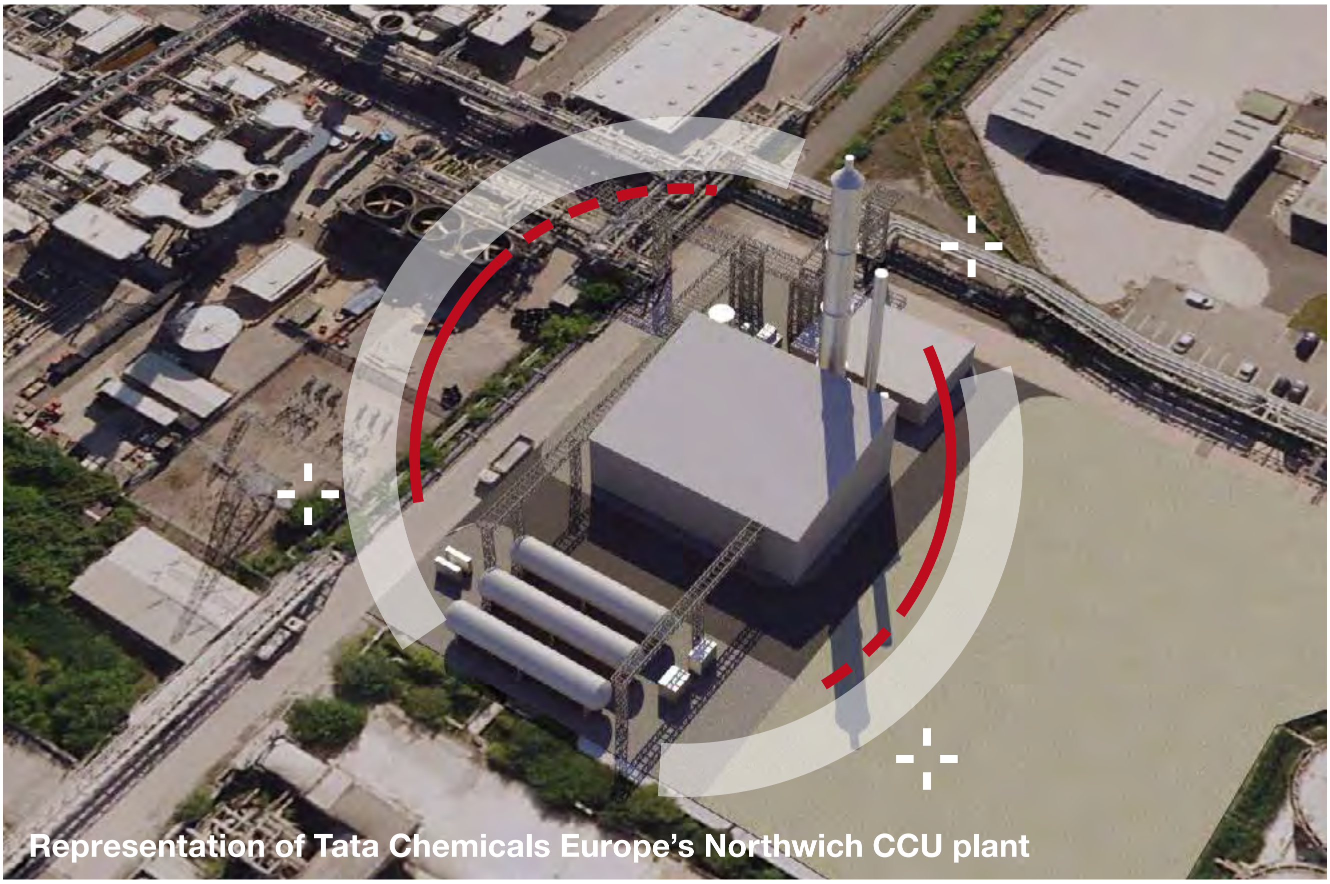
CCUS

The process of capturing carbon dioxide from industrial processes, power generation, certain hydrogen production methods and greenhouse gas removal technologies such as bioenergy with carbon capture and storage and direct air capture. The captured carbon dioxide is then either used, for example in chemical processes, or stored permanently in disused oil and gas fields or naturally occurring geological storage sites.

CASE STUDY

Tata Carbon Capture and Utilisation (CCU)

Tata Chemicals Europe (TCE) are constructing, with the support of a £4.2 million grant from the Energy Innovation Programme, the UK's first industrial-scale CCU demonstration plant at their site in Northwich, for the manufacture of high purity sodium bicarbonate. The plant will be commissioned in 2021 and will be capable of capturing up to 40,000tCO$_2$e per year, and will reduce carbon emissions at the plant by 11 per cent. TCE exports 60 per cent of its sodium bicarbonate production in the UK to over 60 countries across the globe. The CCU project will be a springboard for TCE to unlock further expansion into its export markets.[181]



Representation of Tata Chemicals Europe's Northwich CCU plant

We have created the Carbon Capture and Storage (CCS) Infrastructure Fund to commit the investment needed to realise this opportunity. In his Budget of March 2020,[182] the Chancellor committed at least £800 million through the Fund to support CCUS deployment. As announced in the Prime Minister's Ten Point Plan, we are now raising our commitment to £1 billion up to 2025 to facilitate the UK's deployment of operational CCUS in four industrial clusters by the end of the decade. This new carbon capture industry could support up to 50,000 jobs in the UK by 2030.[183] Developing carbon transport and storage infrastructure will require large upfront capital expenditure, to construct offshore and onshore pipelines and develop storage sites and wells. We will help to put in place this critical network, as the foundation for the scaling up of CCUS across the UK.

For the majority of industrial sectors, CCUS is not yet a viable investment. The market currently does not provide a sufficiently robust price signal to make industrial carbon capture viable. In addition, low-carbon products do not attract a price premium, making investment harder to justify without a support mechanism. It can be hard for early investors to fully reap the benefits of learning and innovation which is generated from backing this first-of-a-kind technology. This is why we are designing and implementing a business model to provide revenue support and improve companies' confidence for investing in carbon capture solutions. We aim to finalise a new commercial framework by 2022.

CLEAN HYDROGEN

The production and use of clean hydrogen will be important in achieving net zero emissions by 2050.

As a gas that can be used as a fuel without emitting harmful greenhouse gasses, hydrogen will be critical in reducing emissions from heavy industry, as well as in power, heat and transport. When heavy goods transport or a process such as steel production relies on fuel for energy, hydrogen can provide a crucial, low-carbon alternative to fossil fuels.

- **We will publish a dedicated Hydrogen Strategy in early 2021 which positions the UK as a world leader in the production and use of clean hydrogen.**

Around 95 per cent of global hydrogen production is fossil-fuel based.[184] A complete switch to clean hydrogen is required, together with a major increase in production capacity. The UK currently makes up to 27TWh annually.[185] The Climate Change Committee (CCC) suggest we may need a ten-fold increase by 2050, with the option to go further depending on the scale of hydrogen use in heat, transport and power. [186]

CLEAN HYDROGEN

Hydrogen that is produced with significantly lower greenhouse gas emissions compared to current methods of production – methods include reacting methane with steam to form hydrogen and then capturing the carbon dioxide by-product (steam methane reformation with CCUS) or using renewable electricity to split water into hydrogen and oxygen (electrolysis).

