nationalgrid

UK Future Energy Scenarios

UK gas and electricity transmission

SEPTEMBER 2012

This is the second edition of the UK Future Energy Scenarios document, in which we describe in some detail the assumptions used in our analysis and development of future energy scenarios: for example, developments in electricity generation backgrounds, electricity and gas use and progress against environmental targets.

This represents the start of the second year of our revised consultation process. Following the publication of the first edition of the document we gathered views at stakeholder engagement events and in a series of meetings with interested parties. In this year's edition we have shown how our own views have developed and how we have responded to the views of our stakeholders.

I hope that you find this an informative and useful document and look forward to receiving your feedback.

Richard Smith
Head of Energy Strategy & Policy

Executive summary

The UK has legislation in place setting limits on the emissions of greenhouse gases as far ahead as 2050. There is also legislation mandating a minimum level of renewable energy in 2020. A single forecast of energy demand does not give a sufficiently rich picture of possible future developments so National Grid now carries out analysis based on different scenarios that between them cover a wide range of possible energy futures.

- In the Slow Progression scenario developments in renewable and low carbon energy are comparatively slow, and the renewable energy target for 2020 is not met until some time between 2020 and 2025. The carbon reduction target for 2020 is achieved but not the indicative target for 2030.
- In the Gone Green scenario the renewable target for 2020 and the emissions targets for 2020, 2030 and 2050 are all reached.
- The Accelerated Growth scenario has more low carbon generation, including renewables, nuclear and Carbon Capture and Storage (CCS), coupled with greater energy efficiency measures and electrification of heat and transport. Renewable and carbon reduction targets are all met ahead of schedule.

The assumptions behind the scenarios are described in some detail out to 2030 in this document, including:

- The economic background;
- Fuel prices;
- Developments in the heating market, with particular emphasis on heat pumps;
- Developments in electric vehicles;
- Electricity demand, with discussion of high efficiency technologies, especially lighting, and the application of smart technology for demand side management.

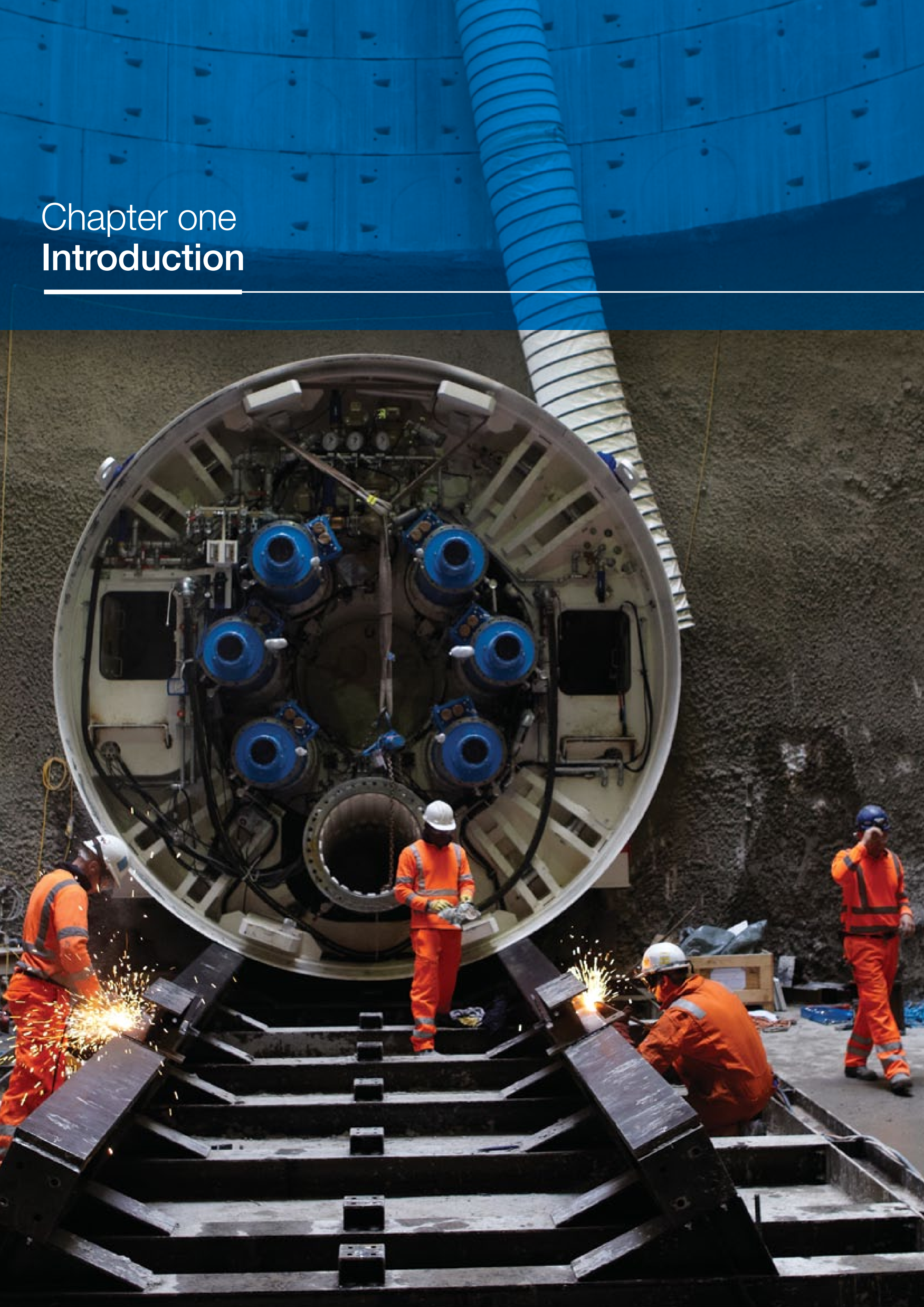
The power generation fleet in each scenario is selected to meet the peak demand with an adequate plant margin, but with different levels of low carbon and renewable capacity.

Having considered the energy demand for heat, transport and electricity, and the break down of electricity generation by fuel type, the effect on total gas demand and gas supply is examined.

Developments from 2030 to 2050 are not considered in the same level of detail, but a brief description of the main demand sectors is given, along with the implications for electricity generation and gas demand.

Contents

Chapter one
Introduction



In 2011 National Grid replaced a single 'best view' forecast of electricity and gas demand with scenarios representing three different views of the future. For 2012 we have developed this approach further, based on feedback from our stakeholders.

In this document we describe the assumptions behind all three scenarios, look at the resulting energy demand, examine the CO_2 emissions and contribution from renewable energy, and, where appropriate, describe how our approach has developed since last year. Projections to 2030 are discussed in considerable detail, while the period 2030 to 2050 is described in a more qualitative fashion.

Detailed tables of gas and electricity demand for all three scenarios are available on the National Grid website[1] and a selection of key facts and figures is given in Appendix 2 of this document.

1 www.nationalgrid.com/uk/Gas/OperationalInfo/TBE/

Chapter two
Creation of scenarios

2.1
Stakeholder engagement

The feedback we received from our stakeholder engagement activities has helped shape our 2012 scenarios. Following the publication of last year's UK (FES) in November 2011, we sought feedback on our scenarios from our stakeholders in an annual consultation.

We used a range of formats, including bilateral meetings, workshops, questionnaires and presentations followed by question and answer sessions and gathered views on a wide range of energy-related topics.

We documented the feedback in a new publication, UK Future Energy Scenarios Stakeholder Feedback[2], and the major themes of macro factors, demand and supply uncertainty as well as other points have led to the 2012 scenarios featuring a broader range of assumptions. This year we have published the underlying assumptions for each of the scenarios, to aid understanding and to encourage debate.

2 www.nationalgrid.com/NR/rdonlyres/2450AADD-FBA3-49C1-8D63-7160A081C1F2/54699/UKFESStakeholderFeedback2012.pdf

2.2 The scenarios

For 2012 we have again produced three scenarios, Slow Progression, Gone Green and Accelerated Growth. In response to feedback we have broadened the range of possible futures covered by the scenarios.

As before, Gone Green has been designed to meet the environmental targets: 15% of all energy from renewable sources by 2020, greenhouse gas emissions meeting the carbon budgets out to 2027, and an 80% reduction in greenhouse gas emissions by 2050. Slow Progression represents slower progress towards environmental goals, for example, the fourth carbon budget is not satisfied. This year's Accelerated Growth is a much more complete scenario than last year, and contains the same level of detail in all areas as the other two scenarios. Last year's Accelerated Growth differed from Gone Green only in having a faster development of offshore generation.

We received some feedback that with three scenarios, Gone Green was likely to be seen as a central case, but this is not intended to be the case; these are scenarios not forecasts and we do not wish to present any of the three as being more likely. Within this document we have sometimes shown charts for one scenario and not the others but this is for reasons of space rather than any intent to give particular weight to that scenario.

With the significant requirement for both development and installation of new technology, Accelerated Growth is clearly going to be extremely challenging. Nevertheless it is important that we carry out the analysis required for the scenario as it allows us to assess the impact of pockets of regional investment, for example wind power, which may develop faster in certain geographies rather than be evenly distributed throughout zones. It is also consistent with the government aspiration to reduce the levelised costs of offshore wind to £100/MWh.

The full detail of our gas and electricity projections, which will be published in the Gas Ten Year Statement and the new Electricity Ten Year Statement, is for Great Britain rather than the whole United Kingdom, as we only operate networks within GB. Environmental targets are all set for the UK so it was necessary to scale up our initial forecast, for which we used a modified version of the Department of Energy and Climate Change (DECC) 2050 calculator[3]. The 2050 calculator was also used to assess greenhouse gas emissions and the level of renewable energy.

We have only created full details for all three scenarios as far as 2030. Beyond 2030 it becomes more difficult to model scenarios in the same level of detail as in earlier years. However, we have modelled Gone Green in detail out to 2050.

3 www.decc.gov.uk/media/viewfile.ashx?filetype=4&filepath=11/tackling-climate-change/2050/3696-2050-calculator-with-costs.XLSX&minwidth=true

2.3 Axioms

Table 1.
Extract from the scenario axioms

2012 axioms			
	Slow Progression	**Gone Green**	**Accelerated Growth**
Domestic Gas Demand	Overall increases in demand with higher comfort levels and new house build exceeding reductions from low levels of energy efficiency.	Demand reduces due to energy efficiency improvements followed later by the high penetration of heat pumps. Comfort levels assumed to remain the same as today. New build houses have low energy use and high use of heat pumps.	Significant demand reduction due to energy efficiency improvements and lower comfort levels followed by very high penetration of heat pumps. New build houses have very low energy use and very high use of heat pumps.

An axiom is a premise or starting point of reasoning. In other words, an axiom is a logical statement assumed to be true. To create our 2012 supply and demand scenarios we have made extensive use of axioms to intentionally create scenarios which encompass a wide range of possible future development. Table 1 shows the axioms used for domestic gas demand as an example. The full list is in Appendix 1.

In our use of axioms we assume that the condition remains for the duration of the scenario rather than behaving in any cyclical or corrective manner. For example in **Slow Progression** we assume sustained low fuel prices; these are sufficient to drive demand despite a depressed economy.

We also assume that the consequences of the axiom occur immediately regardless of current conditions. Hence for **Slow Progression** we assume gas generation is cheaper than coal despite prices at the time the axioms were finalised that favoured coal burn over gas, so there is an immediate increase in the gas demand forecast in **Slow Progression** above that actually being observed at the present.

With the axioms we also make some assumptions that may appear to be counter-intuitive. For example we assume plentiful gas supply in **Slow Progression** compared to **Gone Green** or **Accelerated Growth** despite lower gas prices. Our basis for this assumption is that in **Slow Progression** there is sustained demand for gas and though the forecast price for gas is lower than in the other scenarios, it still remains well above the marginal cost of production.

Chapter three

Background: Now to 2030

In this chapter we discuss the main drivers behind our scenarios out to 2030.

3.1 Government targets

UK and EU legislation sets targets for renewable energy and emission of greenhouse gases. Renewables are governed by the 2009 Renewable Energy Directive[4] which sets a target for the UK to achieve 15% of its energy consumption from renewable sources by 2020.

The Climate Change Act[5] 2008 introduced a legally binding target to reduce greenhouse gas emissions by at least 80% below the 1990 baseline in 2050, with an interim target to reduce emissions by at least 34% in 2020. The Act also introduced 'carbon budgets', which set the trajectory to ensure the targets in the Act are met.

These budgets represent legally binding limits on the total amount of greenhouse gases that can be emitted in the UK for a given five-year period. The fourth carbon budget covers the period up to 2027 and should ensure that emissions will be reduced by around 60% by 2030.

4 www.decc.gov.uk/en/content/cms/meeting_energy/renewable_ener/renewable_ener.aspx
5 www.decc.gov.uk/en/content/cms/legislation/cc_act_08/cc_act_08.aspx

3.2
Government policy

There are a number of policies in place to aid the development of renewable energy and the reduction of carbon emissions. These are all described in detail elsewhere, for example the DECC website, so in this section we only discuss policies which have developed since the 2011 scenarios were published, or which have a significant effect on this year's projections.

3.2.1
Electricity Market Reform (EMR)

Electricity Market Reform[6] as outlined in the draft Energy Bill, includes the introduction of new long-term contracts (Feed-in Tariff with Contracts for Difference), a Carbon Price Floor, a Capacity Mechanism, including demand response as well as generation, and an Emissions Performance Standard (EPS) set at 450g CO_2/kWh to reinforce the requirement that no new coal-fired power stations are built without CCS, but also to ensure necessary investment in gas can take place.

Our analysis of EMR is ongoing, but we have taken account of the main themes in deriving our electricity generation backgrounds, shown in section 4.2, and assume that the mechanisms will play a part in maintaining adequate plant margins and will ensure that there is sufficient renewable and low carbon generation to meet the renewable and carbon targets in the Gone Green and Accelerated Growth scenarios.

6 www.decc.gov.uk/en/content/cms/meeting_energy/markets/electricity/electricity.aspx

3.2.2
Renewable Heat Incentive (RHI)

The Renewable Heat Incentive[7] scheme provides payments for heat generated from renewable technologies including biomass boilers, solar thermal and heat pumps. There are three distinct phases.

- The RHI Phase 1 currently provides financial support to commercial, industrial, public, not-for-profit and community generators of renewable heat.
- The RHI Premium Payment (RHPP) currently provides financial support to off gas grid householders generating renewable heat. Under RHPP householders receive a single payment for the installation of renewable heat technology.
- The RHI Phase 3 will provide financial support to householders generating renewable heat. Householders will receive regular yearly or quarterly payments for heat generated but it is unclear currently whether this will be based on a metered amount of heat generated or on a deemed amount based on house size.

7 www.decc.gov.uk/en/content/cms/meeting_energy/Renewable_ener/incentive/incentive.aspx

3.2.3
Green Deal and Energy Company Obligation (ECO)

8 www.decc.gov.uk/en/content/cms/tackling/green_deal/green_deal.aspx

Green Deal[8] is a market-led framework that will allow individuals and businesses to make energy efficiency improvements to their buildings at no upfront cost.

Central to the Green Deal is a finance mechanism that will allow access to the finance needed for the improvements with repayment, in instalments, attached to the electricity bill.

The Energy Company Obligation will focus on those householders who cannot achieve significant energy savings without an additional or different measure of support. For example, vulnerable and low-income households and those living in harder to treat properties, such as solid walled properties.

3.2.4
Feed-In Tariffs scheme (FITs)

9 www.decc.gov.uk/en/content/cms/meeting_energy/Renewable_ener/feedin_tariff/feedin_tariff.aspx

The Feed-In Tariffs scheme[9] aims to encourage small scale (<5 MW) renewable generation by paying users for each unit of electricity generated, as well as a payment for each unit exported to the grid.

Technologies supported are: Solar PV, Wind, Hydro, Micro combined heat and power (CHP) and Anaerobic Digestion.

3.2.5
Carbon Emissions Reduction Target (CERT)

10 www.decc.gov.uk/en/content/cms/funding/funding_ops/cert/cert.aspx

The Carbon Emissions Reduction Target[10] requires all domestic energy suppliers with a customer base in excess of 250,000 customers to make savings in the amount of CO_2 emitted by householders.

Suppliers meet this target by promoting the uptake of low carbon energy solutions to household energy consumers, thereby assisting them to reduce the carbon footprint of their homes. CERT will be replaced by the Green Deal at the end of 2012.

3.2.6
Carbon Reduction Commitment (CRC)

11 www.decc.gov.uk/en/content/cms/emissions/crc_efficiency/crc_efficiency.aspx

The CRC[11] is a mandatory scheme aimed at improving energy efficiency and cutting emissions in large public and private sector organisations.

The scheme features a range of reputational, behavioural and financial drivers, which aim to encourage organisations to develop energy management strategies that promote a better understanding of energy usage.

3.3
Economic background

Future energy demand will be sensitive to growth in the economy and, especially for the domestic sector, the growth in the housing market. All three scenarios make use of economic and demographic forecasts provided to us by Experian Business Strategies, dating from early 2012, which form the basis for our own econometric modelling. The three scenarios developed take very different assumptions about the economy and fuel prices going forward.

In **Slow Progression** economic growth remains weak due to economic headwinds from Europe and depressed consumer demand, in **Gone Green** the economy recovers to traditional levels of growth with a partial rebalancing of the economy towards manufacturing, while in **Accelerated Growth** the economy booms, driven by a rebalancing towards a green economy which sees the UK become a world leader in many green technologies.

In line with economic growth, fuel prices are stagnant in **Slow Progression**, with moderate increases in **Gone Green** and the highest price increases in **Accelerated Growth**.

3.3.1
Demographic Background to all Three Scenarios

Housing completions in the past three years have hit exceptionally low levels. Following a 42% decline in housing starts as recession hit in 2008, the number of completions fell from their 2007 peak of 211,300 to 142,100 in 2009.

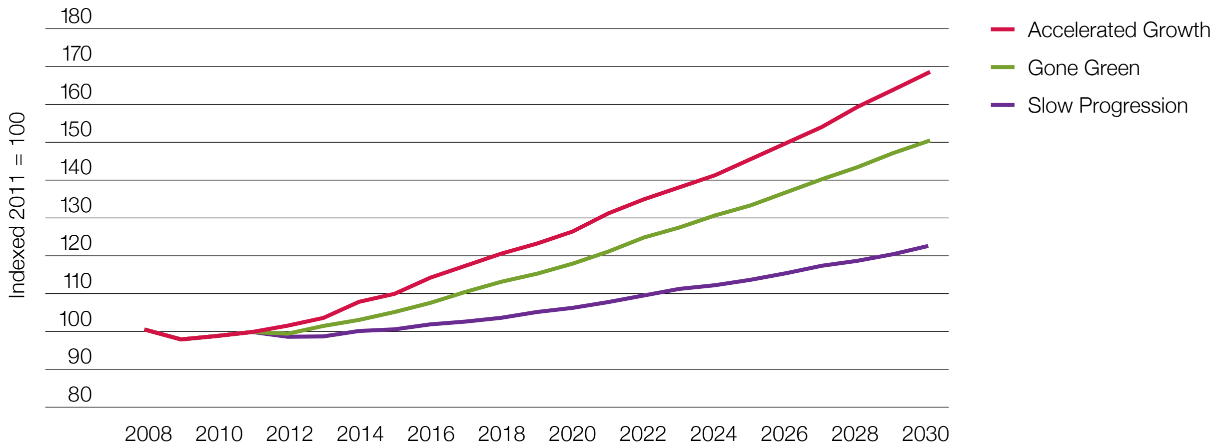
The further fall in housing starts in 2009 entailed another decline for completions in 2010 to 126,100, the lowest figure on record. It is estimated that 2011 saw the same number of completions. Housing starts also failed to pick up last year amid a generally weak housing market, so that completions in 2012 are likely to see little change from the depressed levels of the past two years.