CASE STUDY

ITM Gigastack

ITM Power are a manufacturer of PEM (proton exchange membrane) electrolysers, a technology which enables the generation of hydrogen from water. The company is based in Sheffield, UK. Coupled with a renewable energy supply, this production method is capable of producing zero carbon hydrogen. The Gigastack project explores the potential to scale up electrolyser size and integrate those units with offshore wind facilities. BEIS is currently supporting a consortium led by ITM Power along with Ørsted, Phillips 66, and Element Energy, funded as part of the £505 million Energy Innovation Programme.

£240m available through **Net Zero Hydrogen Fund** up to 2024/25

5GW **aim for low-carbon hydrogen production** capacity by 2030

42TWh **annual low-carbon hydrogen production** by 2030

A variety of production technologies will be required to satisfy the level of anticipated demand for clean hydrogen in 2050. This is likely to include methane reformation with CCUS, biomass gasification with CCUS and electrolytic hydrogen using renewable or nuclear generated electricity.

- **Working with industry, our aim is for the UK to develop 5GW of low-carbon hydrogen production capacity by 2030.**

The exact mix of different end uses for clean hydrogen in 2050 will depend on a variety of factors including cost, availability and technical application. Action is needed now to enable hydrogen to be deployed flexibly in the future. We will need production at scale by the mid-2020s to provide assurance on safety, security, cost and the potential for emissions reduction, before we scale up even further during the 2030s. To put the UK on this pathway, we are aiming for 5GW of clean hydrogen production capacity in 2030, equating to 42TWh, and supporting up to 8,000 jobs by 2030 across our industrial heartlands and beyond.[187] We hope to see 1GW of hydrogen production capacity by 2025 on route to our 2030 goal.

Action now to deploy hydrogen during the 2020s will stimulate domestic supply chains, enabling UK businesses to capture increasing international demand for hydrogen goods and services. Ensuring this happens will be an important part of our upcoming Hydrogen Strategy.

- **We will create a Net Zero Hydrogen Fund to support low-carbon hydrogen production, providing £240 million of capital co-investment out to 2024/25.**

The Net Zero Hydrogen Fund will deliver a major boost to production capacity, ensuring that clean hydrogen can be utilised for decarbonising industrial clusters and play its role delivering net zero.

The Fund will help establish the technology and will ensure that existing mechanisms, such as the Renewable Transport Fuel Obligation, provide an appropriate level of support for renewable hydrogen. However, achieving our 2030 ambition for clean hydrogen will also require the right commercial frameworks which encourage sustained private sector investment. We will put the necessary building blocks in place now to provide confidence that clean hydrogen can be produced reliably and cost-effectively. We will introduce a commercial framework by 2022, which enables project sponsors of all types of clean hydrogen to finance their projects. We will consult on our preferred model in 2021.

A UK EMISSIONS TRADING SCHEME

Creating a new UK carbon market will be the foundation on which the UK achieves net zero emissions cost-effectively.

- **We will implement the world's first net zero carbon cap and trade market, the UK Emissions Trading Scheme.**

The UK has been a pioneer of emissions trading since 2002. The European Union adopted our cap-and-trade approach to carbon pricing, and other countries around the world have followed our lead. There are now 28 trading systems operating across four continents.[188] Having left the EU, we are ready to lead the world again.

We will establish a UK Emissions Trading Scheme (ETS) to replace the UK's participation in the EU ETS. The UK ETS will be a market-based measure which will provide continuity for businesses. A cap is set on the greenhouse gases that businesses can emit (via the total number of allowances in circulation), which will decrease over time. Businesses then buy and sell emissions allowances through government auctions or secondary markets. The UK ETS will initially apply to energy-intensive industries, electricity generation and aviation.

EMISSIONS TRADING SCHEME (ETS)

A method of putting a price on emissions. A cap is set on the total amount of certain greenhouse gases that can be emitted by participants. The cap is reduced over time so that total emissions fall. Within the cap, companies receive or buy emission allowances, which they can trade with one another as needed.

This mechanism of carbon pricing supports businesses to decarbonise at the least cost. Businesses who can abate cheaply will do so, and those that cannot purchase additional allowances to cover their emissions. Knowing that the ceiling on emissions will lower transparently over time enables business to plan and invest to decarbonise, while at the same time protecting the competitiveness of businesses and minimising the risk of carbon leakage.

Following the introduction of the UK ETS, we will consult in due course on how to align the cap with an appropriate net zero trajectory, meaning the system will significantly contribute to ensuring the UK meets our commitment to net zero emissions by 2050. The operation of the cap will provide certainty about the decarbonisation trajectory over the long term. It will deliver a robust carbon price signal; giving businesses the confidence to mobilise the scale of capital investment necessary to deploy clean energy technologies; and to capture new trade opportunities on the back of the energy transition.

The UK ETS will also allow us to expand carbon pricing across the economy and encourage innovation in emerging decarbonisation technologies. We have committed to exploring expanding the UK ETS to the two thirds of uncovered emissions, and will set out our aspirations to continue to lead the world on carbon pricing in the run up to COP26. This will also include how the UK ETS could incentivise the deployment of greenhouse gas removal technologies. In addition to this, the UK is open to linking the UK ETS internationally in principle and we are considering a range of options, but no decision on our preferred linking partners has yet been made.

SUPPORT FOR BUSINESSES

Our strategy includes providing capital support to help industry become more energy efficient and to bring down the costs and risks of key decarbonisation technologies.

This investment will bring forward the date at which technologies such as CCUS and hydrogen can be commercially deployed in industry. However, we recognise that investors need revenue visibility of revenue, delivered by new business and commercial models, for the lifetime of a project, if they are to finance the upfront capital costs of decarbonisation projects.

- **We will bring forward details in 2021 of a revenue mechanism to bring through private sector investment into industrial carbon capture and hydrogen projects via our new business models to support these projects.**

The government is already providing capital support through a number of schemes for industry to decarbonise. The £18 million Industrial Heat Recovery Support programme is helping businesses reuse heat which would otherwise be wasted. The Climate Change Agreements Scheme reduces the amount of a tax that industry pays on energy, called the Climate Change Levy. It has supported industry with an estimated £200 million in tax discounts a year, in return for meeting agreed energy or carbon reduction targets and has now been extended by a further two years until March 2025.[189] The Industrial Energy Transformation Fund (IETF) was launched this year, with funding worth £315 million, to help businesses with high energy use to cut their bills and reduce carbon emissions.

Additionally, the £250 million Clean Steel Fund was announced in 2019 and is designed to support the resilience and longevity of the steel sector by supporting it onto a decarbonisation pathway consistent with net zero. We will also develop user-friendly digital services to improve access to funding for our stakeholders.

In addition, we intend to provide longer-term certainty to industry which goes beyond the need for time-bound support schemes dependent on direct government funding. Over the long term, cost reductions in low-carbon technologies, coupled with a robust carbon price signal and a thriving market for low-carbon products, will drive investment. In the near term, we will bring forward details of a revenue mechanism to bring through private sector investment in emerging technologies. Providing this visibility will enable industry to invest in new technologies, such as CCUS and clean hydrogen at scale, accelerating the decarbonisation of the sector and the economic opportunities which come with it.

Recognising this, we will bring forward further details in 2021 on the revenue mechanism which will encourage private sector capital into the new business models we are creating to support deployment of industrial carbon capture and clean hydrogen.

Our key commitments

We will **publish an Industrial Decarbonisation Strategy in spring 2021** to set out the details of how the government will support the decarbonisation of manufacturing industry.

In line with the increased ambition set out in the Ten Point Plan we will **increase the Industrial Clusters Mission to support the delivery of four low-carbon clusters by 2030** and at least one fully net zero cluster by 2040.

We will **invest £1 billion up to 2025 to facilitate the deployment of CCUS in two industrial clusters** by the mid-2020s, and a further two clusters by 2030, supporting our ambition to capture 10MtCO$_2$ per year by the end of the decade.

We will **publish a dedicated Hydrogen Strategy in spring 2021** which positions the UK as a world leader in the production and use of clean hydrogen.

Working with industry, our **aim is for the UK to develop 5GW of low-carbon hydrogen production capacity** by 2030.

We will **create a Net Zero Hydrogen Fund** to support low-carbon hydrogen production, providing £240 million of capital co-investment out to 2024/25.

We will **implement the world's first net zero carbon cap and trade market**, the UK Emissions Trading Scheme.

We will bring forward details in 2021 of a **revenue mechanism to bring through private sector investment into industrial carbon capture and hydrogen projects** via our new business models to support these projects.

CHAPTER 06

Oil and gas

OUR GOAL

Delivering our net zero target by 2050 means transforming the oil and gas sector in the UK.

We will:

- Work with the sector to **transform the UK Continental Shelf to be a net zero basin** by 2050
- Provide **opportunities for oil and gas companies to repurpose their operations away from unabated fossil fuels to abatement technologies** such as carbon capture, utilisation and storage (CCUS) or clean energy production such as renewables and hydrogen
- Agree a **transformational North Sea Transition Deal** to deliver new business opportunities, jobs and skills as the sector, as well as protect the wider communities which rely on the oil and gas sector
- Ensure that the licensing of domestic oil and gas exploration and production **continues to be compatible with our climate change ambitions**

OIL AND GAS

The strategic context

The UK's domestic oil and gas industry has a critical role in maintaining the country's energy security and is a major contributor to our economy

Much of the crude oil from the North Sea basin is exported, with the UK making extensive use of strong trading links to meet domestic refinery demand. Domestic production still met 46 per cent of the country's supply of gas in 2019, with the vast majority of this supplied from North Sea offshore production with a smaller proportion from the onshore oil and gas sector. [190]

145k **jobs supported** directly or indirectly across the UK in 2018

80% **drop in production of natural gas** (compared to 2017) could be possible by 2050

0.9% **of 2019 UK GVA** was contributed by the offshore oil and gas sector

The offshore oil and gas sector contributed about 0.9 per cent to the UK's GVA in 2019 and has paid around £350 billion in production taxes since 1970/71.[191] The sector is a source of high-quality jobs, supporting directly or indirectly around 147,000 jobs in total across the UK in 2018.[192] Many jobs supported by the sector are located in Scotland, particularly in Aberdeen, a global hub for the oil and gas industry. Critical supply chain clusters have grown in the North, East and South East of England. These jobs and the additional 113,000 induced by the sector help support the wider UK economy.

While the Oil & Gas Authority (OGA) estimates that there are still around 10 to 20 billion barrels of oil equivalent remaining in the UK Continental Shelf,[193] domestic production has more than halved since 2000.[194] The Climate Change Committee (CCC) estimates that production of natural gas could drop by up to 80 per cent by 2050, compared to levels in 2017.[195] However, the projections for demand for oil and gas, though much reduced, is forecast to continue for decades to come.

The UK's offshore oil and gas sector and the smaller onshore sector have both been severely affected by COVID-19. The pandemic led directly to the global collapse in demand for oil and resulted in a roughly 65 per cent drop in the price of Brent Crude between January and April 2020.[196] Oil and Gas UK (OGUK) estimate that the UK sector will respond by cutting expected capital expenditure by around 30 to 40 per cent and operating expenditure by around 10 to 20 per cent compared with anticipated expenditure at the start of the year, while maintaining production levels.[197] During the early months of the UK lockdown, staffing on offshore rigs was reduced by more than a third compared to early March.[198]

The OGA estimates that there are still around **10 to 20 billion barrels of oil remaining in the UK Continental Shelf**

We have supported the oil and gas sector to bounce back from COVID-19 but a return to 'business as usual' is no longer an option. Government support is in the context of delivering our net zero target. The sector is already coming under significant pressure from investors and the public more widely to respond to the challenge. Shareholders, for example, are increasingly requiring listed companies to price carbon into their business models and demonstrate how they can reduce emissions from their operations or support the wider decarbonisation of the economy.[199]

Many oil and gas companies are now responding to the challenge. Their investment decisions are beginning to anticipate a world without fossil fuels beyond 2050.[200] There is great potential for the sector to play an important part in the energy transition and retain vital skills across key regional hubs around the country, supporting the CCUS and hydrogen "SuperPlaces" clusters announced in the Prime Minister's Ten Point Plan. [201]

HOW UK COMPANIES ARE RESPONDING TO THE NET ZERO CHALLENGE

There is great potential for traditional oil and gas businesses to take advantage of the opportunities provided by the energy transition and transform their operating model, whether they are exploration and development companies, service providers, supermajors or independent companies.

Supermajors such as bp and Shell have set out major changes of strategy to achieve net zero by 2050, including addressing emissions that result of the use of their products. All have set aggressive emissions reductions targets. Other approaches include rebalancing their portfolios to increase their renewable energy holdings; investing in and partnering with renewable energy companies; investing in carbon dioxide sequestration, and expanding their consumer-facing offer, such as electric vehicle charging. Privately backed companies, such as Chrysaor, have also set out their emissions reductions targets, while investing in carbon capture and hydrogen in the UK.

We will continue to push for a high level of ambition amongst oil and gas companies, challenging them to go further to reduce their emissions consistent with our net zero target, while transitioning their operations into emerging energy technologies.

We expect to see the supply chain reflect this shift as well.

Wood

Wood Plc has taken substantial steps to transform its business from a traditional oilfield services provider into broader engineering and consultancy work operating across the energy sector. In 2014, 96 per cent of Wood's revenue was derived from oil and gas work including 65 per cent from upstream activity compared with 2020 where upstream activity now accounts for just one third of its total revenue.[202]

Today, Wood offers a blend of consulting, projects and operations solutions including a fast-growing renewables business. It has been involved in solar projects, increasing global wind capacity as well as CCUS studies and has an increased presence in the hydrogen market. In parallel, the company has continued its commitment to the oil and gas sector through helping partners achieve their own energy transition goals.