We expect no real improvement in completion numbers until 2014 when a modest economic recovery is underway, supporting a stronger housing market and boosting starts. The number of completions is expected to pick up steadily to exceed 230,000 annually by 2025.

The number of GB households grew by 1.0% a year during the period 2002–09, but the onset of a tough economic backdrop, entailing more difficult financial circumstances for would-be home buyers, curbed growth to 0.6% in 2010 and 0.5% last year. Despite population growth expected to accelerate from 0.6% a year in the past decade to 0.7% in the next 15 years, we expect household growth to remain well below the annual 1.0% increase seen in the period 2002–09 as housing supply shortages curb aspirations for home ownership.

3.3.2
Economic Background: GDP

Figure 1.
Indexed GDP Growth



The UK economy has performed poorly since 2008 with a rebound in 2009 reversed by slow growth in 2010 and 2011 and a double dip recession being confirmed in the 2nd quarter of 2012.

In the **Slow Progression** scenario recovery is expected to be slow after the recession of 2012, hampered by the continuation of the economic and political uncertainty in Europe and beyond with growth only reaching 1% per annum by 2016 and an average annual growth rate between 2011 and 2030 of 1.1%.

In **Gone Green** GDP is expected to grow by 0.2% from 2012 and not increasing by over 2% until 2015, returning consistently to the historic trend rate of around 2.5% pa only in 2020. Annual GDP growth averages 2.3% over the period 2012 to 2031 inclusive.

In the **Accelerated Growth** scenario the economy grows strongly in the years following 2012 with an average GDP Growth of 2.6% in 2013 and average growth of 2.9% between 2014 and 2030 with GDP growth being equal to historic highs due to increased value being added to the economy with the UK becoming a world leader in renewable and zero carbon technology.

Figure 1 shows indexed GDP growth for all three scenarios, with the 2011 value set to 100.

3.3.3
Economic Background: Manufacturing output

Manufacturing output grew by a healthy 1.5% over 2011, helped by a relatively weak pound and continuation of the rebound since 2009 where a 9.5% drop occurred.

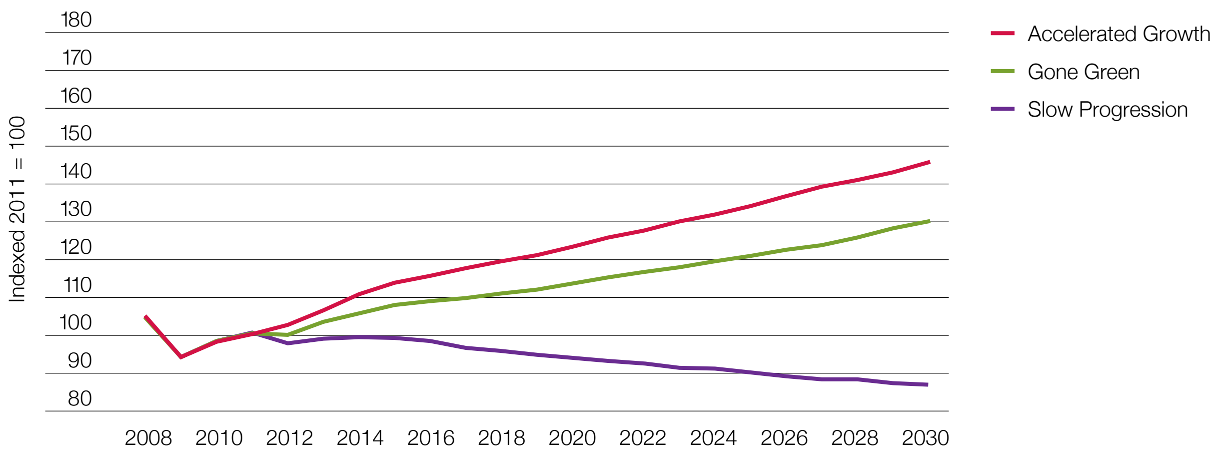
In **Slow Progression** there is a moderate rebound in 2013 and 2014 as output climbs by an average of 0.6% per annum. After this manufacturing output continues its historical trend (there is no rebalancing of the UK economy towards manufacturing) with an average annual decline of 0.7% between 2011 and 2030.

In **Gone Green** conditions are expected to improve post 2013 with manufacturing growth rebounding to around 2.5% in 2013 and 2014 due to continuing spare capacity in the market, before slowing with growth rates approaching 1.4% per annum thereafter. Average annual growth rates for the period 2012 to 2031 are 1.4%.

For **Accelerated Growth** manufacturing output bounces back strongly from the downturn at the end of 2011 and early 2012 with two years of very strong growth of >4% in 2013 and 2014 with slackness in the economy being filled swiftly. After 2014 the economy rebalances towards manufacturing (particularly in green technology) with average manufacturing growth on a par with levels seen in Germany of 1.6% per year between 2015 and 2030.

Figure 2 shows the indexed manufacturing output for the three scenarios.

Figure 2.
Indexed Manufacturing output



3.3.4
Economic Background: Non-Manufacturing output

Non-Manufacturing output grew by 1.9% in 2010, but growth slowed significantly in this sector in 2011 to only 0.5%.

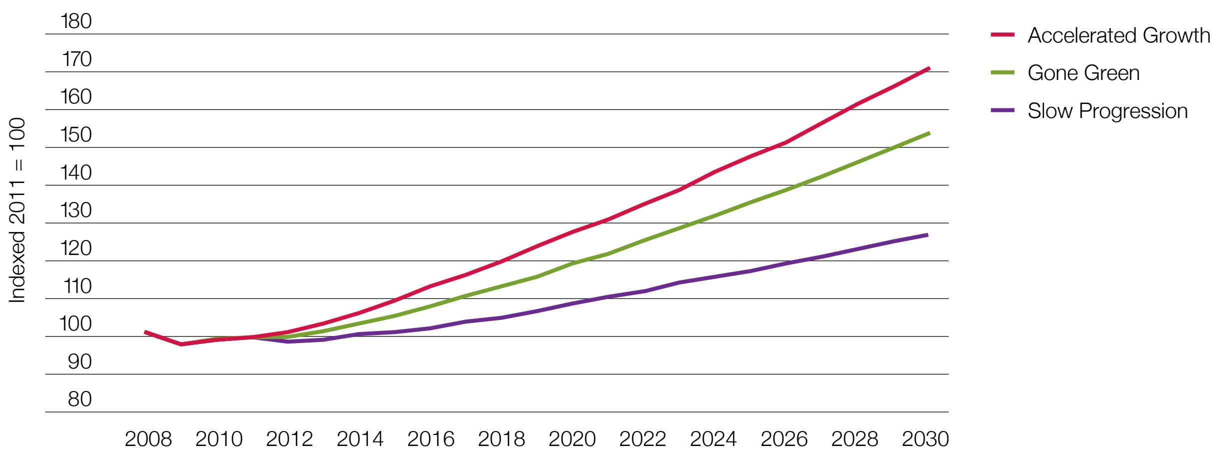
In the **Slow Progression** scenario non-manufacturing output sees low growth in 2013 with 0.3% growth. Post 2014 there is a slow recovery to growth of 1.5% per annum from 2018, which is much lower than rates seen in the decade to 2007.

In **Gone Green** Growth gradually improves to reach over 2% by 2016. Average annual growth rates for the period 2012–2031 are 2.2%.

Accelerated Growth has non-manufacturing output increasing in 2013 and 2014 to 2.5% as the recovery in the economy picks up speed. Post 2014 non-manufacturing grows by an average of 3% year, significantly below the 3.6% in the decade leading up to 2007 which ultimately proved to be unsustainable.

Figure 3 shows the indexed non-manufacturing output for the three scenarios.

Figure 3.
Indexed non-manufacturing output



3.3.5
Economic Background: Fuel prices

Fuel prices have a significant effect on total energy demand and, as such, forman important part of our analysis. We develop our projections based on a number of sources, some publicly available and some that we purchase.

In **Slow Progression** prices of oil, gas, coal and electricity remain flat from 2012 to 2015. After this time fuel prices grow by around 1% year on year to 2030 with prices in real terms in 2030 being at a similar level to today. In **Slow Progression** we have assumed that by 2020 the gas price is no longer linked to the oil price. The carbon price remains low, failing to reach the proposed EMR carbon floor price at any time. In our axioms we assume that gas-fired generation will be cheaper than coal-fired generation.

In **Gone Green** coal and oil prices decrease slightly to 2014 but increase steadily from then on. The gas price shows some linkage to the oil price but this decreases with time. The average annual fuel price increase over 2011–2030 is between 2.3% for industrial gas and 3.8% for industrial electricity users. The carbon price increases towards the EMR floor price in line with increasing industrial demand.

In **Accelerated Growth,** with its more optimistic view of the economy, prices of all fuels rise more than in **Gone Green**. Coal-fired generation is assumed to be cheaper than gas-fired generation. The gas price is more strongly linked to the oil price than in **Gone Green**. The carbon price is at the EMR floor price in all years.

The wholesale gas and baseload power price projections for all three scenarios are shown in Figure 4 and Figure 5.

Economic background

Figure 4.
Wholesale gas price

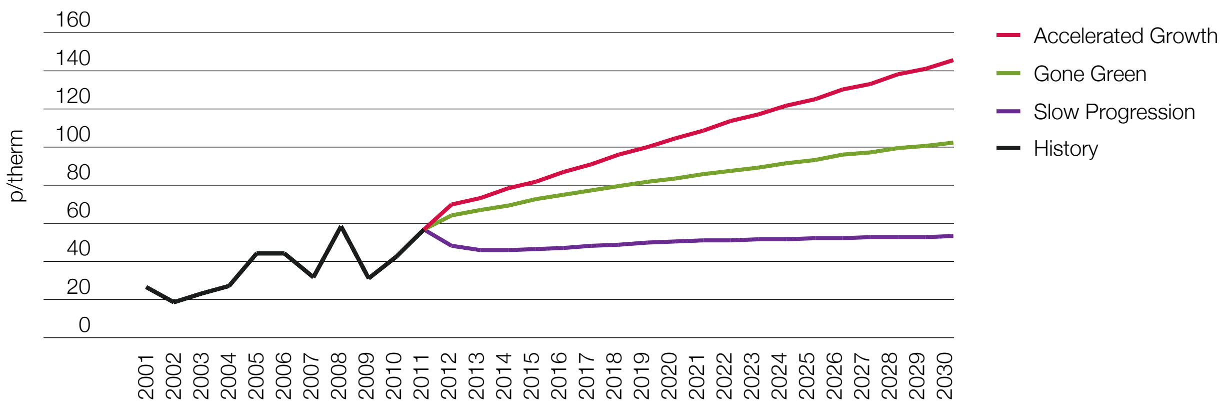
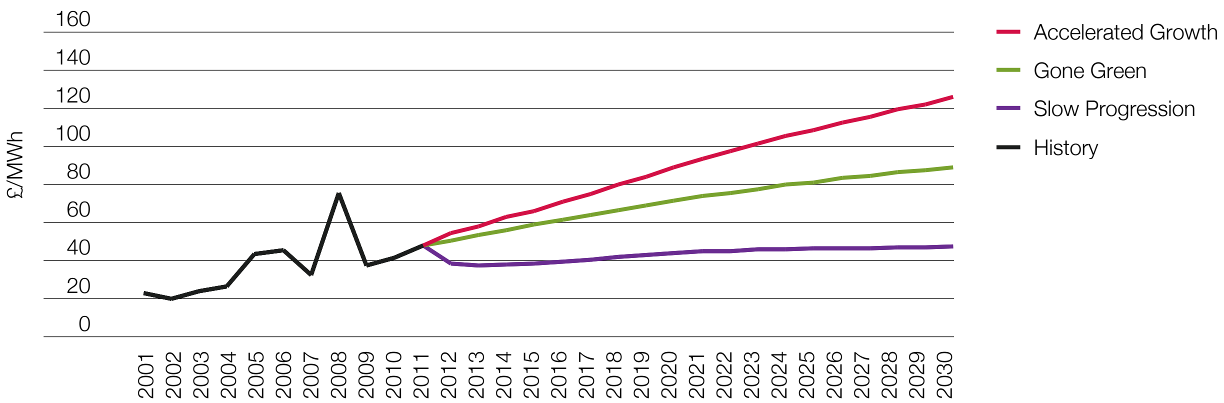


Figure 5.
Wholesale baseload power price



UK Future Energy Scenarios
September 2012

3.4
Heat

The provision of heat is a major use of energy in all scenarios. We have modelled heating in the residential sector in some detail, reflecting the importance of the market. Heating in the commercial and industrial sectors is captured in the generic gas and electricity forecasts as described in Chapter 4.

3.4.1
Heat pumps

Within the residential sector the development of heat pumps[12] will be of great importance in meeting environmental targets and in our gas and electricity demand projections we have devoted considerable attention to this area. We have gathered data from a number of industry bodies and discussed our projections with DECC.

Our assumptions on the type of heat pump fitted in houses are similar to last year in that the majority will be air-water systems, i.e. air source heat pumps supplying radiators. While ground source heat pumps are slightly more efficient than air source units, the extra work involved in laying loops of piping in the ground suggest that costs will be significantly higher. In all cases a high level of insulation is required to make best use of the lower temperature heat delivered by heat pumps.

The market for gas absorption heat pumps has developed in the last year and we now include this technology in the Accelerated Growth scenario.

In our projections heat pumps are initially concentrated in houses not connected to the gas grid, encouraged by the RHI premium payment scheme and the high price of non-gas fuels. The next tranche are installed in new houses with their better insulation and consequent lower heat demand. Growth is further assisted by governmental policy to electrify heat driven by the Green Deal, ECO and Renewable Heat Incentive. Finally heat pumps enter the mainstream heating market for houses on the gas network as economies of scale reduce heat pump unit costs to levels similar to gas boilers.

Market saturation is not reached in any of our scenarios due to some resistance to technological change no matter what the cost/price benefits.

12 For a description of how heat pumps work see www.inference.phy.cam.ac.uk/withouthotair/c21/page_146.shtml

Our views on heat pumps in the 2012 **Slow Progression** and **Gone Green** scenarios are similar to 2011. Data published on the number of installations in the last twelve months suggest that our 2011 projections were soundly based, though as the adoption of the technology is still at an early stage there is inevitably some uncertainty about how it will develop. **Accelerated Growth** in 2011 had the same number of heat pumps as **Gone Green**, but the rate of installation in the 2012 Accelerated Growth is significantly higher, leader to a wider range in our three scenarios.

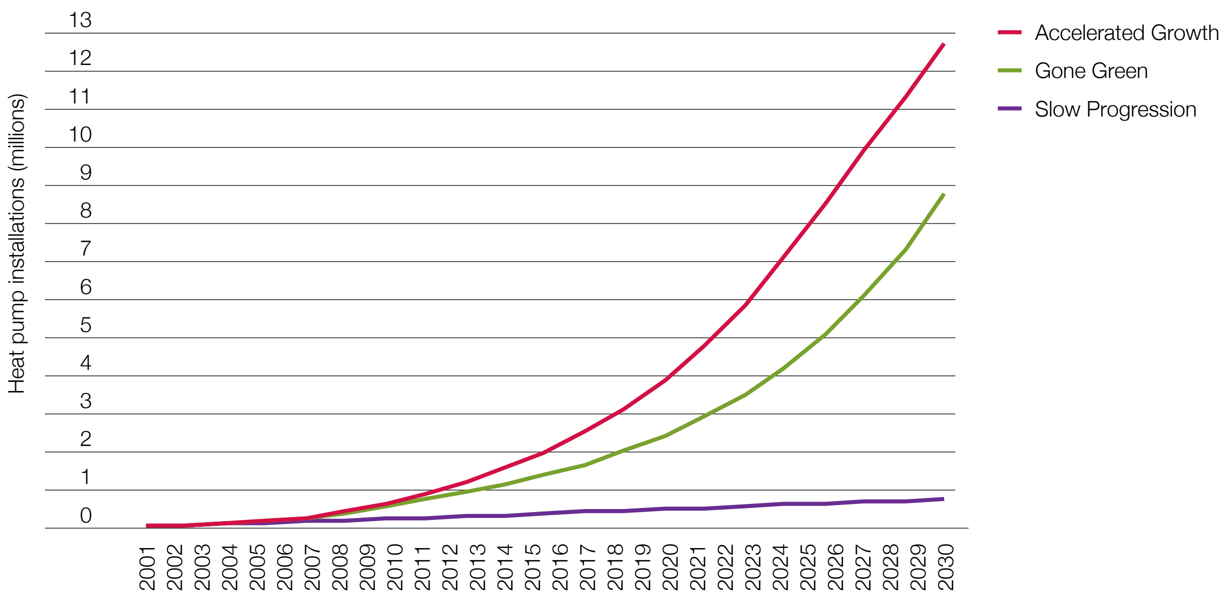
Figure 6 shows the total number of residential heat pumps in all three scenarios.

Effect on annual electricity demand
As the first heat pumps are installed they are assumed to displace electric resistive heating, resulting in a net reduction in demand, shown for **Gone Green** by the red sector in Figure 7.

By 2030 the electricity demand from heat pumps in new houses together with the added demand from installations which are displacing gas rather than electric resistive heating, as shown by the green and blue sectors in Figure 7, outweighs the losses, leading to a net increase in demand.

Figure 8 shows the net change in demand for all three scenarios, on the same scale as Figure 7 for ease of comparison. Note that in **Slow Progression** the net change is very small in all years.