A recent survey by OGUK revealed that more than half of its members had already diversified into other energy sectors, even as oil and gas remained their primary source of income.[203] The UK Petroleum Industry Association has set out scenarios and the technology pathways for how the refining and downstream sector can play an active part in achieving net zero emissions.[204] Many supply chain companies are diversifying into other energy sectors.

Reducing emissions from oil and gas will need careful management to avoid disruption to our daily lives and minimise rising costs, as well as to mitigate wider economic impacts. It requires a policy and regulatory framework which continues to promote good environmental practice, alongside effective stewardship of the North Sea by both regulators and oil and gas operators. To achieve this, we expect industry to respond effectively to the net zero challenge but will encourage continued healthy levels of investment. Ensuring that the UK remains an attractive destination for global capital is the best way to secure an orderly and successful transition away from traditional fossil fuels.

Our key commitments

A NET ZERO BASIN BY 2050

It is critical that the sector focuses on cutting the emissions associated with offshore oil and gas production.

- **Working with the regulators, we will drive the reduction of greenhouse gas emissions from all offshore oil and gas operations to make the UK continental shelf a net zero basin by 2050.**

In 2018, upstream oil and gas activities in the UK accounted for four per cent of UK greenhouse gas emissions.[205] According to OGUK, in order to meet net zero, the oil and gas sector will need to reduce its emissions from offshore production and operations to 0.5MtCO$_2$e by 2050, from 19MtCO$_2$e today.[206] Methane will be a special focus, given its potency as a greenhouse gas.

The industry has signed up to the OGUK-led ambition to achieve net zero emissions across all its upstream activities, as set out in the OGUK's Roadmap 2035.[207] It has already set itself the challenge of becoming a net zero basin by 2050, with a 50 per cent absolute emissions reduction by 2030 and 90 per cent by 2040.[208] The sector was amongst the first industrial sectors in the UK to make such a commitment. We expect real and ambitious change from industry to deliver this commitment. We want the industry to go further and faster, wherever possible.

The World Bank estimated that, in 2019, global levels of gas flaring had increased to approximately 150 billion cubic metres of natural gas, emitting about 400MtCO$_2$e, in addition to the waste of the valuable resource.[209]

- **We will commit the UK to the World Bank's 'Zero Routine Flaring by 2030' initiative and will work with regulators towards eliminating this practice as soon as possible in advance of this date.**

The World Bank's 'Zero Routine Flaring by 2030' initiative invites governments and industry to put an end to the operational practice of routine flaring by 2030. Some UK Continental Shelf operators have reduced routine flaring but much more can be done to drive down the practice, notwithstanding the challenges posed by the maturity of the basin and its assets. The OGA will take a more robust stance to push for reductions in flaring and venting and the resulting greenhouse gas emissions, through its consents, field development process and project stewardship role.[210] As part of our discussions with the sector on emissions reduction in the North Sea Transition Deal, we will seek to end this practice before 2030.

We will also tackle regulatory and policy barriers to the use of clean electricity, such as offshore wind, to power offshore oil and gas facilities, as opposed to the current practice of using diesel or gas generators on platforms.

In addition to reducing emissions from direct operations, known as Scope 1 and 2 emissions, we will challenge the sector to address embodied emissions from the consumption of their products or from supply chain activities, so-called Scope 3 emissions.

SCOPE 1,2 AND 3 EMISSIONS

The Greenhouse Gas Protocol Corporate Standard classifies a company's GHG emissions into three scopes:

- **Scope 1:** emissions directly from owned or controlled sources
- **Scope 2:** indirect emissions from the generation of purchased energy
- **Scope 3:** indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions

Many of the larger companies are already setting out plans for taking on this challenge. This will largely be achieved through changes to their corporate strategies to focus their business on abatement of emissions, and new low-carbon energy sources. The approach will vary according to the size and structure of individual companies. Any future government support is dependent on the sector adopting meaningful measures which reduce emissions and report transparently on progress, for example through adhering to the recommendations of the Taskforce on Climate-Related Financial Disclosures.

As we face the challenge of decommissioning end-of-life oil and gas infrastructure in the UK Continental Shelf, we will take account of the potential to use existing infrastructure in CCUS transport and storage supporting carbon capture from industry, power generation and hydrogen production. This will require giving appropriate consideration to responsible management of decommissioning costs.

- **We will support the UK oil and gas sector to repurpose its existing infrastructure in support of clean energy technologies.**

Using oil and gas assets at the end of their existing commercial life could realise significant cost savings in the deployment of CCUS and prove instrumental in getting the technology operational by the mid-2020s. Upfront capital cost savings for the developers of some CCUS projects could be in excess of £100 million, compared to the cost of building new offshore pipelines and associated infrastructure.[211] The re-use of existing assets can also lower the carbon footprint of the construction process.

In August 2020, we published our response to a consultation on the re-use of oil and gas assets for CCUS projects.[212] Our review has identified assets which could have the greatest potential for re-use in CCUS. We will now work with industry and regulators to provide clarity on the regulations for re-purposing assets and to develop technical guidance on how this can be done safely and securely.

A REGULATORY REGIME WHICH INCENTIVISES THE SWITCH TO CLEAN ENERGY

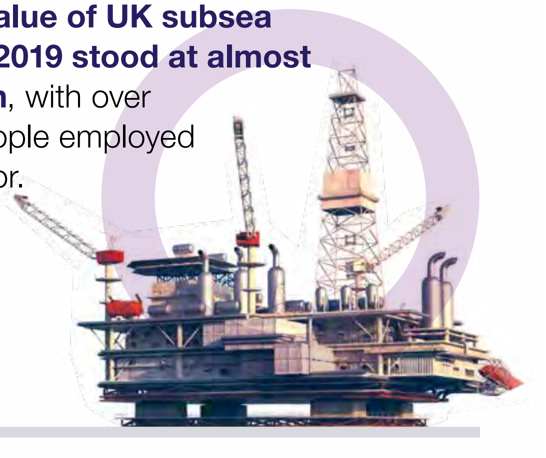
It is vital that our regulators are well positioned to address the net zero basin challenge and help deliver our ambition.

We will work closely with the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) and the Oil & Gas Authority, the principal offshore oil and gas regulators, to ensure that their roles, powers and priorities reflect the government's policy for delivering net zero emissions, without imposing significant additional regulatory burdens.

- **We will undertake a review of the Offshore Petroleum Regulator for Environment and Decommissioning to ensure that it is fully equipped to drive up environmental standards in its regulatory role, as well as supporting the sector's progress towards net zero emissions.**

OPRED is the environmental and decommissioning regulator for offshore oil and gas, gas storage and offshore carbon capture and storage activities. OPRED will increase its focus on the further reduction of greenhouse gas emissions from all offshore oil and gas operations and will put in place a regulatory framework to support emerging decarbonisation technologies. This will include OPRED utilising its existing data collection system to track progress on emissions reduction.