Figure 6.
Number of heat pumps in the residential market



Heat

Figure 7.
Changes in electricity demand due to domestic heat pumps: Gone Green

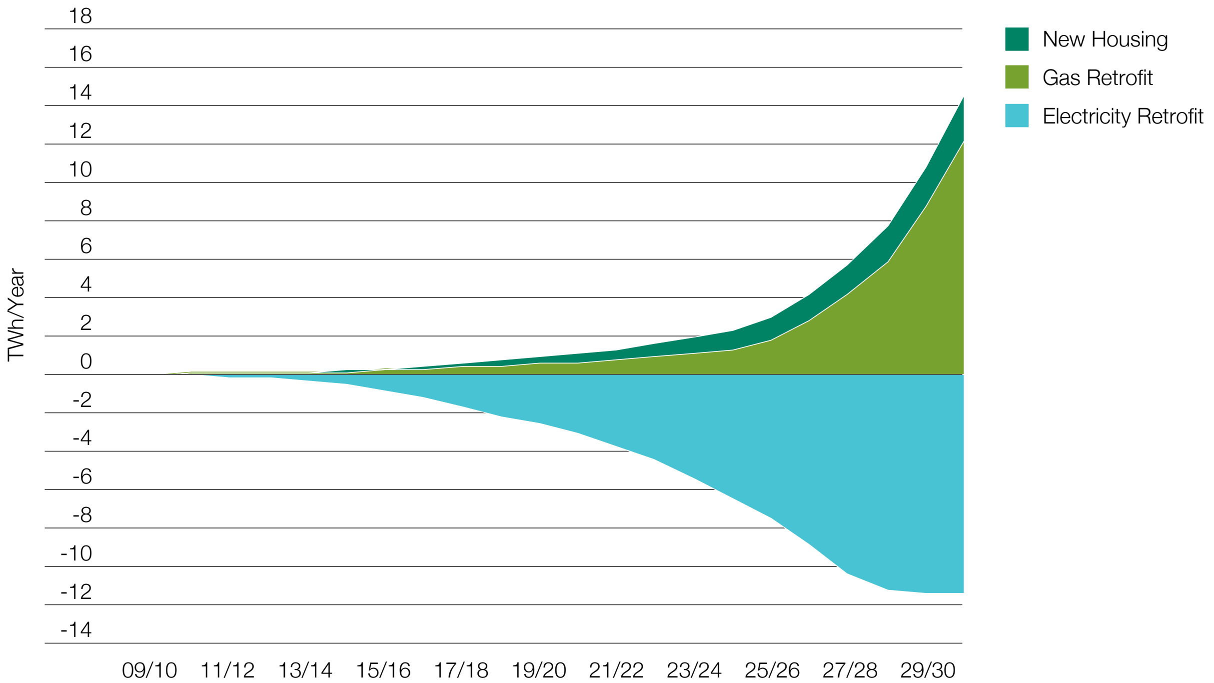


Figure 8.
Net change in electricity demand due to domestic heat pumps

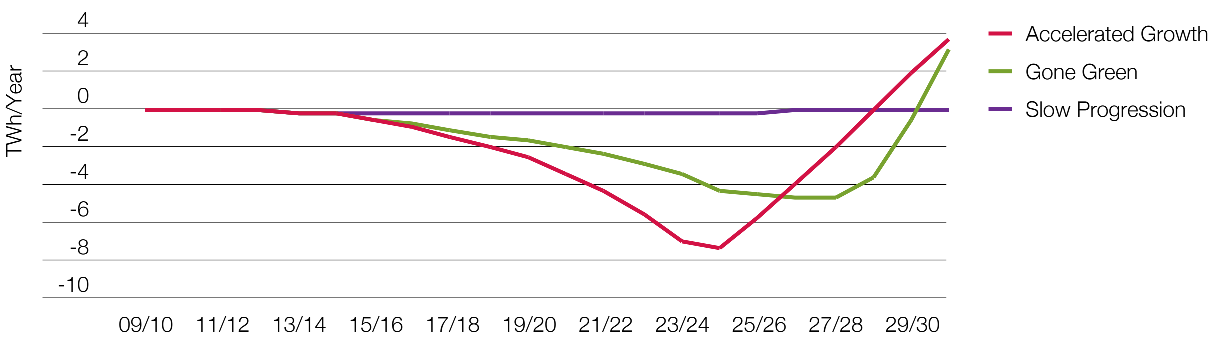
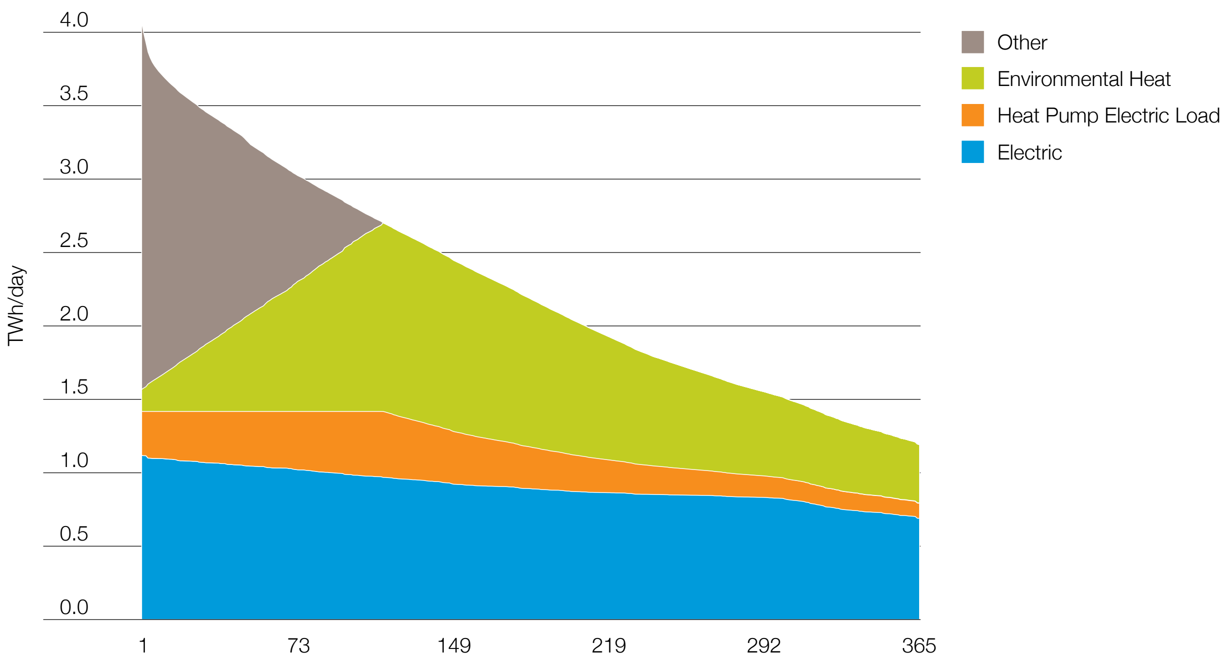


Figure 9.
Electricity and heat load duration curves



Seasonality

Demand for heat is much 'peakier' than demand for electricity, as shown in the load duration curve in Figure 9. Note, there is no assumption of demand-side response in this illustrative analysis. The bottom series shows demand for electricity excluding heating, which ranges from a maximum of 1,110 GWh/day to a minimum of 690 GWh/day (62% of peak daily heat demand). The remaining series represent heating load, which ranges from a maximum of 3,000 GWh/day to a minimum of 500 GWh/day (17% of peak daily heat demand).

The 'other' series includes gas, biomass and, for houses not connected to the gas network, oil. As a result of the large range in the heat demand it will be very difficult to electrify the entire heat load.

Electric heat pumps can be used to supply a significant fraction of the heat demand, represented by the orange and green sectors on the chart, with little requirement for extra electricity generation capacity, but in order to satisfy the entire load, filling the grey sector as well, it will be necessary to build between 100 GW and 150 GW of new capacity, most of which will run for half the year or less, with correspondingly unfavourable economics.

In this illustrative analysis we have assumed that the maximum coefficient of performance (COP) of heat pumps will be around 5, but the upper limit of 150 GW of new capacity assumes that at times of peak heat demand, when external temperatures will be low, the COP of pumps will be around 1.5.

3.4.2
Efficiency improvements: Heat

While it has long been recognised in the industrial and commercial sector that energy efficiency is an effective way of reducing costs, in the domestic sector relatively low energy prices before 2005 meant that there was less pressure to adopt efficiency measures.

Since 2005, significant and continuing increases in energy prices, combined with government policies, have realised substantial increases in domestic energy efficiency and have meant that energy efficiency measures previously considered unviable or marginal in terms of investment payback have become more attractive to industry and commerce alike.

As a result, we have carried out analysis of recent demand reductions and have developed specific energy efficiency scenarios to be incorporated in our demand scenarios to account for potential future demand. These have been mainly focused on the domestic sector, as:

- Energy policy has been focused on this sector, due to its high potential savings at relatively low cost
- There is good availability of energy data in the domestic sector
- Data are published on the uptake of energy efficiency measures which have been delivered via various schemes

The energy efficiency improvements in the industrial and commercial sectors have been developing over a longer period. As a result, longer term trends are recognised and included in our main econometric forecasting process, so a separate energy efficiency forecast for these sectors would be redundant, though we do model the effect of new policies that were not covered by history. In the 2012 scenarios the Carbon Reduction Commitment was the only policy to be so treated.

All our energy efficiency scenarios are concerned with the energy demand reductions from existing houses. Energy demands from new houses are forecast separately (although they use many assumptions derived from the energy efficiency forecast as a starting point).

Energy Efficiency Assumptions

In the heating sector we have concentrated on

- Insulation – applicable to gas and electricity
- Boiler replacement – gas only

The choice of heating supply is covered in section 4.3.1.

Insulation

Insulation covers cavity and solid wall insulation and loft insulation take up, as these areas are where the greatest potential energy demand improvements can be or have been realised. It does not cover areas such as double glazing and draught-proofing as improvements from these areas are seen to be marginal and incremental, and as such are captured by the econometric modelling.

Significant savings have occurred in the last 5–10 years due to insulation. This has been primarily due to government energy efficiency schemes CERT (and formerly EEC1&2), with notable but lesser impact of Warm Front[13]. The Community Energy Saving Programme (CESP)[14] has recently contributed to an increase in solid wall insulation, mostly instigated by Local Authorities in social housing, treating whole streets at once rather than individual houses.

In October 2012 the Green Deal replaces CERT. Instead of buying heavily discounted insulation around (>75% discount), householders will now pay a higher price using a loan that will be repaid from savings on energy bills. The government's assessment is that loft and cavity wall insulation will pay for itself in around five years, in line with our view.

In all our scenarios energy savings from cavity wall insulation are greater than savings from loft and solid wall insulation, due to the combination of the numbers of measures and the amount each installation can save. All loft installation measures are assumed to be 'top up' insulation, as over 95% of households have some form of loft insulation[15]. The cavity wall insulation savings account for slightly more than the other two measures added together by 2020. Solid wall insulation has the greatest variability between scenarios due to uncertainty over how the Green Deal and CESP incentivise take up of this measure, though they do not reach the level of savings from loft insulation in any scenario by 2020.

All our scenarios assume

- The insulation market is beginning to saturate – the remaining houses will be reluctant and harder to treat
- There is the potential for Green Deal not to work as well as CERT for insulation

Both of these factors are assumed to be detrimental to insulation rates.

Around 23 million of the 26 million UK houses are gas heated with around 2 million electrically heated. The energy savings from insulation are split in this ratio between gas and electricity demand.

Differences between scenarios

The difference in insulation rates in the three scenarios is driven by the effectiveness or otherwise of the Green Deal.

In **Slow Progression** there is a very significant reduction of the rate of energy efficiency take up as remaining households are very resistant to take up insulation and the Green Deal fails to encourage many of these consumers.

In **Gone Green** the Green Deal is fairly successful at encouraging insulation, though not as good as CERT. There is quite a significant reduction in the rate of take up of energy efficiency measures due to greater prevalence of harder to treat and reluctant households. Solid wall insulation rates increase slightly over time due to the Energy Company Obligation (ECO) – but by nowhere near as much as the government Impact Assessment[16] anticipates.

In **Accelerated Growth** the Green Deal is very successful at encouraging insulation. Insulation installation rates remain broadly the same as now. Solid wall insulation rates increase considerably, though still not to the levels assumed by the Impact Assessment.

Rates of installation of insulation measures are shown for all three scenarios in Figure 10 to Figure 12 (overleaf).

13 www.direct.gov.uk/en/Environmentandgreenerliving/Energyandwatersaving/Energygrants/DG_10018661
14 www.decc.gov.uk/en/content/cms/funding/funding_ops/cesp/cesp.aspx
15 www.decc.gov.uk/assets/decc/11/stats/climate-change/3224-great-britains-housing-energy-fact-file-2011.pdf (table 6g)
16 www.decc.gov.uk/assets/decc/11/consultation/green-deal/3603-green-deal-eco-ia.pdf

Heat

Figure 10.
Take up of loft insulation

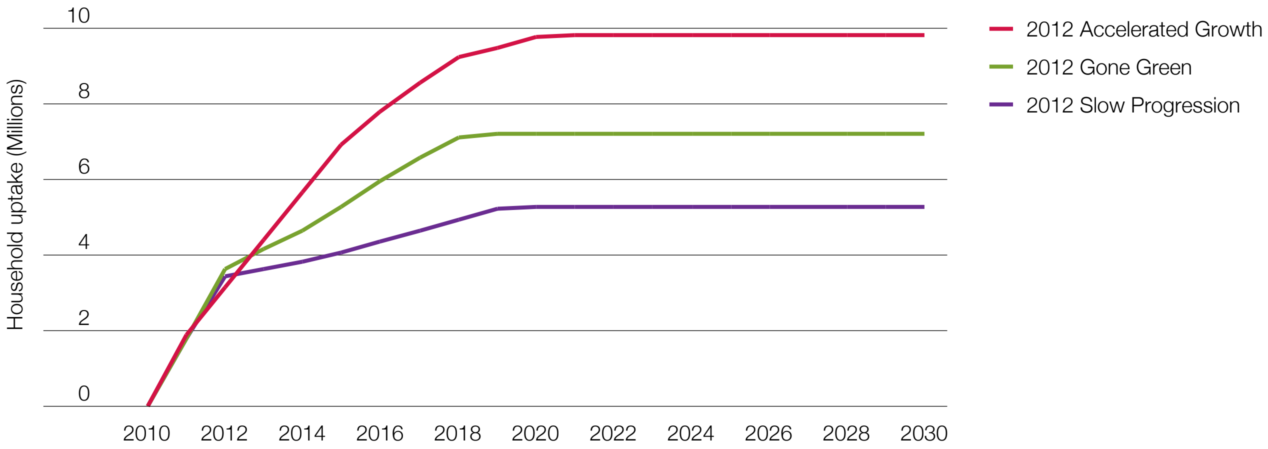


Figure 11.
Take up of cavity wall insulation

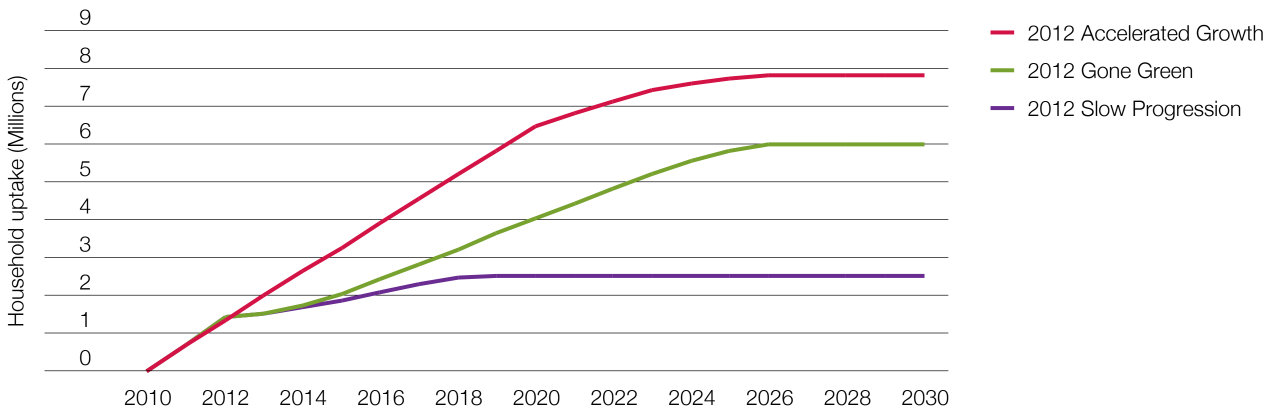
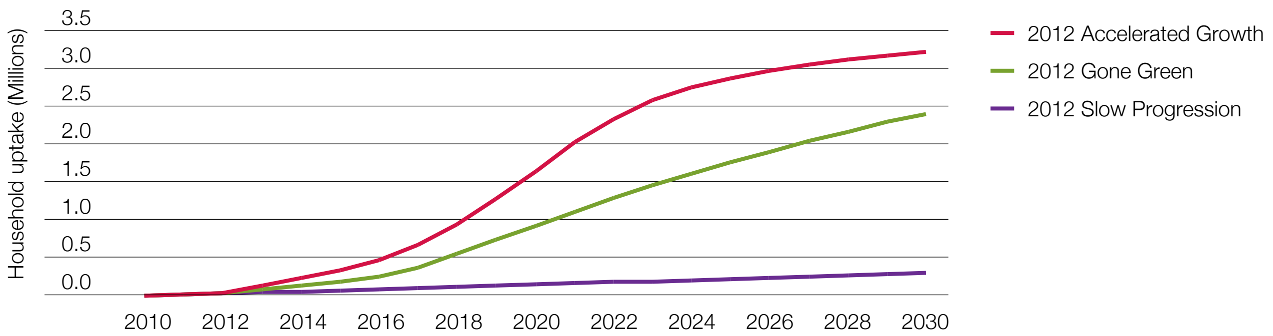


Figure 12.
Take up of solid wall insulation



Boilers

Savings from boiler replacements are considerable in all scenarios. Differences between scenarios are small, as boilers tend to be replaced only due to the failure of an existing unit. The energy savings potential is easier to establish than other forecasting areas as the efficiencies of new boilers are legislated and well documented.

Aggregate savings in gas demand for domestic heating are shown in Figure 13 to Figure 15 (overleaf) and savings in domestic electricity demand are shown in Figure 16 (overleaf).

Heat

Figure 13.
Gas demand savings from domestic energy efficiency measures: Slow Progression

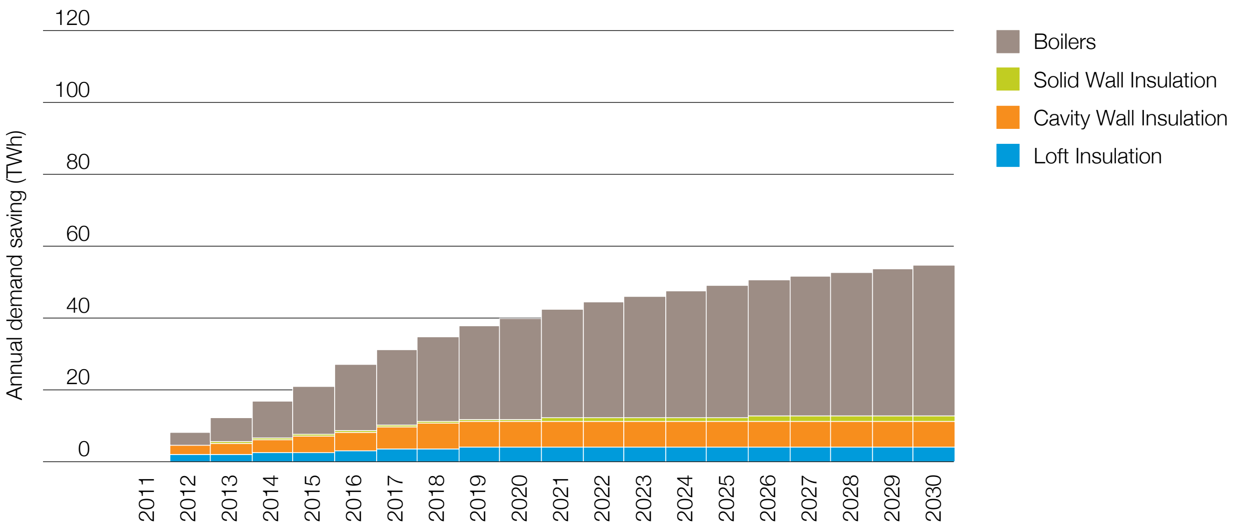


Figure 14.
Gas demand savings from domestic energy efficiency measures: Gone Green

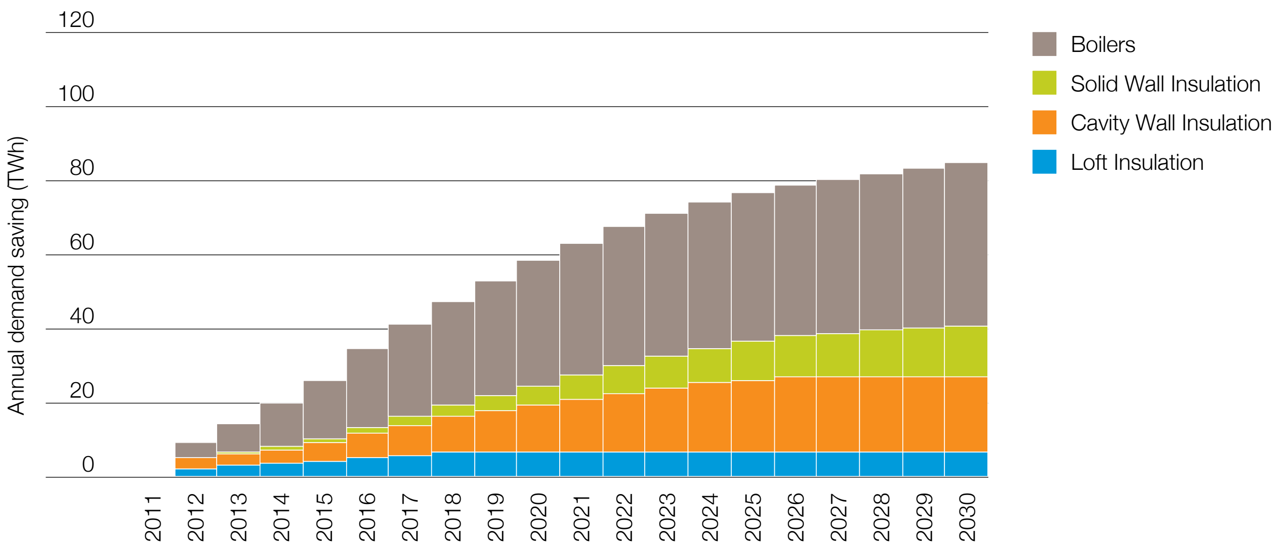


Figure 15.
Gas demand savings from domestic energy efficiency measures: Accelerated Growth

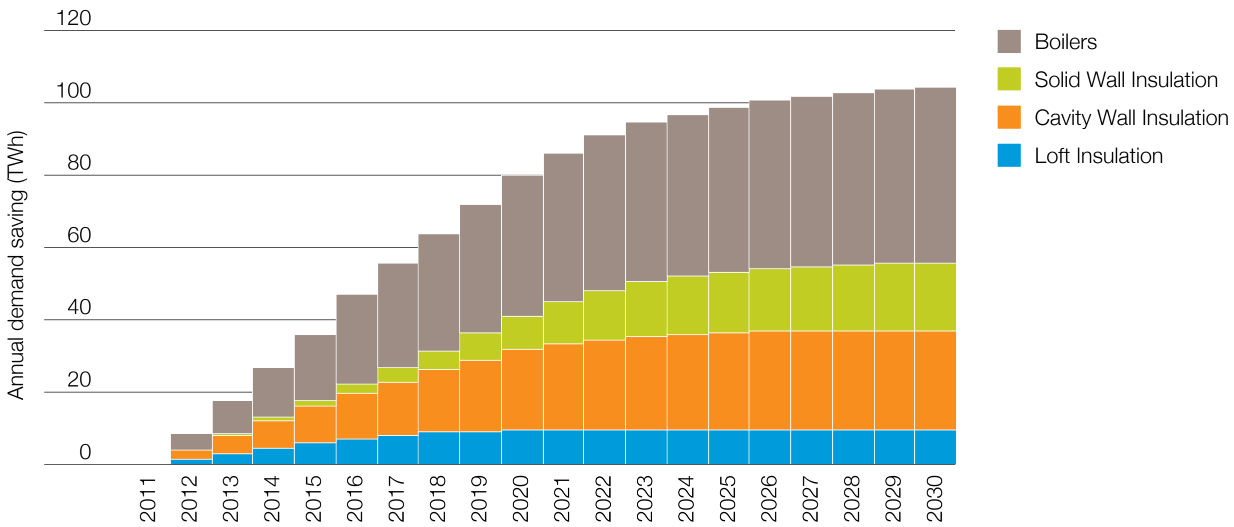
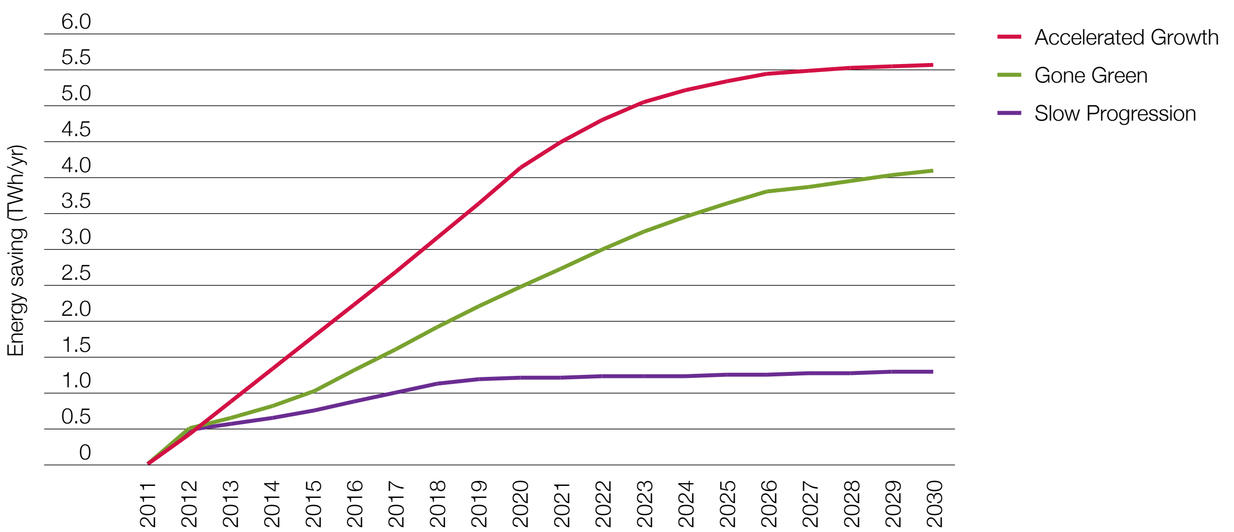


Figure 16.
Electricity demand savings from domestic energy efficiency measures



New houses

Changes in building regulations, leading to the zero carbon homes, or 'code 6' standard[17] by 2016, mean that new houses will be increasingly efficient. Gas is still assumed to be part of the mix as zero carbon is an offsettable measure (i.e. gas can be used for heating a new housing estate if extra renewable generation is installed away from the estate). Differences between the scenarios are due to different views of when the zero carbon standard is achieved, and boiler efficiencies, and different hot water requirements.

The main differences between the scenarios are:

Slow progression

- Assume the zero carbon homes standard comes into effect six years late in 2022, from a combination of relaxing of building regulations by four years to 2020 and an average two-year delay between achieving planning permission (at code 6) and household completion
- Assume no reduction in hot water energy requirements

Gone Green

- Assume the zero carbon homes standard comes into effect two years late in 2018, due to an average two-year delay between achieving planning permission (at code 6) and household completion
- Energy requirement for hot water reduces by around 0.5% per year, in line with trajectory 3 in the DECC 2050 calculator

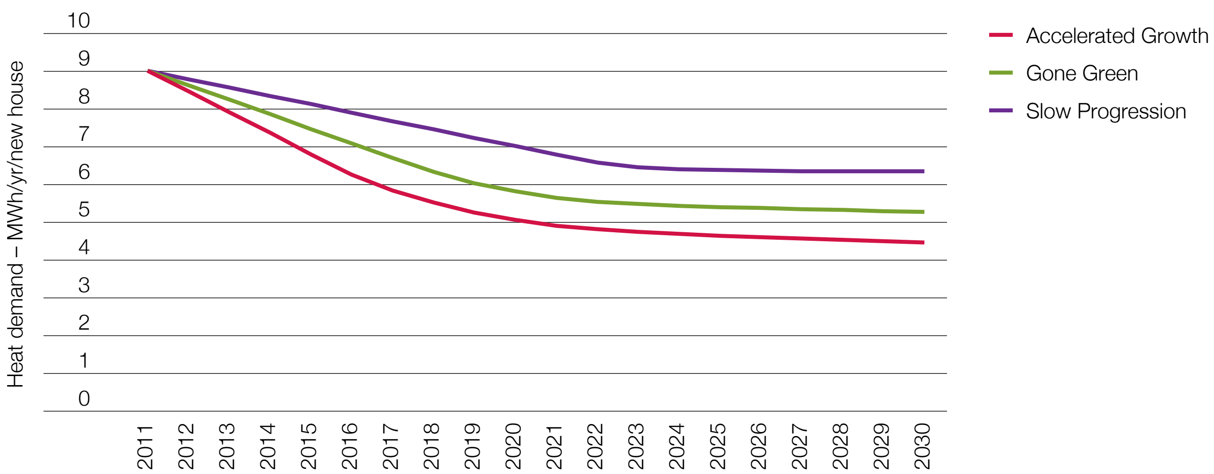
Accelerated Growth

- Assume the zero carbon homes standard is implemented from 2016 as planned
- Energy requirement for hot water reduces by around 1% per year, between DECC's trajectories 3 and 4

Figure 17 shows how the heat requirement for a new house decreases with time in the three scenarios.

17 http://www.communities.gov.uk/documents/housing/pdf/2033676.pdf

Figure 17.
Decreasing heat demand from new houses



UK Future Energy Scenarios
September 2012

3.5 Electricity efficiency improvements

3.5.1 Lighting

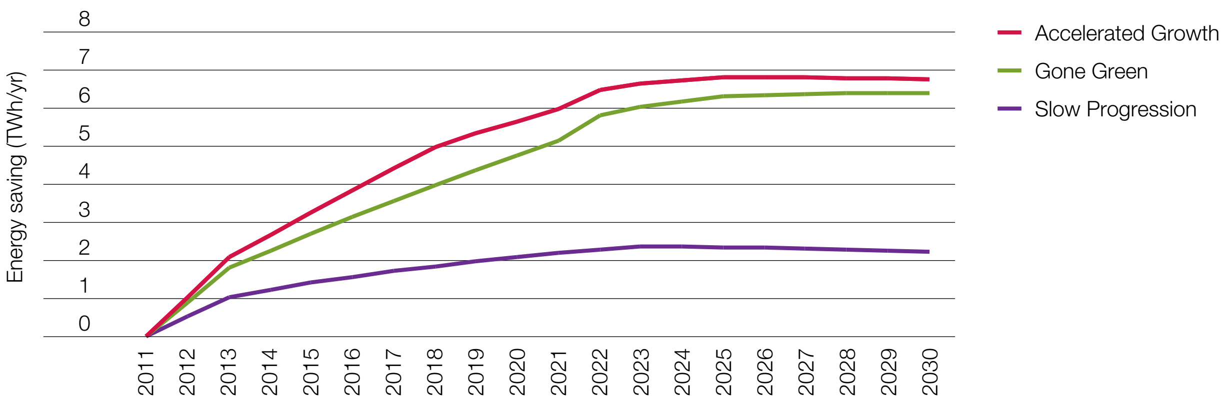
In 2011 Domestic lighting accounted for around 13TWh of electricity demand. This is a little over 10% of total domestic demand. This amount has reduced by around a quarter since 2005 predominantly due to the replacement of standard light bulbs with halogen and compact florescent bulbs (CFLs), with the emergence of LED bulbs beginning to be notable.

Government policy, most notably via CERT has enabled the delivery of very significant amounts of CFLs to large proportions of the nation, at subsided cost. Legislation is slowly phasing out standard incandescent light bulbs, and all our scenarios show this leading to significant reductions in electricity demand for lighting over the forecast period, with differences between the scenarios due to the speed, timing and differing views of what replaces incandescent bulbs.

- **Slow Progression** – assumes increases in CFLs. No real increase in LEDs
- **Gone Green** – assumes increase in CFLs and LEDs (replacing downlighters)
- **Accelerated Growth** – increase in CFLs and quicker increase in LEDs (replacing all lighting)

Figure 18 shows savings between 2 and 7 TWh are possible by mid-2020s in the three scenarios.

Figure 18.
Energy savings in domestic lighting



3.5.2 Appliances

This section is concerned only with domestic electric appliances.

Our scenarios for appliances have been developed looking at the categories of appliances outlined in the Energy Consumption UK[18] report published by DECC. These are:

- Lighting – (already covered)
- Cold – fridges and freezers
- Wet – washing machines dishwasher and dryers
- Consumer appliances – TVs, games consoles – etc.
- Home computing – including printers
- Cooking – including kettles

The greatest savings in all our scenarios were due to:

- Fridge freezers
- TVs
- Set-top boxes
- DVD / VCRs
- Desktop PCs

Savings from TVs and fridge freezers are due to the increasing efficiency of these items feeding through the population as newer more efficient items are slowly replacing older items that are taken out of use at the end of their lives. In both cases it is assumed to take some time for the increasing efficiencies of new appliances to be fully realised as it takes a notable length of time before old appliances are retired.

Fridge freezers are often only removed from the population once they have stopped working. Fridge freezers have a long life-span and are generally in constant use. Fridges have been required to reach a certain level of efficiency for some years so savings here are not expected to be as great.

TVs are likely to also be used regularly, initially as a primary TV, and then relegated to spare rooms and used less. TVs have been getting much more efficient over many years. Newer technologies such as LED TVs are significantly more efficient than older designs but even LCD and plasma TVs are becoming significantly more energy efficient. For example, many plasma TVs use half the energy than an equivalent from around five years ago. The increases in efficiency also significantly outweigh the trend to larger television sizes.

Savings from set-top boxes, DVD / VCRs and desktop PCs are assumed to be due more to changes in use than improvements in technology.

The main differences between the scenarios are due to differing views on take up and energy savings from:

Fridge freezers – in **Slow Progression** savings diminish considerably from the start of the 2020s, whereas in **Gone Green** savings continue through until 2030 and a little beyond

Set-top boxes – in **Gone Green** and **Accelerated Growth** streaming of TV via the internet reduces the need for set-top boxes dramatically, whereas this does not happen in **Slow Progression**

Desktops – in **Gone Green** and **Accelerated Growth** the number of desktops decreases and monitors become more efficient. There is little change in **Slow Progression**.

18 http://www.decc.gov.uk/en/content/cms/statistics/publications/ecuk/ecuk.aspx

3.5.3
Smart Meters

The introduction of Smart Meters when coupled with time-of-use tariffs is intended to provide demand-side management at times of peak demand. Government plans call for smart meters to be installed in all households by 2019. All our scenarios assume maximum installation is 95%, but by different dates as discussed below.

The installation of a smart meter is only a first step, and will in any case not necessarily be at the customer's request. The technology only becomes useful once the customer begins to interact with it by means of time-of-use (TOU) tariffs and possibly appliances that respond automatically to price signals. This leads to reductions in annual energy and peak demand. The effect on annual energy consumption is less than on peak as in many cases demand is moved from peak time to off-peak time rather than lost altogether.

In **Slow Progression** smart meter installation rate is in line with current progress. In this scenario, completion is met in 2030 with the assumption that 4.7% of peak demand could be shifted and 2% of annual demand could be reduced. This equates to around 2.5 TWh of annual reduction in 2030.

In **Gone Green** smart meter installation reaches completion by 2022. In this scenario, it is assumed that 6.7% of peak demand could be shifted and 4% of annual demand could be reduced, resulting in around 4.5 TWh demand reduction in 2030.

In **Accelerated Growth** installation rate follows Government's plans, reaching completion by 2019. In this scenario, it is assumed that 10% of peak demand could be shifted and 7% overall reduction could be made annually. This equates to around 7.3 TWh annual reduction in 2030.

Figure 19 shows the roll-out of smart meters in all three scenarios. Figure 20 shows the reduction in annual and peak demand for each smart meter installation when combined with time of use tariffs.

Figure 19.
Roll-out of smart meters

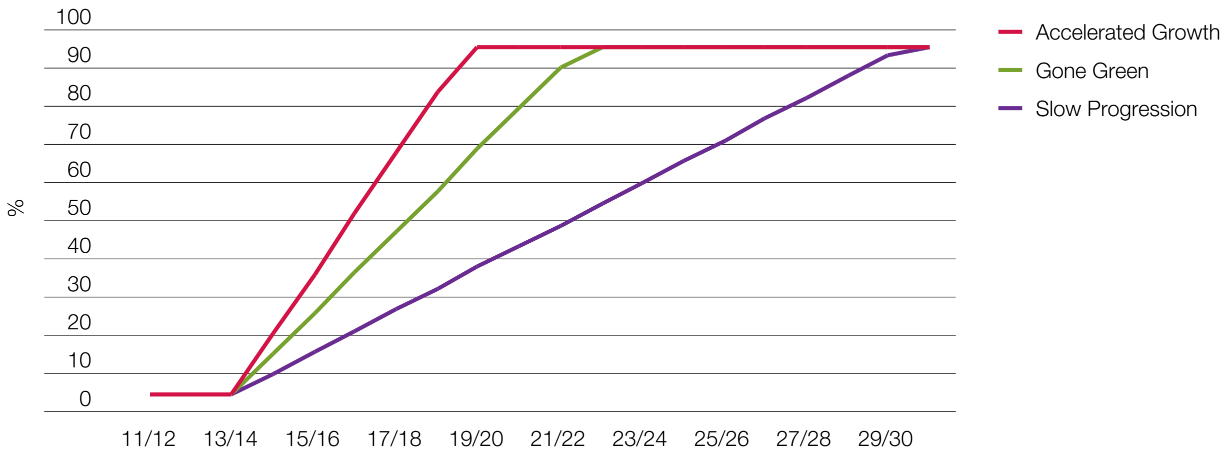


Figure 20.
Impact of smart meters and TOU tariffs on annual consumption and peak demand

3.6 Transport

3.6.1 Electric vehicles

19 http://www.nextgreencar.com/electric-cars/charging-points.php

The successful introduction of electric vehicles will be a key part of the move towards meeting environmental targets. We have modelled three types of vehicle:

- Pure Electric Vehicles (EV) use an on-board rechargeable battery to store electrical energy. The battery is recharged by connecting it to an electricity supply
- Plug in Hybrid Electric Vehicles (PHEV) have a much smaller battery, and when they run out of power they can run on petrol or diesel as a primary source of drive
- Extended Range Electric Vehicles (E-REV) are similar to PHEVs, but are always driven by the electric motor, when the battery power runs out a small engine recharges the battery, which in turn drives the electric motor

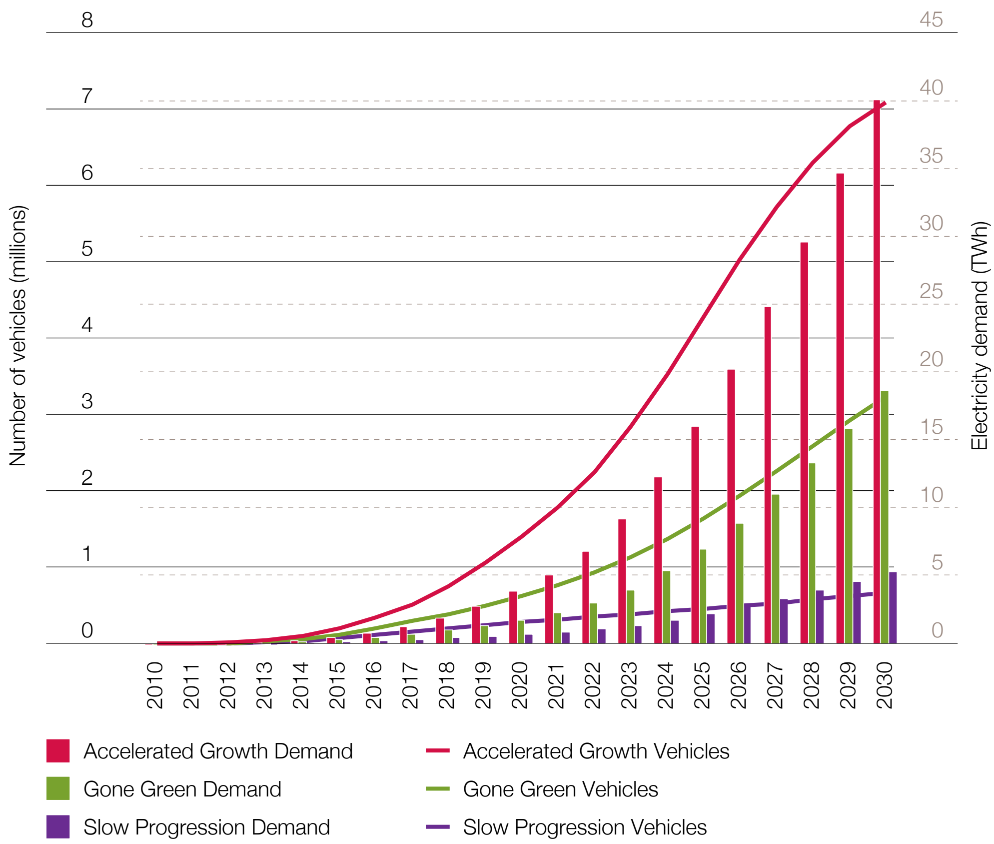
All variants of electric vehicles can be slow or fast-charged; there are public charging points[19] that can deliver an 80% charge in under 30 minutes, though the most common method is overnight charging, which typically takes 3 to 8 hours. There has been considerable activity and publicity from manufacturers since the 2011 scenarios, but there are still only a small number of vehicles on the road.