The total **value of UK subsea output in 2019 stood at almost £7.8 billion**, with over 45,000 people employed in the sector.



The principal objective of the OGA, the upstream licensing regulator, is to maximise the economic recovery of petroleum from the UK Continental Shelf, a statutory goal established in the wake of the oil price crash in 2014. The OGA has supported the production of oil and gas in the most cost-effective way possible but its focus has been evolving.

- **We aim to lay a new strategy for the Oil & Gas Authority before the end of 2020 to bolster the regulator's ability to focus the sector on helping deliver net zero emissions.**

The OGA consulted over the summer of 2020 about its intention to refresh its core aim, including a requirement for industry to take appropriate steps to support the delivery of the government's net zero target.[213] We agree with the OGA's assessment that the sector must go considerably faster in reducing its own carbon footprint or risk losing its social licence to operate. The changes proposed in the OGA's consultation have the potential to make a significant contribution to achieving our goal.

The industry has the skills, technology and capital to unlock innovative solutions which could be instrumental in helping to deliver net zero emissions successfully for the whole economy. It can play a critical role in the deployment of CCUS, hydrogen production and renewable electricity generation, particularly offshore wind. The OGA is clear that consideration of the sector's contribution to this goal is a proper part of Maximising Economic Recovery.

The OGA will take wide ranging action to implement its revised strategy. This will include benchmarking greenhouse gas emissions to drive performance and creating a new asset stewardship expectation for net zero. The OGA will update its guidance and its economic assessments, which support regulatory decisions, to include full carbon costs.

A new strategic approach will allow the OGA to take a much greater role in driving the sector's contribution to the clean energy transition. It will further enhance the OGA's role as an environmentally responsible steward.

To respond to the changing landscape in which the UK oil and gas sector is operating, we are currently undertaking a review of policy on the future licensing of domestic offshore oil and gas exploration and production. This review seeks to ensure the continued compatibility of the UK's licensing regime with our climate obligations and delivering our net zero target by 2050. This review is an opportunity for the UK to demonstrate that effective climate leadership can be compatible with maintaining a strong economy and robust energy security.

To ensure that licensing continues to be compatible with our climate change ambitions over the coming decades, we are considering formalising aspects of our existing process.

As we develop our policy options, we believe that a sensible step for the UK may be to develop the existing checkpoints in our processes before proceeding with future licensing rounds. Such a step could involve regularly seeking independent advice on how proceeding with future licensing would impact our climate and energy goals. This could serve to further formalise existing processes and provide an extra layer of assurance that oil and gas licensing remains consistent with our future policy objectives. We will assess what added benefit such a move would bring as part of our review.

In addition to this measure, we are considering a spectrum of options to ensure that the regime continues to be consistent with our wider aims. We will assess all options against a range of factors, including our energy transition goals; emissions reductions; and impacts on the supply chain and jobs. We expect to publish our conclusions in early 2021.

A NEW PARTNERSHIP BETWEEN GOVERNMENT AND INDUSTRY

In our Manifesto, the government committed to agreeing a Sector Deal with the offshore oil and gas industry which secures the sector's long-term future consistent with net zero.

- **We will agree a transformational North Sea Transition Deal with the industry during the first half of 2021, focused on the economic opportunities of net zero and providing support for the people and communities most affected by the move away from oil and gas production.**

The proposed North Sea Transition Deal represents a quid pro quo partnership between the government and industry for taking long-term action which transforms the sector and delivers the energy transition. We are negotiating the substance of the deal with the sector and aim to reach agreement by the first half of 2021. We will use the deal as a vehicle to create new jobs as well as trade and investment opportunities. The deal will also set out how we can retain existing skills and capabilities in the sector, many of which are of vital regional and national significance and which could give the UK first mover advantage in emerging low-carbon sectors.

The Prime Minister's Ten Point Plan included ambitious commitments on supporting the delivery of clean energy technologies such as hydrogen and CCUS. Given the proximity of UK oil and gas hubs – particularly Scotland and the North East of England, this presents a great opportunity for the sector to unlock additional funding through the North Sea Transition Deal. The sector can contribute meaningfully to the Green Industrial Revolution by providing essential skills across key regions of the UK economy.

NORTH SEA TRANSITION SECTOR DEAL

Key deliverables

Cleaner energy production through rigorous emissions reductions;

Supporting the **delivery of CCUS;**

Diversification of the oil and gas supply chain into new energies;

Supporting the **development of hydrogen production;** and

Safeguarding existing jobs and establishing tens of thousands of new high-quality jobs across the sector in diversified energy technologies.

SECURING NEW TRADE AND INVESTMENT OPPORTUNITIES

Through the UK's international leadership on climate change action, we will seek new opportunities in overseas markets to export our expertise in subsea engineering, decommissioning and other supply chain capabilities.

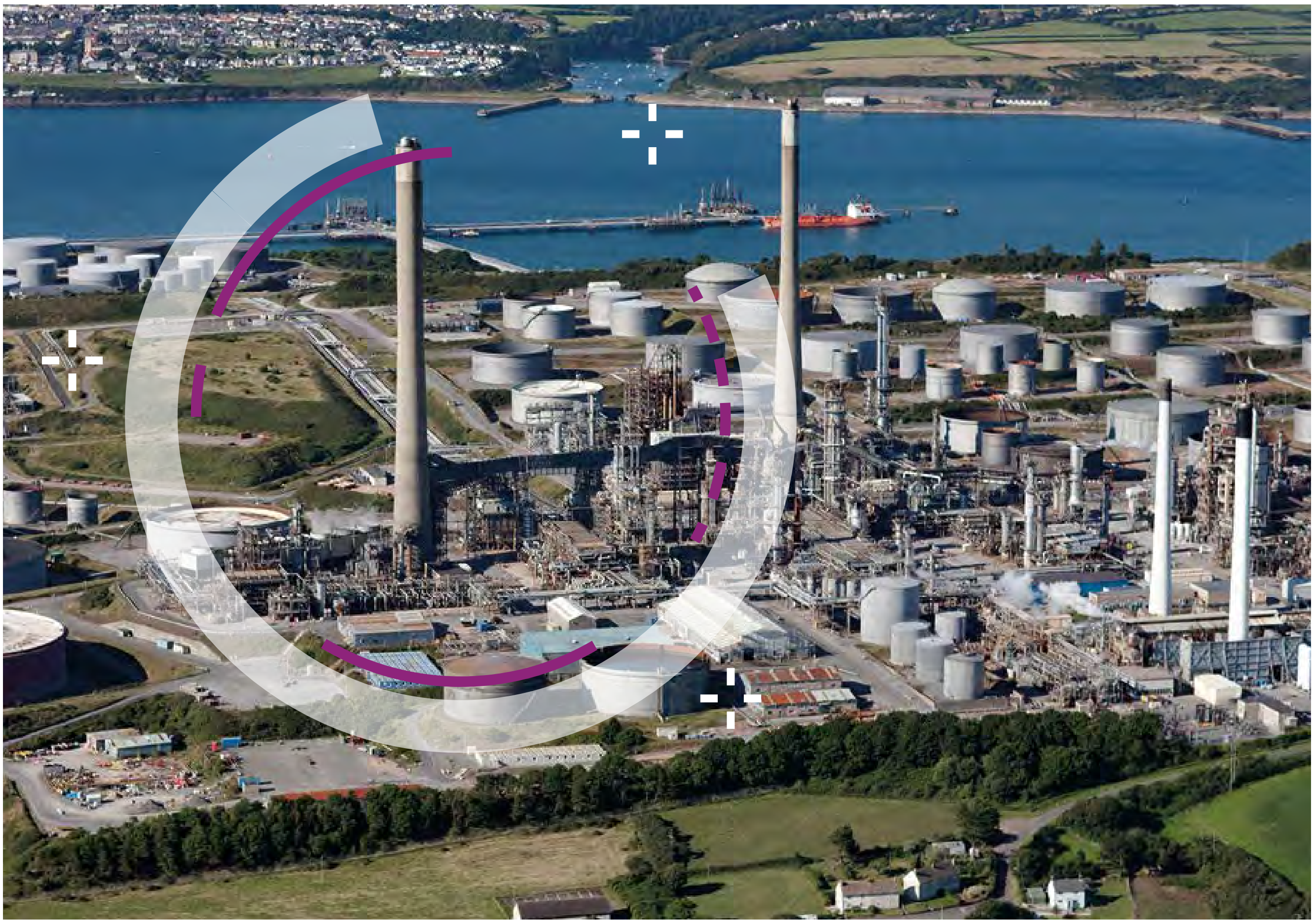
- **We will use our North Sea Transition Deal to support the UK-based oil and gas supply chain to secure new low-carbon export opportunities in overseas markets, capitalising on the global reach of the UK's world-class trade promotion and diplomatic resources.**

The UK's offshore oil and gas supply chain sells a range of products, services and expertise to domestic and world markets. With innovative providers of oil field services and capability across all sub-sectors, including marine and sub-sea operations, it had an estimated turnover in 2018 of £27 billion and employs around 116,000 people.[214] Many of these capabilities are readily exportable to new markets, as the world decarbonises.

The UK is forecast to become the largest decommissioning market globally over the next decade, with decommissioning expenditure forecast to be around £1.5 billion per year for the next ten years.[215] This will enable the UK supply chain to develop a world-leading decommissioning industry. If the sector can decommission our offshore infrastructure in a safe, efficient and environmentally responsible manner, while also meeting the OGA's ambitious cost reduction targets, it will be well-positioned to service the global market, by one estimate worth around £80 billion in the next decade[216] and near £270 billion from 2022 onwards.[217]

£27bn	**estimated turnover** of the UK's offshore oil and gas supply chain in 2018
£8bn	**total value of UK subsea output** in 2018/19
<1%	UK contribution to **overall global greenhouse gas emissions**

As announced in the 2020 Spending Review, we will commit funding towards the Global Underwater Hub in Aberdeen with satellites in North East England And Southern England. This new economic development hub will take a strategic approach to growing our world-leading subsea engineering, technology and services sector as the global subsea market diversifies away from oil and gas and shifts towards supporting new marine growth sectors such as renewables.



In parallel with this white paper, we will publish proposals for helping develop decommissioning opportunities, both domestically and in overseas markets.

The UK's world-leading subsea engineering industry is already positioned for global growth across a range of diversified sectors which make up the so-called 'Blue Economy', economic activities relating to the world's oceans and coastlines. The total value of UK subsea output in 2018/19 stood at around £8 billion, with over 45,000 people employed in the sector.[218]

The UK contributes less than one per cent to overall global greenhouse gas emissions[219] so we must leverage our role as a world leader on climate change and ensure we use all available levers to support global clean growth opportunities.

This is why in January 2020 the Prime Minister announced that the UK government will no longer provide any new direct support for thermal coal mining or coal power plants. To bolster our commitment to supporting a clean energy transition, The Prime Minister has now announced that the UK government will no longer provide direct financial or promotional support for the fossil fuel energy sector overseas. Both announcements extend to any new official development assistance, investment, export credit and trade promotion activity. For oil and gas activities there will be a few - tightly bound - exemptions allowed for activities that support health and safety improvements, form part of wider clean energy transitions, support decommissioning, or are associated with a humanitarian response.

A public consultation process will take place on the implementation date for this policy and to help align government's support for clean technologies. The consultation will close in February 2021 and its findings will help form the North Sea Transition Deal. Our ambition is to lead by example, working towards establishing the UK at the forefront of the global supply chain and capitalising on the skills of the UK sector while working in close partnership with those seeking to transition to a cleaner future.

We will identify the international clean growth projects and emerging clean technology sectors in the UK which can benefit from our export finance mechanisms, from innovation to export, with a particular focus on technologies where the UK has first mover advantage. We will also help UK based companies to diversify and take advantage of the opportunities in emerging energy technologies.

DOWNSTREAM OIL RESILIENCE

The downstream oil sector provided 96 per cent of the energy used in the transport sector in 2019.[220] It will continue to play a vital role in the transition to a net zero economy, delivering fuels to consumers.

The sector is already actively exploring the potential for low-carbon liquid fuels, particularly in aviation, shipping and heavy goods vehicles, which are more challenging to decarbonise.

We will work with industry to promote innovation and remove regulatory barriers which hinder the switch from fossil fuels. The Department for Transport will shortly publish a consultation over the use of fuels produced from non-biogenic waste, which is currently incinerated. It offers the potential to convert non-recyclable plastic and industrial waste gases to jet fuel or substitute for diesel and petrol in cars and vans.

As we make the transition away from fossil fuels, we must maintain secure supplies of fuel to the people and businesses whose livelihoods depend upon it.

- **We will take powers to ensure we maintain a secure and resilient supply of fossil fuels during the transition to net zero emissions.**

Our net zero future undoubtedly represents a challenge to the downstream oil sector, which has already been hit hard by falling demand and reduced refining margins resulting from the COVID-19 pandemic. We believe that it is necessary for government to have powers to monitor the resilience of the fuel supply market and, should it be necessary, to intervene to ensure there is an orderly transition to clean energy supplies. We will explore options for delivery and look to publish a draft Downstream Oil Resilience bill while we seek an opportunity to introduce these measures to Parliament

Our key commitments

Working with the regulators, we will m**ake the UK continental shelf a net zero basin** by 2050.

We will **commit the UK to the World Bank's 'Zero Routine Flaring by 2030'.**

We will **support the UK oil and gas sector to repurpose its existing infrastructure** in support of clean energy technologies.

We will **undertake a review of the Offshore Petroleum Regulator for Environment and Decommissioning** to drive up environmental standards in its regulatory role, and support the sector's progress towards net zero emissions.