Our analysis has used data from manufacturers and industry bodies and has been benchmarked against forecasts from the Department for Transport (DfT) and the Office for Low Emission Vehicles (OLEV). We have used a similar approach for all three scenarios, and assumed that the same technology is available in each case but that the rates of adoption differ between the scenarios. We see range extended and plug in hybrids dominating initially, followed by pure electric vehicles as high battery prices and range issues are addressed. Users in London and fleet buyers are likely to make up the bulk of the early adopters; London drivers will benefit from congestion charge exemption, parking and charging concessions. The market for second family cars develops next as prices reduce and the range of vehicles on offer increases. EVs enter the mainstream market when they reach cost parity with internal combustion engines, though even in our most optimistic view this does not happen until the mid-2020s.

Figure 21 shows the number of electric vehicles in all three scenarios together with the annual electricity demand. Note that the number of vehicles increases faster than the electricity demand; in the earlier years there are more hybrids than pure EVs and sales are concentrated in London and in the second car market. Electricity demand increases faster when pure EVs enter the main car market and are used for everyday motoring, including longer journeys.

Our projections for electric vehicles are lower than in the 2011 scenarios. In our consultation following the publication of our 2011 scenarios the majority view was that our views on EV penetration were extremely optimistic, so our revised projections have gone some way towards addressing this concern.

Figure 21.
Number of electric vehicles in all three scenarios



3.6.2
Alternative fuels

We have not included hydrogen power fuel cell vehicles in any of our scenarios, nor have we used natural gas powered vehicles as neither of these technologies is at the same level of commercial development as electric vehicles.

Chapter four

Scenarios: Now to 2030

4.1
Electricity demand

Annual and peak electricity demands for all three scenarios are based on the axioms described in Appendix 1 using the same model, allowing direct comparisons across all three scenarios.

4.1.1
Annual demand

In 2011, comparisons between Slow Progression and Gone Green scenarios were based on transmission generation requirement. Based on the feedback from our stakeholders, for this year's report, we are focusing on annual energy consumed by end-users and total GB generation requirement.

Our annual electricity demand projections are derived from a number of key drivers, with the following factors that make-up the end-users demand:

- Historic annual electricity consumption
- Economic background, including fuel price (see section 3.3)
- Energy efficiency measures (section 3.5)
- Impact of smart meters and time-of-use tariffs (section 3.5.3), and
- New emerging technology such as heat pumps and electric vehicles (see sections 3.4.1 and 3.6.1)

In addition, the following factors affect total annual GB generation requirement:

- Pumping demand at pumped storage stations
- Losses through distribution and transmission networks
- Exports via external interconnectors

Figure 22 and Figure 23 show annual demand for domestic and non-domestic sectors for all three scenarios. For the domestic sector demand in **Slow Progression** is higher than **Gone Green** which, in turn, is higher than **Accelerated Growth**. Economic growth increases from **Slow Progression** to **Accelerated Growth**, but the principal effect of this, coupled with Government incentives, is that more money is available for energy saving and low carbon measures, leading to lower overall demand. The roll-out of heat pumps initially reduces domestic demand as electric resistive heating is replaced by more efficient technology. Demand in **Gone Green** and **Accelerated Growth** increases towards 2030 as heat pumps start to displace gas-fired heating and electric vehicles increase their market share.

In the non-domestic sector however, economic growth is the principal driver of electricity demand so demand increases from **Slow Progression** to **Gone Green** to **Accelerated Growth**.

4.1 continued
Electricity demand

Figure 22.
Annual electricity demand: Domestic

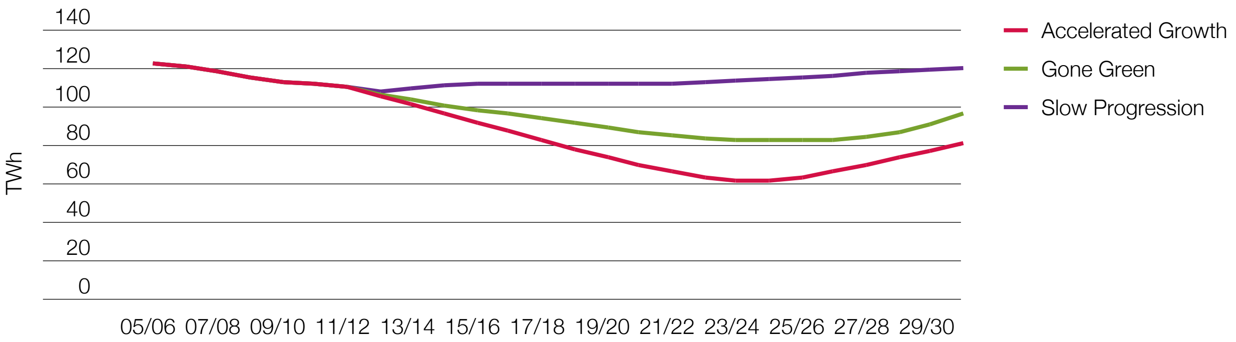


Figure 23.
Annual electricity demand: Non-domestic

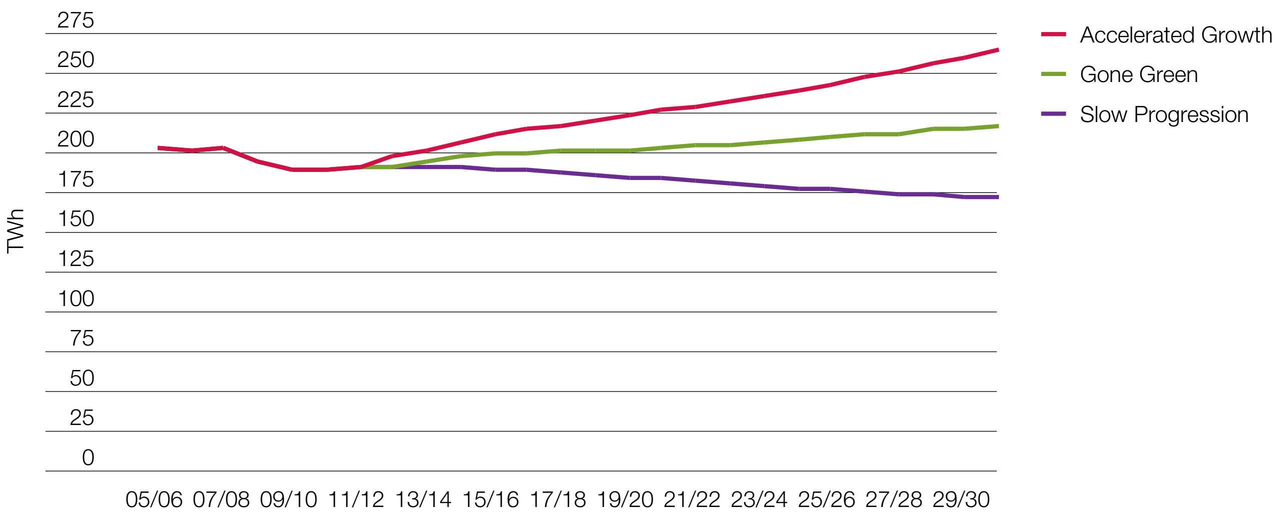
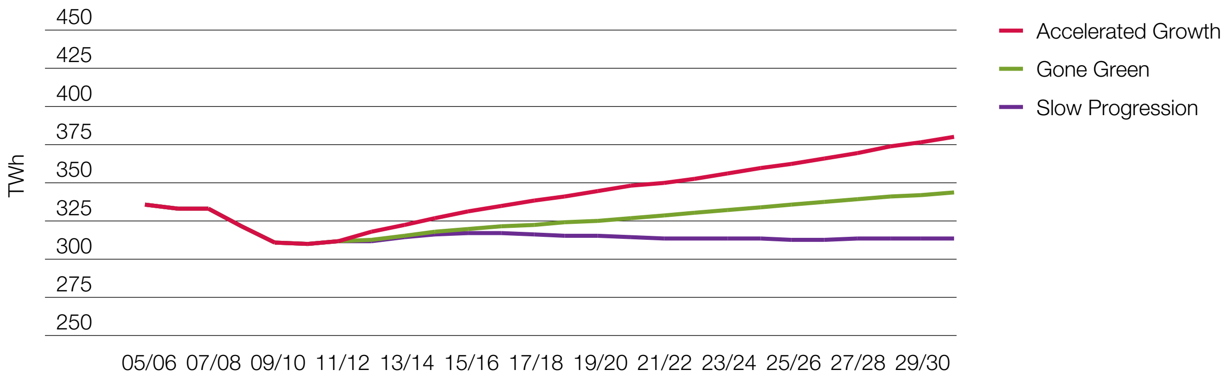


Figure 24 shows the total end-user demand for all three scenarios. The demand depicted does not include pumping demand at pumped storage stations, losses through distribution and transmission networks or exports via external interconnectors, which are used to project the generation requirement for GB.

Figure 24.
Total end-user electricity demand



4.1.2
GB peak demand

20 GB Peak demand discussed here is GB Average Cold Spell (ACS) peak demand with embedded generation treated as generation rather than negative demand, including exports to Ireland, excluding exports to Continental Europe and power stations' own demand. http://www.nationalgrid.com/uk/sys_08/default.asp?action=mnch2_15.htm&sNode=4&Exp=Y

GB Peak Demand[20] is derived from annual demands, using a historical relationship between peak and annual demand. In addition, new emerging technologies that affect electricity demand are accounted for separately as these have no history.

These could either increase or decrease peak demand:

- Smart meters and time-of-use tariffs will displace demand from the peak to off-peak periods
- Electric vehicle charging could take place at time of system peak. It is assumed that time-of-use tariffs in conjunction with smart meters could change consumers' charging patterns. Each scenario depicts a different implementation rate of time-of-use tariffs; therefore each scenario would contain different levels of EV charging at peak
- Heat pumps will displace fossil fuel heating and electric resistive heating. The increase in demand due to heat pumps is more than offset by the loss of demand in resistive heating. In addition, heat pumps have a flatter demand profile than other heating types, and in many cases the peak heat load will be met by gas rather than the heat pump, as described in section 3.4.1

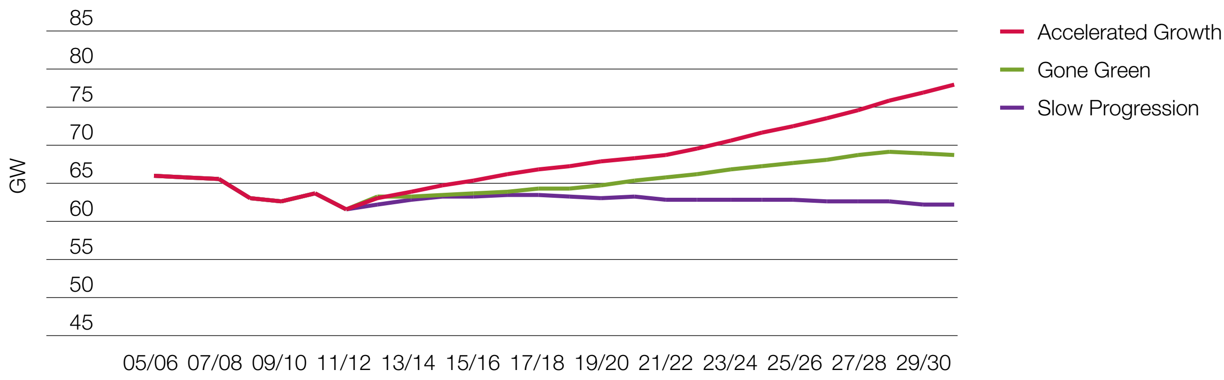
Peak demand for all three scenarios is shown in Figure 25. The total GB peak demand includes exports to Ireland but excludes exports to Continental Europe and generators' station demand.

In **Slow Progression**, end-users peak demand is anticipated to fall, predominantly from industrial and commercial sectors as economic growth is slow. In this scenario, electric vehicles and heat pumps have minimal effects at peak.

In **Gone Green**, non-domestic demand is anticipated to grow steadily. The number of electric vehicles increases compared to Slow Progression; however, time-of-use tariffs limit peak charging in this scenario, adding around 1GW to peak towards 2030. Heat pumps reduce peak demand up to middle of next decade as the saving from replacing existing resistive heating outweighs the increase from displacement of gas heating. By 2030 domestic heat pumps are replacing gas heating and add around 1GW to peak demand.

In **Accelerated Growth**, non-domestic demand grows rapidly in line with economic assumptions. The number of electric vehicles increases significantly, but again, time-of-use tariffs limit charging at times of peak demand. In this scenario, up to 3 GW of EV charging could take place at peak. For heat pumps, there are similar trends in this scenario compared to Gone Green, though additional heat demand (from new housing and displacement of gas fired heating) is greater in Accelerated Growth. Heat pumps add around 1.2 GW to the peak by 2030.

Figure 25.
Total GB peak demand



4.1.3
Imports and exports

Our assumptions on the capacity of interconnectors with continental Europe vary between scenarios, although we have assumed the same level of interconnection capacity to Ireland across all three scenarios.

In all years for **Slow Progression** (and to a lesser extent **Gone Green**) and in this decade for **Accelerated Growth**, we expect Great Britain to be a net exporter of electricity to Northern Ireland via the existing Moyle interconnector and to Ireland via the new East-West interconnector. We anticipate that exports from GB will increase following the addition of the East-West interconnector, although some displacement of flows may take place. For **Slow Progression** we expect the level of Irish exports to increase slightly to 2030. Over the longer term in **Gone Green** and **Accelerated Growth**, we expect net exports from GB to gradually decline as Ireland develops more indigenous power generation, notably wind capacity and in the **Accelerated Growth** scenario, we anticipate imports from Ireland will exceed exports from GB by the 2020s.

In all scenarios and years electricity flows in both directions between continental Europe and GB.

In the **Slow Progression** scenario there is limited new interconnection, with total GB capacity reaching 6.6 GW by 2030. We anticipate that GB will continue to be a net importer from continental Europe with imports increasing by 2030 in line with the gradual increase in interconnection capacity.

In **Gone Green** the level of interconnection capacity increases to 8.6 GW by 2030. We expect both annual imports and exports to rise from current levels in line with the increase in interconnection capacity, with exports increasing markedly from the latter part of this decade onwards as renewable generation increases so that GB becomes a net exporter to the continent by the early 2020s.

For **Accelerated Growth** the level of interconnection capacity increases significantly to 11.6 GW by 2030. We anticipate that the growth in renewable generation and increase in interconnection capacity will result in GB becoming a net exporter at the end of this decade with significant increases in exports and reductions in imports by 2030.

In our plant margin calculations, we assume that at times of peak demand, electricity will always be flowing from GB to Ireland (except for **Accelerated Growth** in the 2020s), but that the interconnectors between GB and continental Europe will be neither importing nor exporting at times of peak demand.

4.2
Electricity generation

Each scenario has a mix of generating capacity that is adequate to meet forecasts of ACS peak demand on the transmission system, assuming that continental interconnectors operate at 'float' (neither import nor export) and interconnectors to Ireland export at their scenario specific levels.

We constructed each scenario to maintain a margin of at least 20%, assuming no imports from Europe and a contribution of 5% from wind generation. As an additional constraint, we aimed to keep a plant margin around 10% when calculated using Equivalent De-rated Capacities[21], in which not only is the contribution from wind reduced to 5% of capacity, but the contribution from conventional plant is also reduced from nameplate capacity to reflect likely availability.

Following stakeholder feedback, we have amended the charts in this section to show total GB generating capacity margin including embedded generation and microgeneration as well as transmission connected generation. Similarly we now show total GB ACS peak demand on these charts including demand met by embedded generation and microgeneration in addition to the transmission connected generation.

We have also responded to stakeholder feedback in producing a broader range of generation mix outcomes across the scenarios, for example there is now a greater range in the start dates for new nuclear plants and the total new nuclear capacity deployed by 2030.

We have also included a broader range of outcomes resulting from the Industrial Emissions Directive (IED) with some coal plants opting in and fitting the relevant emissions control technology, some opting out and running for 17,500 hours before closing by the end of 2023 and some opting into the Transitional National Plan[22] until mid-2020 before limited running for a maximum of 1,500 hours per year until closure by the mid to late 2020s.

We have built the generation scenarios using the axioms described in Appendix 1 which differentiate each scenario in the relevant areas such as economic growth, fuel prices and technological development. However, in the short-term to 2016/17, the scenario generation backgrounds are broadly similar, given project lead times for new generation, with significant differences between the scenarios only occurring after this point.

21 EDC – Equivalent Derated Capacity. Concept explained in Winter Outlook Report 2010/11 Consultation http://www.nationalgrid.com/uk/Gas/TYS/outlook

22 See page 12 in http://www.decc.gov.uk/assets/decc/11/meeting-energy-demand/energy-security/3425-statutory-security-of-supply-report-2011.pdf

4.2.1
Generating technologies

In **Slow Progression** we have assumed a focus on extending existing plant and building new gas plants, with a much slower deployment of renewable / low carbon generation than the other scenarios.

In **Gone Green** we have assumed a balanced approach with contributions from different generation sectors to meeting the CO_2 and renewable targets. In **Accelerated Growth** we have assumed a faster development of low carbon generation than **Gone Green** leading to CO_2 and renewable targets being exceeded. In this section we have included generation capacity connected to the transmission system and embedded generation (generation connected to the electricity distribution network rather than the transmission network). Generating capacity split by station type is shown for all three scenarios in Figure 26 to Figure 28.

Nuclear
In each scenario the existing AGR are assumed to have life extensions:

- **Slow Progression** on average a ten-year life extension
- **Gone Green** on average a seven-year life extension
- **Accelerated Growth** on average a five-year life extension

In **Slow progression** the new nuclear programme is significantly delayed with the first new nuclear plant connecting in the mid-2020s, with a slow build up of new nuclear capacity to around 8 GW of new nuclear plant by 2030.

In **Gone Green** the new nuclear programme is delayed with the first new nuclear plant connecting in the early 2020s and the total new nuclear capacity reaching just over 10 GW by 2030.

In **Accelerated Growth** the new nuclear programme is slightly delayed with the first new nuclear plant connecting in 2020 and the total new nuclear capacity reaching just around 15 GW by 2030.

Coal/Coal CCS
In each scenario it is assumed that the current LCPD and IED regulations will not change from today. This will lead to the closure of around 8 GW of coal capacity by 2016 in all scenarios. Under the IED there will be 9 GW of coal capacity closing in 2023 in both **Gone Green** and **Accelerated Growth** and 11 GW closing in **Slow Progression** in 2023. The remaining capacity either opts into the IED and fits environmental upgrades, converts to a CCS plant or takes the transitional route with limited running hours and gradual closures from 2023.