We aim to **lay a new strategy for the Oil & Gas Authority before the end of 2020** to bolster the regulator's ability to focus the sector on helping deliver net zero emissions.

To **ensure that licensing continues to be compatible with our climate change ambitions** over the coming decades, we are considering **formalising aspects of our existing process.**

We will **agree a transformational North Sea Transition Deal** with the industry during the first half of 2021.

We will use our North Sea Transition Deal to **support the UK-based oil and gas supply chain to secure new low-carbon export opportunities** in overseas markets.

We will take powers to **ensure we maintain a secure and resilient supply of fossil fuels during the transition** to net zero emissions.

Glossary

Phrase	Meaning
Advanced Nuclear	Includes Small Modular and Advanced Modular Reactors.
Advanced Nuclear Reactors	Reactors which use novel cooling systems or fuels and may offer new functionalities (such as industrial process heat).
Balancing	Matching supply with demand, which is important to keep the gas and electricity systems within safe operating limits. For electricity this needs to be done on a second-by-second basis.
Balancing services / balancing market	The tools and markets that are used to make sure it is possible to match supply with demand.
Bioenergy with Carbon Capture and Storage	Refers to bioenergy processes (such as burning it for electricity) during which carbon is captured and stored. If carefully managed, using sustainable biomass, BECCS can generate 'negative emissions' because while providing energy it also it also captures and stores the atmospheric CO_2 that is absorbed by plants as they grow.
Bioenergy	Refers to heat or electricity produced using biomass or gaseous and liquid fuels with a biological origin such as biomethane produced from biomass.
Biomass	Refers to any material of biological origin used as a feedstock for products (e.g. wood in construction to make chemicals and materials, like bio-based plastics), or as a fuel for bioenergy (heat, electricity and gaseous fuels such as biomethane and hydrogen) or biofuels (transport fuels).
Biomethane	A form of gas that is produced by processing biomass It can be used for the same purposes as natural gas, like producing electricity or heat, and can use the same infrastructure for transmission and end-user equipment.
Capacity market	Is our primary policy mechanism for delivering security of electricity supply. It provides generators and flexibility providers with a payment for firm (reliable) capacity to ensure they deliver electricity generation or demand reduction, when required.
Carbon intensity	The amount of CO_2 emitted when generating a unit of electricity, measured in gram of CO_2 per kWh of electricity produced.

Phrase	Meaning
Carbon capture readiness	Is a requirement imposed on thermal plants (such as coal and gas plants) to enable future capturing and storing of carbon following a plant upgrade. Such plants currently emit CO_2 directly into the atmosphere.
Carbon Capture Utilisation and Storage (CCUS)	The process of capturing carbon dioxide from industrial processes, power generation, certain hydrogen production methods and greenhouse gas removal technologies such as bioenergy with carbon capture and storage and direct air capture. The captured carbon dioxide is then either used, for example in chemical processes, or stored permanently in disused oil and gas fields or naturally occurring geological storage sites.
Carbon Leakage	Refers to the situation that may occur if, for reasons of costs related to climate pricing policies, businesses were to transfer production or reallocate future investments to other countries with laxer emission constraints or carbon pricing. This could lead to an increase in total global carbon emissions.
Carbon Price	A cost applied to carbon pollution to encourage polluters to reduce the amount of greenhouse gases they emit into the atmosphere.
Clean Electricity	Types of electricity generating technologies that emit little or no fossil fuel derived greenhouse gas from generation.
Competitive tendering	A process inviting eligible organisations to compete to carry out work or supply services, with the winner decided by who can offer the best price and quality.
Contracts for Difference Scheme (CfD)	The main support mechanism for large scale low-carbon electricity generation projects. Successful projects are awarded a long-term contract which secures a price to which they will either be topped up if electricity prices are low, or pay back to if electricity prices are high.
Contract for Difference allocation round	The competitive allocation process of CfD contracts. Participants bid the strike price they require to build their project with the cheapest ones winning on a pay-as-clear system.
Data triage	A logical step by step process to ensure energy data can be made openly available when it is secure and safe to do so.
Decarbonisation	A process of reducing the amount of carbon dioxide we release into the atmosphere.

Phrase	Meaning
Demand Side Response (Solutions)	Is when consumers adjust their energy usage in response to an external signal. Examples include either reducing it, delaying it, or using on-site generation or storage. DSR was historically provided by large industrial and commercial consumers, but technology development is making it easier for smaller consumers to provide these services for example by charging their electric car with a smart charger.
Digitalisation	Is the integration of digital technologies into a process, organisation, or system. For example, smart meters which automatically send meter readings to energy suppliers, meaning more accurate bills for customers.
Direct Air Carbon Capture and Storage	Use of engineered processes to capture carbon dioxide (CO_2) directly from the atmosphere, for storage or use.
Dispatchable generation	Is electricity generation that can be turned on, off, up or down as needed.
Dispatch signals	A pricing mechanism designed to encourage power stations to produce and send electricity to the grid when it is needed
Distribution networks	Regional networks that transport gas or electricity into homes and businesses and import electricity from small-scale generation.
Distributed flexibility	Technologies that can deliver flexibility (see flexibility) that are connected to the distribution network across the country.
Domestic Load Connection Allowance	The duty that network owners have to provide the first 10 metres of a gas connection free of charge to customers.
Downstream Oil and Gas	The industries and processes in which oil and gas are converted into finished products
Electricity Capacity	The amount of electrical power a generator can produce when it is running at maximum output.
Electricity Generation	Is the total electrical energy created over a period of time.
Electricity System	A system consisting of generators, interconnectors, transmission and distribution networks, and storage that deliver electricity to the final consumer (businesses, industry, public sector and homes). As well as the markets and control infrastructure such as smart and digital technologies, that play a key role in making sure the system balances supply and demand.
Electrification	Switching from using fuels such as gas or petroleum, to using electricity. For example, switching from a petrol car to an electric car.

Phrase	Meaning
Emissions Trading System (ETS)	A method of putting a price on emissions. A cap is set on the total amount of certain greenhouse gases that can be emitted by participants. The cap is reduced over time so that total emissions fall. Within the cap, companies receive or buy emission allowances, which they can trade with one another as needed.
Energy codes	The detailed technical and commercial rules of the energy system.
Energy data	Historical, current, and future information covering things such as how, where and when energy is generated, transported, used, and stored.
Energy efficiency	When something performs better using the same amount of energy, or delivers the same performance for less. The principle of energy efficiency can be applied to many things: buildings, products, appliances, manufacturing processes, to name a few.
Energy Performance Certificate	Energy Performance Certificates (EPCs) are required in the UK to provide a prospective owner or tenant with information on the energy performance of a building and recommendations for improvement. EPCs use an A-G rating scale based on the modelled energy bill costs of running the building.
Engineering standards	The specifications to which the energy system is designed and operated.
Flaring	The controlled burning of unwanted or excess natural gases.
Flexibility	The ability to change generation and/or demand in response to an external signal (e.g. price or contract terms). Flexibility enabling technologies include batteries, demand side response, interconnectors and fossil fuel generators.
Fossil fuels	Oil (and fuels derived from oil), coal and natural gas
Fuel poverty	The government definition of fuel poverty is where a household has fuel costs that are above average and, were they to pay that amount, would be left with a residual income below the official poverty line.
Gas quality standards	Are rules to ensure that the gases we use, including natural gas, biogas and hydrogen, meet all of the specifications needed to be safe and effective as an energy source.
Gas system	A system consisting of gas producers, refineries, interconnectors, transmission and distribution networks that delivers gas from its original sources to the final consumer (businesses, industry, public sector and homes). As well as the physical infrastructure, markets play a key role in making sure the system balances supply and demand.

Phrase	Meaning
Generation mix	A mix of technologies designed to meet electricity demand.
Greenhouse Gas Emissions	Addition to the atmosphere of gases that are a cause of global warming, including carbon dioxide, methane and others.
Greenhouse Gas Removal Technologies (or negative emissions)	Methods that actively remove greenhouse gases from the atmosphere, ranging from engineered to nature-based solutions.
Gross value added (GVA)	Gross value added is the value generated by any unit engaged in the production of goods and services.
Heat network	A heat network, sometimes called district heating, is a system of insulated pipes that takes heat or cooling generated from a central source and distributes it to a number of domestic and non-domestic buildings.
Heat pump	A device that extracts heat from the air, ground or water and concentrates it to a higher temperature and delivers it elsewhere, for example to a central heating system. It can replace traditional fossil fuel heating, such as a gas or oil boiler. Heat pump systems are designed to extract a greater amount of heat energy from the surrounding environment than the energy they consume in doing so, therefore they can act as a more efficient source of heat than a conventional electric heater, producing two to three times (or more for very efficient systems) as much heat output as they consume in electricity input.
Hybrid interconnector projects	Projects that combine electricity generation with the ability to feed electricity to two (or more) different markets. For example, an offshore wind project that has multiple connections and is able to provide electricity to both the UK market and to European markets.
Hydrogen for heat	The combustion of hydrogen produces no long-lived greenhouse gas emissions at point of use, making it a possible low-carbon replacement for natural gas as a fuel source for heating homes and other buildings.
Clean hydrogen	Hydrogen that is produced with significantly lower greenhouse gas emissions compared to current methods of production – methods include reacting methane with steam to form hydrogen and then capturing the carbon dioxide by-product (steam methane reformation with CCUS) or using renewable electricity to split water into hydrogen and oxygen (electrolysis).
Industrial Sector	Businesses and organisations involved in manufacturing, refining, coke production and mining.

Phrase	Meaning
Interconnection	Interconnectors are cables or pipes, that transport electricity or gas between different markets internationally. As Great Britain is an island our interconnectors tend to run underneath the sea.
Low-carbon electricity generating technologies	Types of electricity generating technologies that emit little or no carbon, which include renewables, nuclear, CCUS.
Long-duration storage	Storage technologies capable of storing energy for days, weeks or even seasons.
Negative Emission	Achieved by removing greenhouse gases from the atmosphere, for example, through direct air capture or bio-energy production with carbon capture.
Net zero	Refers to a point at which the amount of greenhouse gas being put into the atmosphere by human activity in the UK equals the amount of greenhouse gas that is being taken out of the atmosphere.
Nuclear fusion	Is the process that powers the sun: the fusing of hydrogen atoms into helium, which releases large amounts of energy. Scientists are developing technology to use this process to provide fusion energy, which could be clean, safe and inexhaustible with no long-lived radioactive waste.
Ofgem	The Office for Gas and Electricity Markets (Ofgem) is the independent GB energy regulator for gas and electricity. Its role is to protect consumers now and in the future by working to deliver a greener, fairer energy system.
Peaking Capacity	Electricity generators that don't normally operate but are ready to do so when needed at times of peak demand or low generation.
Policy costs	Cost on energy bills of programmes to save energy, reduce emissions, and provide financial support to the fuel poor.
Price signals	Changes in market price that send messages to consumers and producers about whether to enter or leave a market. For example, rising prices give a signal to consumers to reduce demand, and at the same time they give a signal to potential producers to increase supply.
Real-time markets	In the context of energy this is a market which has no, or very little, time between the finalisation of all trading activity and the physical delivery of energy to the customer. This is very difficult to achieve so the phrase "closer-to-real-time" is often used to indicate a direction of travel.

Phrase	Meaning
Refineries	Industrial facilities which converts crude oil and gas into specific products such as jet fuel or diesel.
Renewable Energy	Energy that is collected from resources which are naturally replaced in human timescales such as sunlight, wind, rain, tides and waves.
R&D	Research and development: thinking up new ideas and applying them.
Regulated Asset Base (RAB)	A type of economic regulation typically used in the UK for monopoly infrastructure assets such as water, gas and electricity networks. The return on a RAB is regulated by an economic regulator.
Small Modular Reactors (SMRs)	SMRs are usually based on proven water-cooled reactors similar to current Nuclear Power station reactors, but on a smaller scale. They use nuclear fission to generate low-carbon electricity. SMRs are called modular reactors as their components can be manufactured in factories using innovative techniques and then transported to site to be assembled.
Smart charging	Connecting an electric vehicle to the electricity grid using a charging device which includes a data connection. This allows electric vehicles that are plugged in using smart chargers to be charged when it is the most efficient, in terms of cost for the consumer and/or from the point of view of balancing supply and demand across the electricity system.
Smart meters	The next generation of gas and electricity meters, which use a secure smart data network to automatically and wirelessly send meter readings to energy suppliers, enable remote topping up of balances for pre-payment customers and near real time energy consumption and expenditure to be visible to domestic energy consumers via an In-Home Display. Smart meters also enable innovations such as time of use tariffs which will help support delivery of our net zero objectives.
Strike price	The price a generator bids into a CfD allocation process. The strike price of the last successful project becomes the clearing price, which all successful generators are awarded in their contracts.
Suppliers (retail energy suppliers)	Licensed companies that buy gas and electricity primarily in the wholesale market and sell it to energy users including domestic and non-domestic consumers.
System constraint	A limit or restriction, which the current system does not have the ability to go beyond. For example, when electricity from a particular location is unable to be transported to the location of demand, due to restrictions on the network.

Phrase	Meaning
System cost	The annualised costs of building and operating the energy system, including generation, transmission and distribution, balancing and carbon costs.
System operators	Manage the whole energy system and keep it in balance so that gas and electricity are available when needed.
Transmission networks	National networks that transport gas and electricity long distances across Great Britain; the motorways of our energy network.
Unabated (gas) generation	Electricity generation where carbon from burning natural gas is not captured and stored.
Upstream Oil and Gas	The industries and processes involved in exploration and extraction of oil and gas
Vehicle-to-grid	Technologies that allow electric vehicles (and their charging equipment) to export energy back to the electricity grid in response to communications to and from the electricity network.
Wholesale costs	The amount energy companies pay to buy gas and electricity

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