In **Slow Progression** CCS is not commercially viable in the period to 2030; as such no new coal plants are built. In **Gone Green** a pilot large scale CCS project connects in 2025 with commercial deployment following; around 4 GW of coal plant is fitted with CCS by 2030. In **Accelerated Growth** a pilot large scale CCS project connects in 2020 with commercial deployment following leading to around 8 GW of coal plant fitted with CCS by 2030.

Gas/Gas CCS/Open Cycle Gas Turbine (OCGT)

In **Slow Progression** in order to maintain the required level of capacity most existing gas-fired plant remain open, with only 3 GW of existing plant closing by 2020. Around 20 GW of new gas-fired generation is constructed in the period between 2015 and the mid-2020s. The total gas / CHP capacity by 2030 is around 45 GW. Similarly to Coal CCS the technology for gas CCS is not commercially viable in the period to 2030.

In **Gone Green** some existing gas-fired plants close early, with 6 GW closing by 2020, and around 13 GW of new conventional gas-fired generation is constructed in the period between 2015 and the mid-2020s. The total gas / CHP capacity by 2030 is around 39 GW with 1 GW of Combined Cycle Gas Turbine (CCGT) capacity being fitted with CCS by 2030.

In **Accelerated Growth** some existing gas-fired plants close early, with 7 GW closing by 2020, and around 7.5 GW of new conventional gas-fired generation is constructed in the period between 2015 and the early 2020s. The total gas / CHP capacity by 2030 is around 36 GW with 5 GW of, mostly new, CCGT capacity being fitted with CCS by 2030.

In each scenario there is assumed to be 400 MW of OCGT built around 2023. Stand-alone OCGTs all remain open but OCGTs associated with large coal or oil stations close when the parent station closes.

Biomass

Embedded biomass generation has grown four-fold since 1996, mainly driven by an increase in landfill gas and waste generation in the early years and more recently by increases in the firing of plant waste. In all scenarios the use of landfill gas is approaching its peak, as reductions of waste sent to landfill lower the generational capacity available.

In **Slow Progression** there is limited growth in biomass due to a low level of subsidies available and fuel source restrictions. There are no further biomass conversions apart from those already operational or currently under construction and those plants will close by 2016. There is around 3 GW of biomass capacity in total by 2030. Economic conditions mean there is more pressure to recycle, reuse and prolong the life of existing materials, reducing the waste going to landfill.

In **Gone Green** there are fewer concerns over fuel subsidies, which are sufficient for both new build and conversions. There is a total capacity of around 5 GW by 2020 and over 6 GW by 2030, of which nearly 1 GW is biomass conversions.

In **Accelerated Growth** there is strong growth in biomass with a total capacity of around 6 GW by 2020 and nearly 9 GW by 2030, of which around 1.5 GW is biomass conversions.

Wind

Much of the early wind capacity is embedded, just over 2 GW installed by the end of 2009. There is a small amount of embedded offshore capacity from the Round 1 licensing, but the vast majority of embedded wind is, and will continue to be onshore rather than offshore. At the start of 2012 there was 280 MW of embedded wind under construction with nearly 2 GW of consented projects and a further 2.9 GW still in the planning stage.

In **Slow Progression** the build up of wind generation is slow due to its higher costs when compared to conventional generation. There is a total of 16 GW of wind capacity connected by 2020 (10 GW offshore) and 31 GW (19 GW offshore) by 2030.

In **Gone Green** the build up of wind generation reaches around 30 GW of capacity by 2020 (17 GW offshore) and 55 GW (37 GW offshore) by 2030.

Electricity generation

In **Accelerated Growth** the build up of wind generation is fast due to the levelised cost of offshore wind reaching the Government's target of 100 £/MWh. There is a total of around 39 GW of capacity by 2020 (24 GW offshore) and 73 GW (49 GW offshore) by 2030.

Marine

Marine is a technology which is still in its infancy and has not yet reached commercialisation so predictions on progress within this sector are solely reached by using the axioms and examining potential and forecasts for parties operating within the sector. Less than 2 MW were installed each year in the period up to 2010 though there was an increase to 7 MW installed in 2011. However there are significant developer aspirations, with the Renewable UK State of the Industry report 2011[23] highlighting 2.17 GW of potential by 2020; the Renewable Energy Action Plan stated 1.3 GW by 2020 and the Pentland Firth and Orkney Waters could have 1.6 GW developed.

For the scenarios, considering the pace of technological development implied by the axioms it is likely that for **Slow Progression** marine technology remains in the R & D stage until beyond 2020, after which time medium scale projects enter development; for **Gone Green** the technology becomes commercial before 2020 and in **Accelerated Growth** the technology becomes commercialised by around 2015.

In **Slow Progression** marine generation is assumed to develop very slowly, due to high costs, with minimal deployment by 2030, less than 0.5 GW.

In **Gone Green** there is limited build up of marine generation, mainly post 2020. There is total marine capacity around 1.5 GW by 2030.

In **Accelerated Growth** there is strong build up of marine capacity, mainly post 2020, including one lagoon project. The total marine capacity reaches around 4.5 GW by 2030.

23 http://www.bwea.com/pdf/marine/Wave_Tidal_energy_UK.pdf

Figure 26.
Demand and Generation Background: Slow Progression

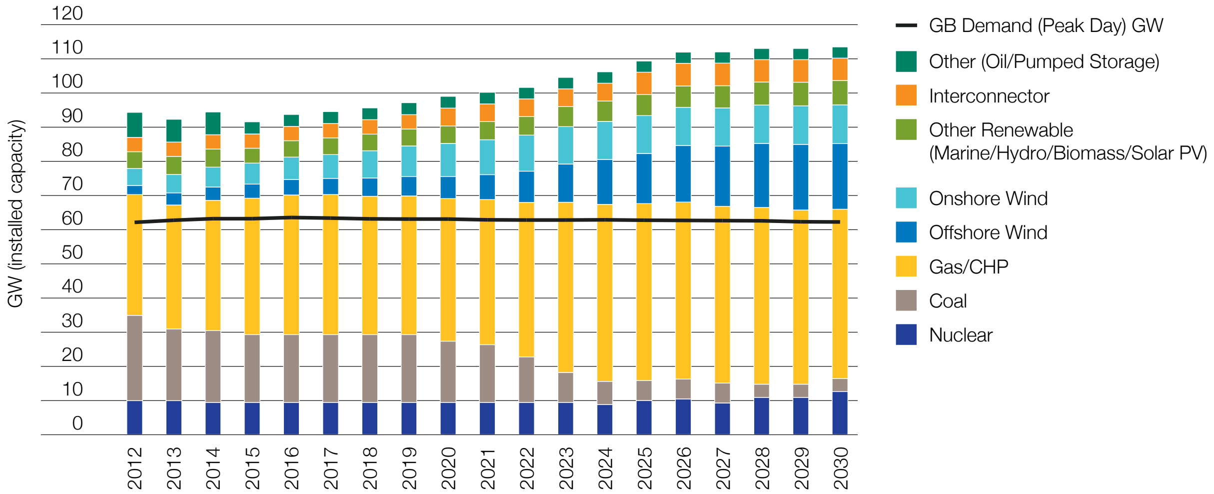


Figure 27.
Demand and Generation Background: Gone Green

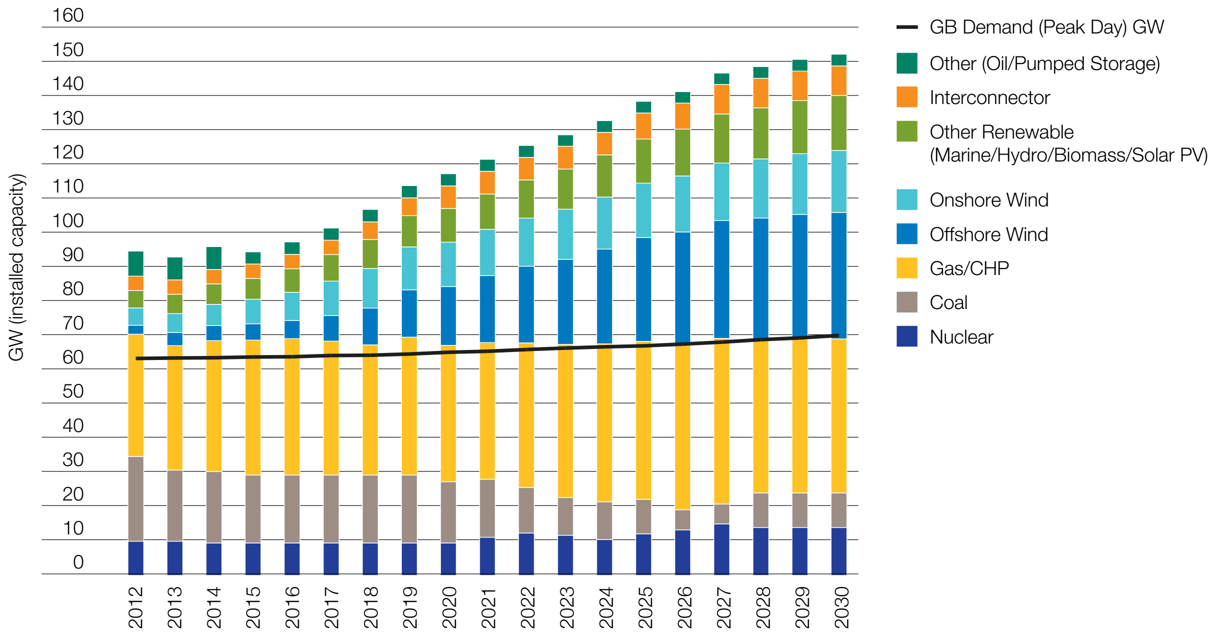


Figure 28.
Demand and Generation Background: Accelerated Growth

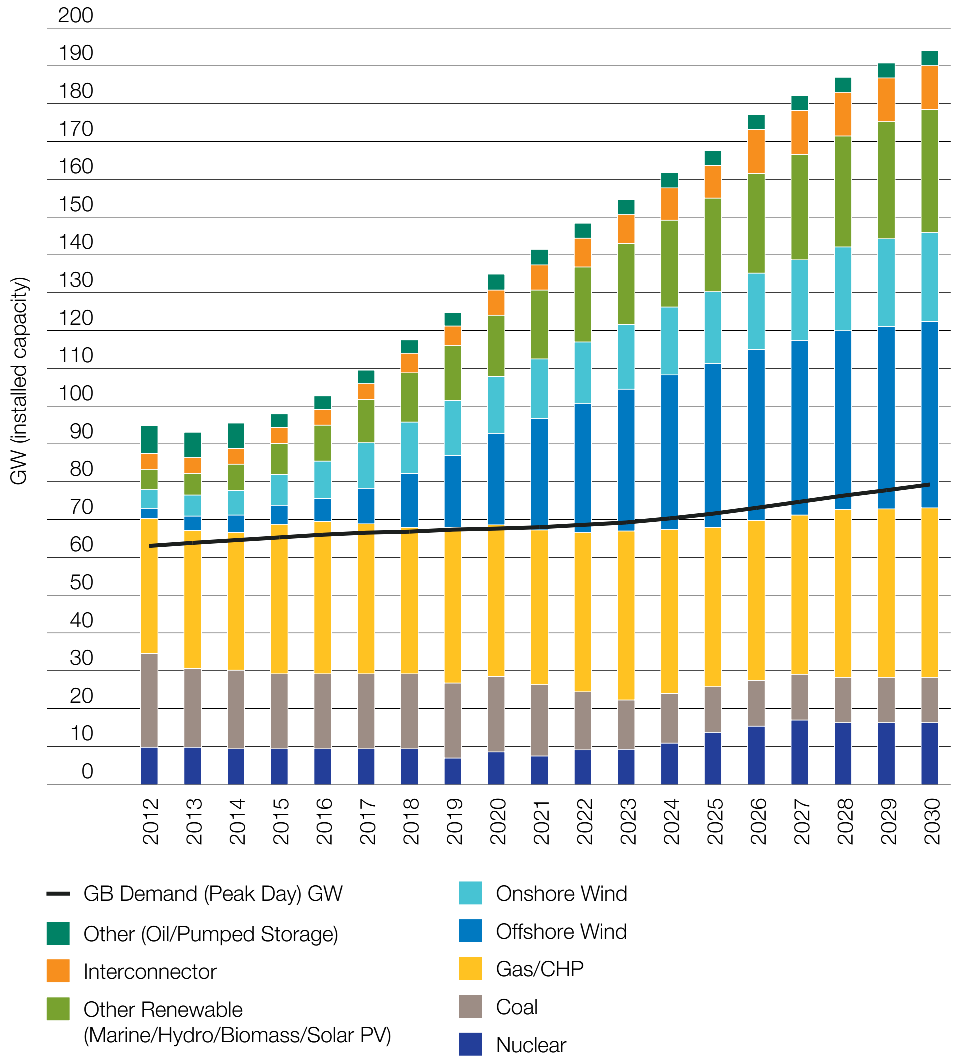
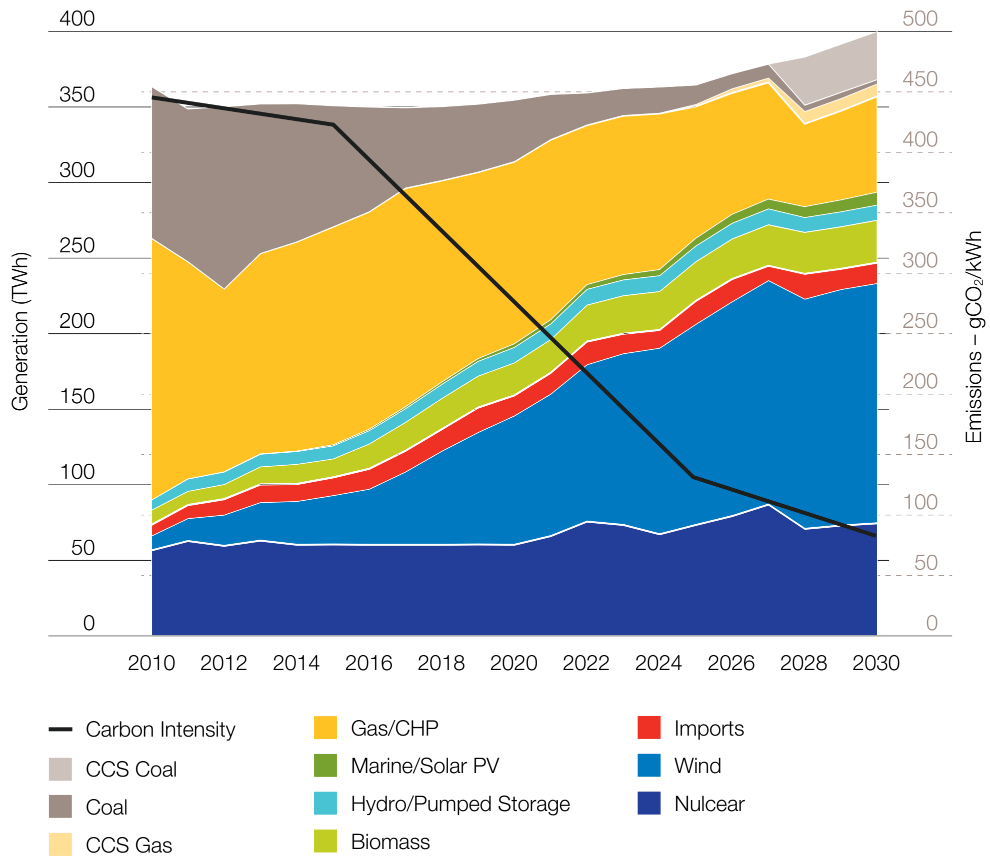


Figure 29 shows GB annual generation for **Gone Green** aggregated by fuel type. Also shown on this chart is the carbon intensity of generation (excluding imports).

Figure 29.
GB Generation by fuel type and carbon intensity: Gone Green

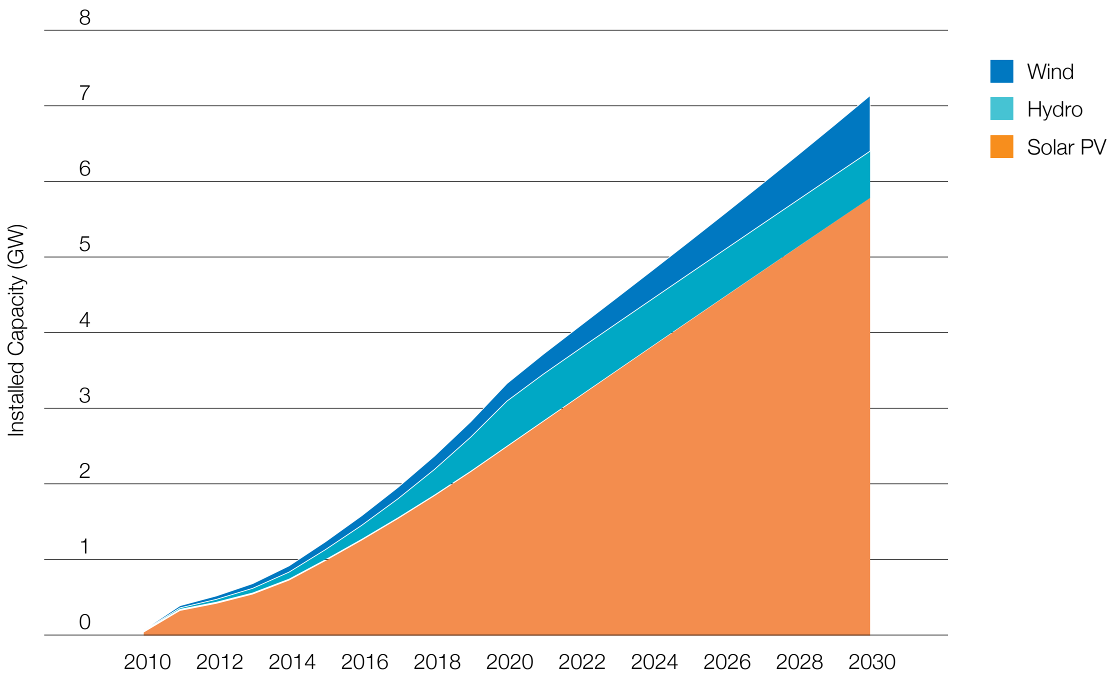


4.2.2
Micro generation

So far the vast majority of installations registered under the FITs scheme (see section 3.2.4) are Solar PV. We have included Solar PV, wind and hydro in our scenarios, and a small amount of micro CHP in **Accelerated Growth**. Figure 30 shows the split of technologies in **Gone Green**.

The distribution is similar in the other scenarios, with PV representing more than 80% in 2030 in all cases. Micro generation reaches a total of 2 GW by 2030 in **Slow Progression**, 7 GW in **Gone Green** and 19 GW in **Accelerated Growth**.

Figure 30.
Micro generation installed capacity in Gone Green



UK Future Energy Scenarios
September 2012

4.3
Gas demand

Our gas demand projections have always been defined in terms of customer annual consumption rather than customer type as this is the information available to us. These bands do not map directly to traditional descriptions such as domestic, commercial or industrial. Domestic demand maps reasonably well to the non-daily metered 0–73 MWh per year category but above that level it is often safer to consider industrial and commercial demand in aggregate as customers with demand greater than 73 MWh per year.

4.3.1
Domestic gas demand

Domestic gas demand accounts for around a third of total UK gas demand. There are four main reasons for potential demand changes in the domestic sector:
- Behaviour change
- Energy efficiency
- Extra demand from new houses
- Change of heating fuel

We have sought views on all of these via stakeholder engagement.

Behaviour change

There are a number of behavioural changes that customers can make to reduce their energy consumption, for example lowering the thermostat setting, turning heating off earlier in the evening or earlier in the year, but they can mostly be captured by considering their effect on the average internal temperature of the house.

In our stakeholder engagement around half of the respondents thought internal temperatures would remain the same in the future, 20% thought they would reduce and 20% thought they would increase. We included these views in our axioms as;
- **Slow Progression** – Domestic internal temperatures increase
- **Gone Green** – Domestic internal temperatures do not change
- **Accelerated Growth** – Domestic internal temperatures continue to reduce

Energy efficiency and extra demand from new houses

These have been covered in detail in section 3.4.2.

Change of heating fuel

Heat pumps have been discussed in section 3.4.1. We assume that early deployment of heat pumps will be in houses not connected to the gas grid, so the effect on gas demand will be small. We assume that the next wave of heat pump installation is in new houses. These have lower heat demand than existing houses so although some gas demand is lost at this stage it is not as significant as when heat pumps are installed in existing houses.

A breakdown of the change in domestic gas demand is shown in Figure 31 to Figure 33 and Figure 34 (overleaf) shows domestic gas demand in all three scenarios.

Figure 31.
Changes in domestic gas demand: Slow Progression

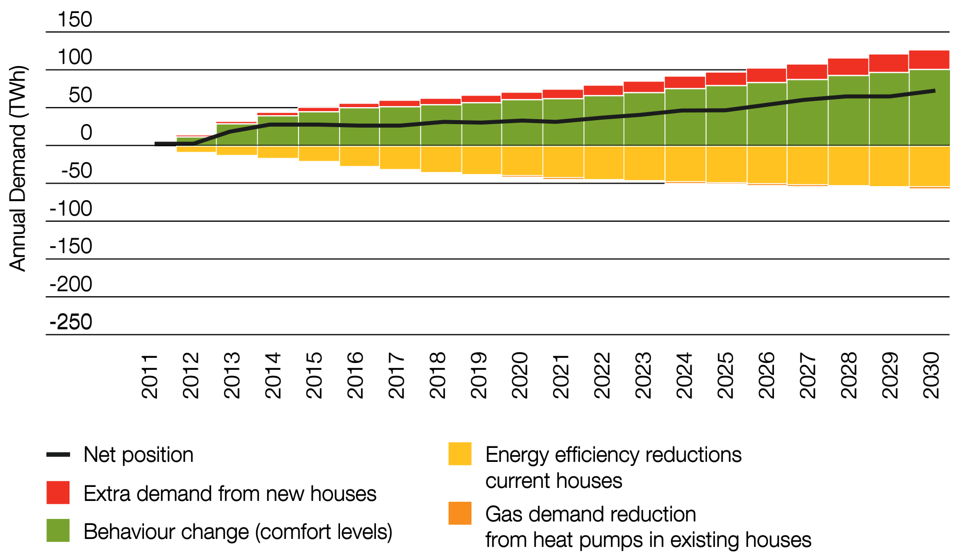


Figure 32.
Changes in domestic gas demand: Gone Green

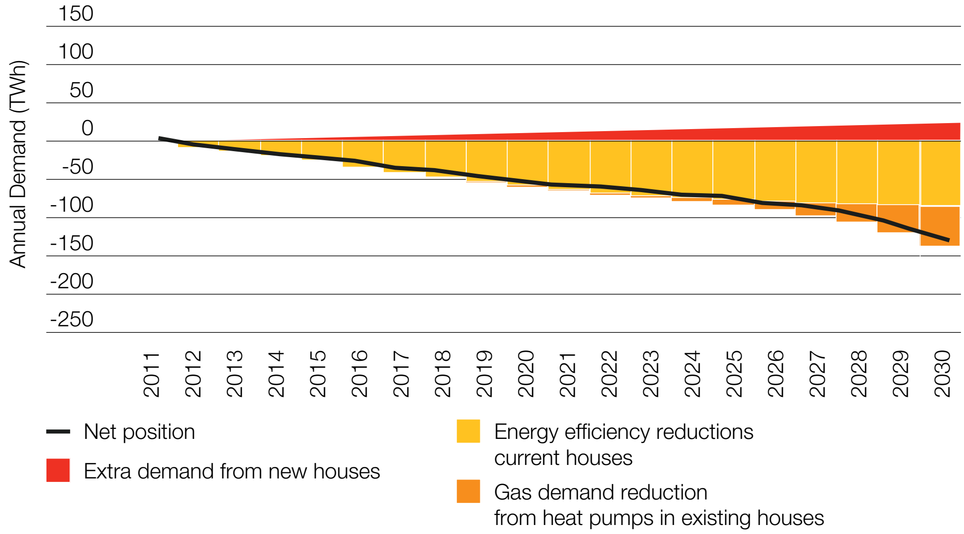


Figure 33.
Changes in domestic gas demand: Accelerated Growth

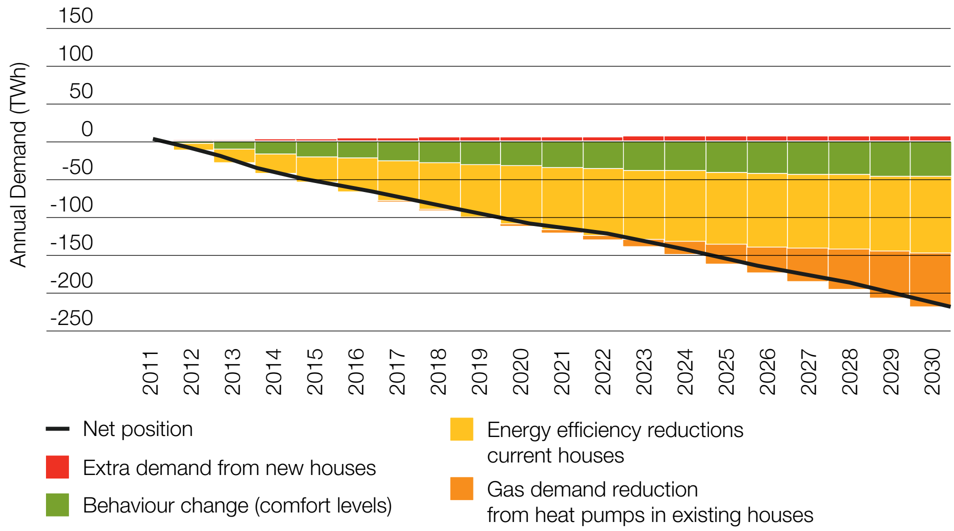
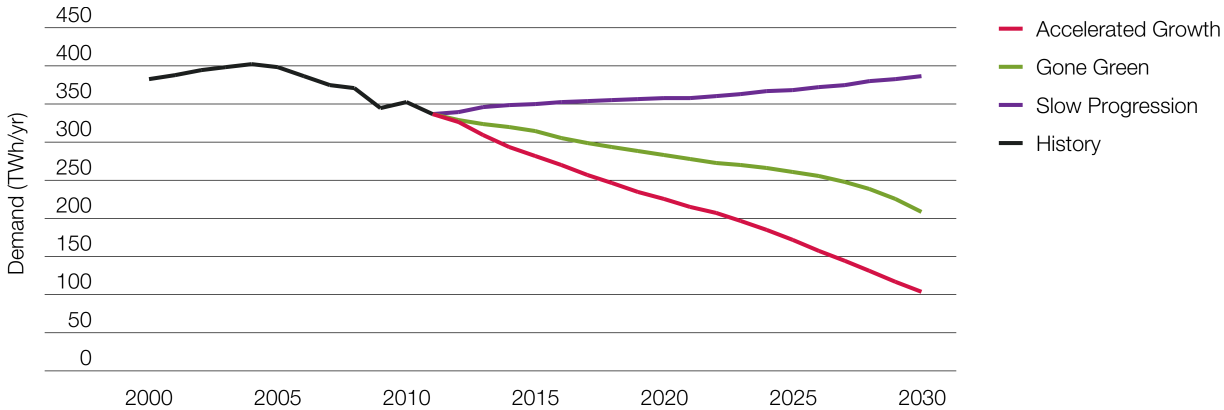


Figure 34.
Domestic gas demand in all three scenarios



4.3.2
Industrial and commercial demand

The level of detailed information relating to energy use within buildings for heating, lighting, water and so on for Industrial and Commercial (I&C) customers is far less than for the domestic sector.

As a result, industrial and commercial demand scenarios rely far more on econometric output as described in section 3.3 than is the case for domestic demand. The bands we use in the I&C forecast are:

- 73–732 MWh
- >732 MWh LDZ connected demands
- Industrial loads connected directly to the National Transmission System (NTS)

The projections for the 73–732 MWh load band are all taken from our econometric modelling. The projections for the >732 MWh load band are largely based on our econometric modelling, but in addition we identify sites that do not follow the econometric trends and forecast these via a separate site by site process.

All of the NTS directly connected industrial demands are forecast via a site by site process, as there are relatively few of them and they tend to have fairly consistent demands.

4.3.3
Exports: Ireland and Europe

The gas exported to the Republic of Ireland and Continental Europe is important for network operation purposes, although it does not contribute to UK renewable energy or carbon emissions targets.

The forecast level of gas exports to Ireland is heavily influenced by the development of indigenous Irish gas supplies via the Corrib gas field, the prospects of future LNG imports and assumptions regarding Irish gas demand. For all three scenarios we assume similar Irish supplies namely gas production from Corrib post 2015/16, no development of the proposed Shannon LNG project and no new Irish storage projects. On the demand side we assume similar energy trends in Ireland to that in the UK for each scenario, hence Irish demand is essentially flat in Slow Progression, declines in Gone Green and significantly declines in Accelerated Growth.

Gas can flow in both directions between UK and the Continent through the Interconnector (IUK) as described in Section 4.4.4. IUK exports are higher in Slow Progression than in Gone Green which in turn is higher than Accelerated Growth. This is due to the assumptions regarding the overall supply availability to the UK from other supply sources. In the period to 2030, export decrease in Gone Green and Accelerate Growth, and increase in Slow Progression. In terms of imports, all scenarios identify the possibility of IUK imports, while these are anticipated to be seasonal, they may materialise at any time through the year. This is an important consideration in terms of network design and operation. In terms of scenario volumes we assume very low levels of IUK imports in Slow Progression and progressively higher imports for Gone Green and to a greater extent in Accelerated Growth.

4.3.4
Power generation gas demand

In **Slow Progression** we expect power generation gas demand to increase strongly initially and then remain fairly flat to the early 2020s with new gas-fired power generation capacity offsetting the closure of coal and oil plants due to the Large Combustion Plant Directive. From the mid-2020s, we anticipate that new nuclear capacity and gradually increasing renewable capacity and continental imports will starts to erode gas' share of the power generation market.

In **Gone Green** in the short term, we anticipate that gas demand in the power generation sector will increase slightly then remain fairly stable as new gas capacity completes commissioning while coal and oil plants close due to the Large Combustion Plant Directive. We expect that gas demand will fall steadily from around 2018 onwards in response to substantial offshore wind development and the first new nuclear station in the early 2020s, with the trend continuing out to 2030.

In **Accelerated Growth** we envisage that power generation gas demand will remain fairly stable for a few years as new gas capacity completes commissioning and thermal plant closes due to the Large Combustion Plant Directive, before declining from 2016 onwards with the closure of existing gas plants and significant increases in renewable generation (particularly offshore wind). We anticipate that the connection of new nuclear plants in the 2020s combined with further deployment of renewable generation will result in a significant decline in power station gas demand until the late 2020s when some new gas plants fitted with CCS connect to the system.

4.3.5
Total gas demand

Total gas demand is shown in Figure 35 to Figure 37. Historical values have been included from 2000 to 2011 showing the decline in domestic and I&C demand since around 2004.

Figure 35.
Total gas demand: Slow Progression

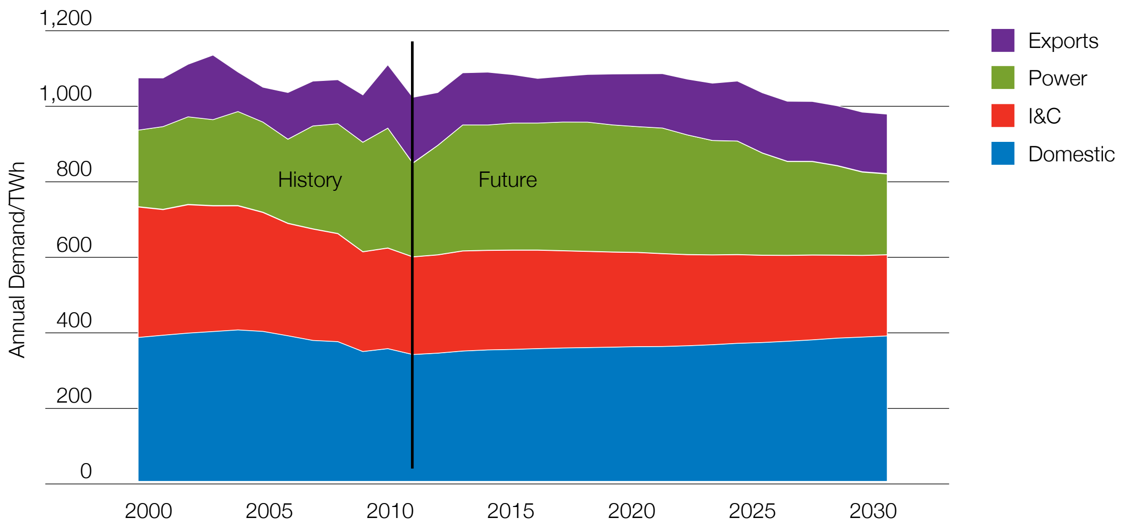


Figure 36.
Total gas demand: Gone Green

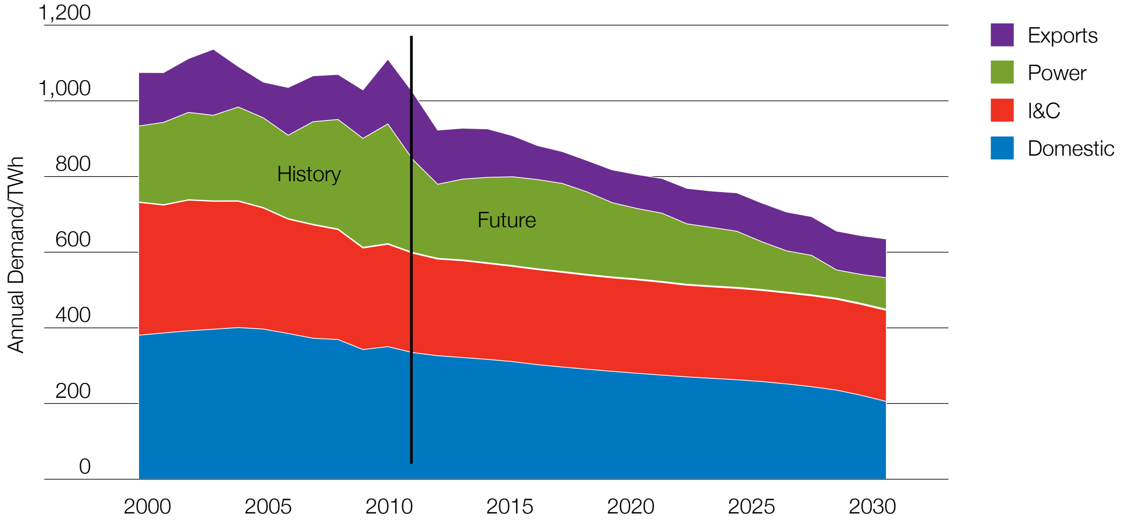
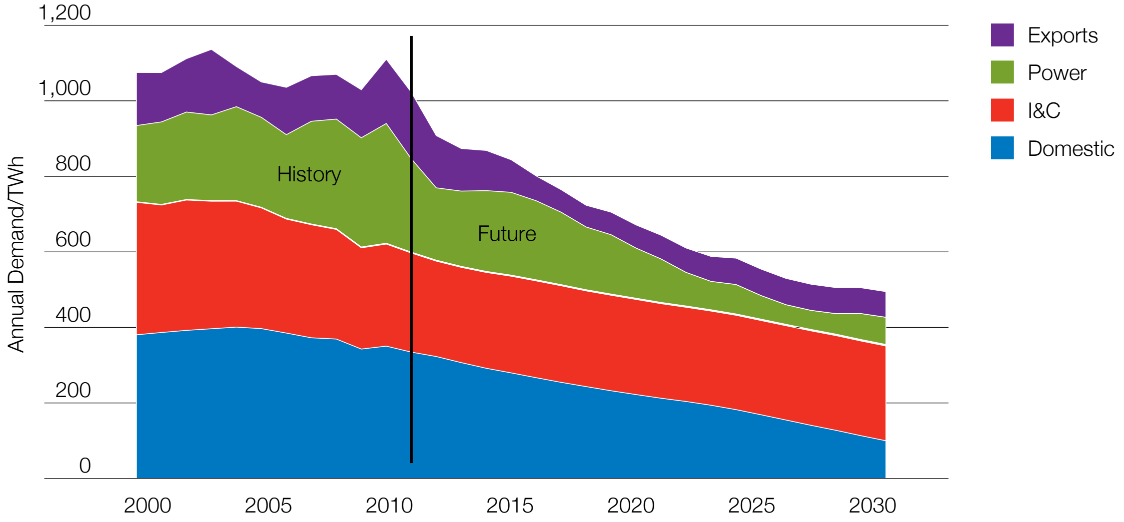


Figure 37.
Total gas demand: Accelerated Growth



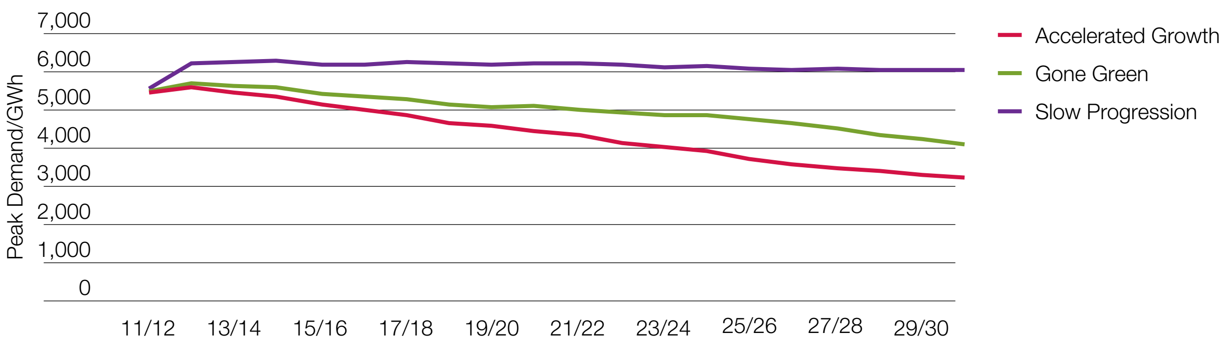
4.3.6
Peak gas demand

Peak gas demand is based on a historical relationship between daily demand and weather combined with the amount of gas-fired electricity generation expected on a peak day.

In contrast to the electricity market, where the peak demand is expected to fall relative to the annual demand over time, the trend in gas peak demand is harder to predict. Consequently the relationship between peak and annual demand is retained unchanged over time for each load band. The relationship between total annual demand and peak will change as the market mix changes. Peak gas fired electricity generation is less related to weather and more dependent on assumptions about generation availability and the position of gas power stations in the generation order. In our 2012 scenarios the total peak demand includes a high gas generation sensitivity which assumes gas favoured over coal generation and lower availability for nuclear and wind generation compared to the base case sensitivity.

Figure 38 shows the peak demand for all three scenarios. The peak is higher in **Slow Progression** even in 2012/13, reflecting the axiom that states that in **Slow Progression** gas will be cheaper than coal, thereby favouring gas-fired power generation over coal-fired generation.

Figure 38.
Peak gas demand: all three scenarios



4.4
Gas supply

For each demand scenario there is a dedicated supply scenario based on assumptions derived from the axioms. These are used to create three distinct supply and demand scenarios.

While each supply scenario is dedicated to a specific demand scenario, the supply scenarios should not be considered as exclusive to each demand scenario but as a means to create a breadth of supply forecasts reflecting some of the level of supply uncertainty and some of the supply options that could happen over the forecasting period. In determining the gas supply scenarios, each of the five main supply components are initially determined separately and then again collectively such that the aggregate level of annual supply matches the annual demand in each scenario. The determination of peak supply is calculated separately. With the exception of the UKCS component, peak supply tends to be based on utilisation of available import and storage capacity.

The five main supply components consist of:

1. UK Continental Supplies (UKCS)
2. Norwegian imports
3. LNG imports
4. Continental imports
5. Storage

4.4.1
UK Continental Supplies (UKCS)

The UKCS supply forecasts, are shown in Figure 39. As in previous years there is a general trend of declining production albeit this is temporarily halted in the near term due to the development of numerous new sources of UKCS supply including West of Shetland.

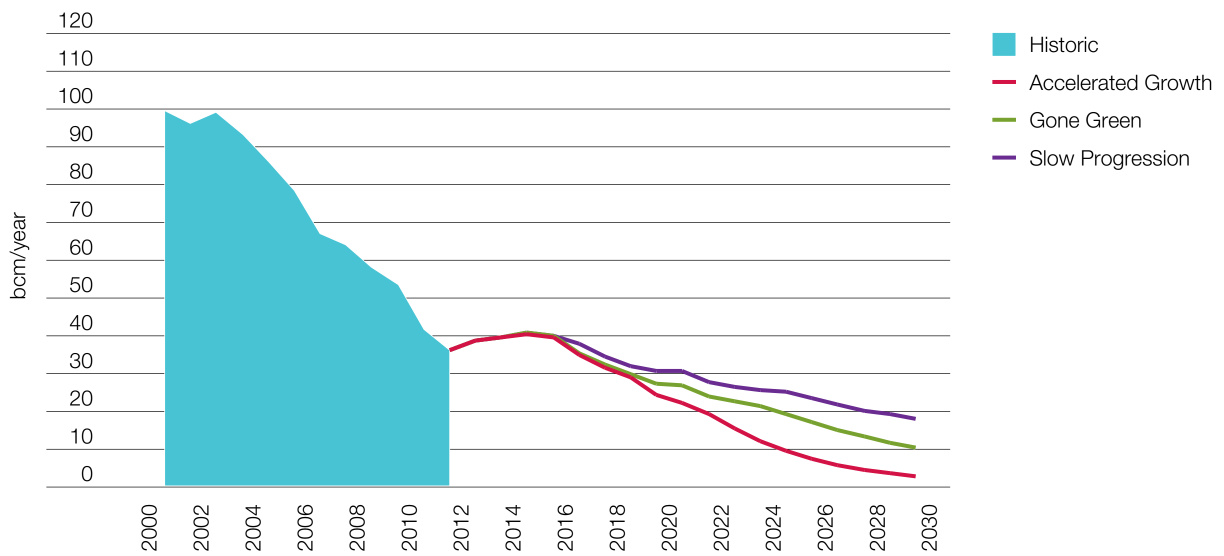
The forecasts are based primarily on data from Oil and Gas UK gathered as part of National Grid's FES consultation and then adapted for use in the scenarios. The data from Oil and Gas UK broadly reflects the aggregate view of UKCS upstream parties.

Despite the diversity of assumptions there is relatively little difference in the UKCS forecasts for all three scenarios, particularly in the short term as these levels are based on fields that are currently in production and those that are currently under development. Over time there is some divergence in the UKCS supply forecasts with higher longer-term UKCS production in **Slow Progression** due to the assumption of more new developments than **Gone Green** and particularly when compared with **Accelerated Growth**. This trend follows the direction of gas demands set out through the axioms. In terms of UKCS production, the forecasts in **Slow Progression** also benefit from a stable gas regime albeit in an environment with relatively low energy prices.

As a proportion of UK demand, the contribution of UKCS in the scenarios falls from about 40% today to about 30–40% in 2020 and about 5–15% in 2030, with the highest proportion being associated with **Slow Progression**.

Gas supply

Figure 39.
UKCS (History and Scenario Projections)



Though not shown, the supply forecasts include a modest contribution from onshore gas sources, specifically shale, coal bed methane (CBM) and biogas. Each of these sources is considered independently for all three scenarios. As one would expect, the 'greener' agendas of **Gone Green** and **Accelerated Growth** favour biogas with a bias towards CBM in **Slow Progression**. Shale is assumed to make a small contribution in both **Slow Progression** (from about 2015) and **Gone Green** (from about 2020). For all three onshore gas sources there is considerable uncertainty over development timescales and potential volumes, hence the assumed modest contributions could be significantly understated.

As a proportion of UK demand, the contribution of onshore gas sources in the scenarios increases from near zero today to about 1–2% in 2020 and about 3–4% in 2030, with the highest proportion being associated with **Slow Progression** and **Gone Green**.

The level of UKCS and onshore gas sources determines the import requirement. For all three scenarios future imports are assumed through a combination of Norway, LNG or the Continent. Due to proximity and limited export options, imports from Norway are considered ahead of LNG and the Continent.

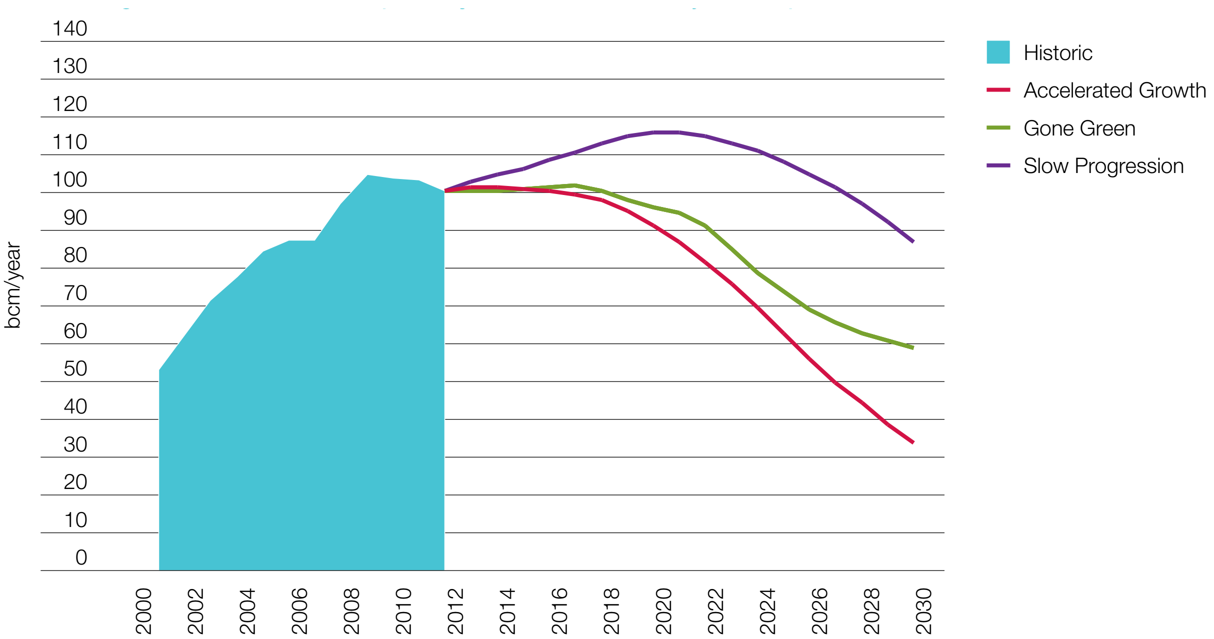
4.4.2
Norwegian supplies

To determine our forecasts for Norwegian flows to the UK we make two discrete stages, the first is to determine an aggregated level of Norwegian production. This is followed by determining the partition of Norwegian gas exported to the Continent and the UK and that used in Norway. For each demand scenario we create a different Norwegian production forecast and a different forecast of supply to the UK.

The total Norwegian production forecasts shown in Figure 40 are based on reported total reserves for the Norwegian Continental Shelf (NCS), external forecasts for Troll and Ormen Lange and an assessment of the development of remaining Norwegian gas reserves. It is the assessment of the remaining reserves that provides most of the variation in future Norwegian production and hence supplies to the UK.

In terms of the partition of Norwegian production we assume relatively modest levels for gas consumed in Norway. The majority of Norwegian production is therefore exported to the Continent and the UK. Due to long term supply contracts and exports close to pipeline capacity, Continental exports are assumed to be relatively stable therefore the proportion of Norwegian gas to the UK follows a similar profile for total Norwegian production.

Figure 40.
Norwegian Gas Production (History and Scenario Projections)



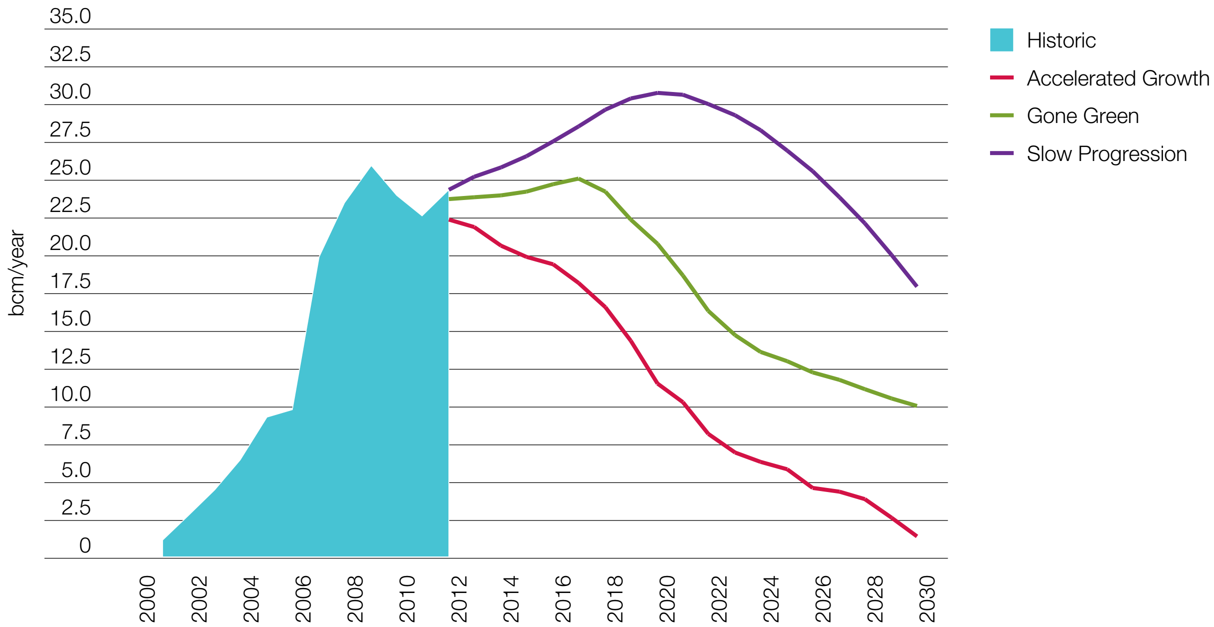
Gas supply

For each demand scenario we assume different levels of Norwegian production. The lowest level of Norwegian production (hence exports to the UK) is associated with Accelerated Growth and highest production with Slow Progression.

This follows the same assumptions as used in the UKCS forecasts. For the lowest level of Norwegian production (as used in Accelerated Growth) we assume limited new field development beyond that already planned. For Gone Green we assume numerous further developments including access to reserves in the Norwegian Sea, while in Slow Progression we assume a high case for future Norwegian production based on developing reserves in the Norwegian Sea and the possibility of longer term developments in the Barents Sea.

Figure 41 shows our forecasts for Norwegian imports to the UK for all three demand scenarios.

Figure 41.
Norwegian Gas Supply (History and Scenario Projections)



The remaining import requirement in all scenarios is met by either LNG or from the Continent. To create breadth in the scenarios there are marked differences in the approach to determining both sources of supply.

4.4.3
Liquified Natural Gas (LNG) supplies

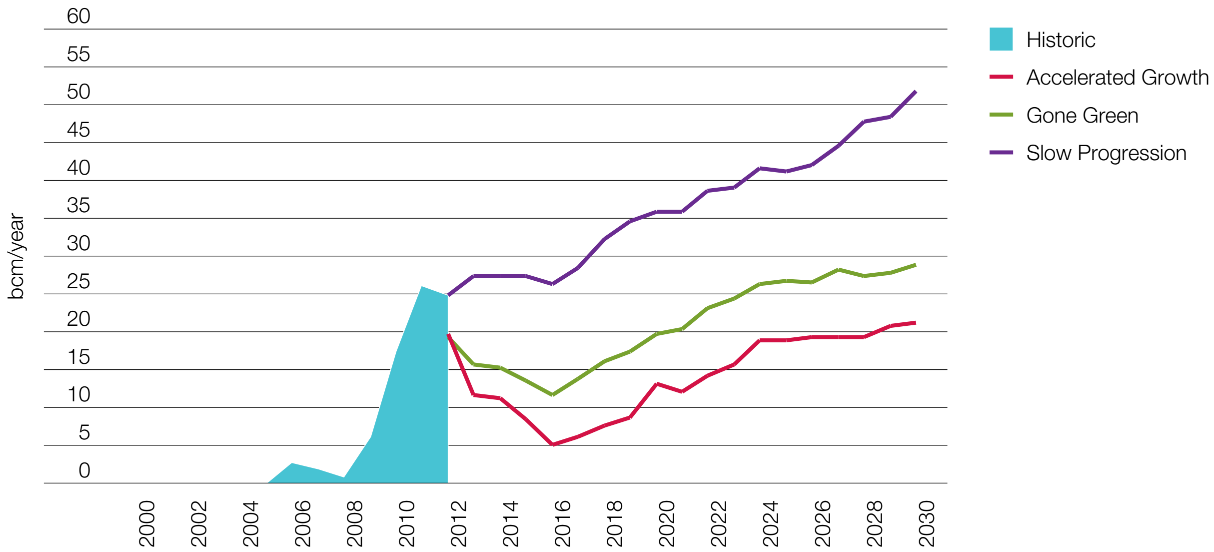
In **Slow Progression** the axioms dictate that the UK has not only sustained demand but is well supplied despite gas prices that are lower than in the other scenarios. As a consequence the UK attracts appreciable LNG imports and continues to be a net exporter of gas through IUK. This may appear unlikely but there are many reasons why in the future the UK could attract high volumes of LNG despite relatively low prices, these include:

- The gas price forecasts used in the scenarios remain well above the cost of production of many, possibly most, LNG sources
- Increased LNG supply, for example the under construction facilities in Australia, proposals to export US gas as LNG and possible new LNG from Africa (Mozambique) and Russia
- Lower LNG demand in other markets, notably if the Japanese nuclear fleet returns

The consequence of high LNG imports in **Slow Progression** is the expectation of expansion at existing LNG facilities or even new LNG import terminals. In **Gone Green**, LNG imports decline from existing levels until about post 2015 when LNG imports again increase as a consequence of declining UKCS and the commencement of declining supplies from Norway. In **Accelerated Growth**, LNG imports are significantly squeezed in the medium term due to declining gas demand. Post 2015 LNG imports increase due to declining supplies from UKCS and Norway but only to historic import levels.

Figure 42 (overleaf) shows our forecasts for LNG imports to the UK for all three demand scenarios.

Figure 42.
LNG (History and Scenario Projections)



4.4.4
Continental supplies

The Continental gas supply forecasts are subject to considerable uncertainty, due to the possibility of imports or exports to the Continent through IUK (bi-directional for physical and commercial flow) and BBL (physical imports and part bi-directional for commercial flow).

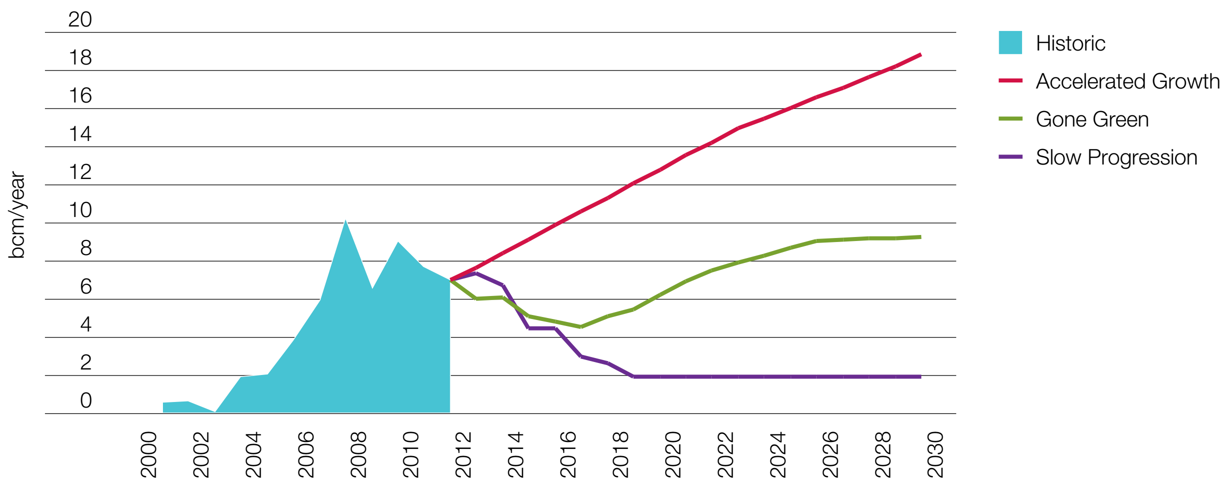
While it is the final import component to be assessed it is more than just a supply balancer. This is because each supply source is assessed individually based on the axioms and then again collectively so that the aggregate level of annual supply matches the annual demand in each scenario.

In Slow Progression the level of imports from the Continent to the UK falls from relatively modest current levels, to even lower levels. This is due to a well supplied UK from both Norway and LNG and UK prices that tend to be lower than those on the Continent. In this scenario the UK is a net exporter to the Continent. In Gone Green, the level of Continental imports is comparable to current levels. In Accelerated Growth, much higher levels of Continental imports are assumed. This is due to lower supplies from all other sources and the assumption that UK gas prices are higher than those on the Continent.

In terms of peak imports from the Continent, all three scenarios assume that most or all of the import capacity of BBL and IUK could at times be utilised. Indeed, future Continental imports at peak could increase due to the increased access to Continental storage (via IUK or BBL) including the 'open access' Bergermeer storage facility. This storage facility offshore in the Netherlands is expected to provide 4.1 bcm of storage from 2015.

Figure 43 shows our forecasts for Continental imports to the UK and exports from the UK for all three demand scenarios.

Figure 43.
Continental Europe Gas (History and Scenario Projections)



4.4.5
Gas supply: Annual forecasts

The following three charts show the annual supply forecasts for Slow Progression, Gone Green and Accelerated Growth.

Figure 44 shows the annual gas supply forecast for Slow Progression. It predicts high levels of gas supply from UKCS and Norway compared to the other scenarios, due to increased market confidence and certainty. LNG supplies are buoyant due to higher global production facilities. On an annual basis, flows to the Continent are weighted more to exports than imports due to high supply availability. At peak import flows from the Continent are expected, though the likelihood of exports at peak remains a possibility. In **Slow Progression**, there is new seasonal storage development to accommodate market requirements.

Figure 44.
Annual Gas Supply: Slow Progression Scenario

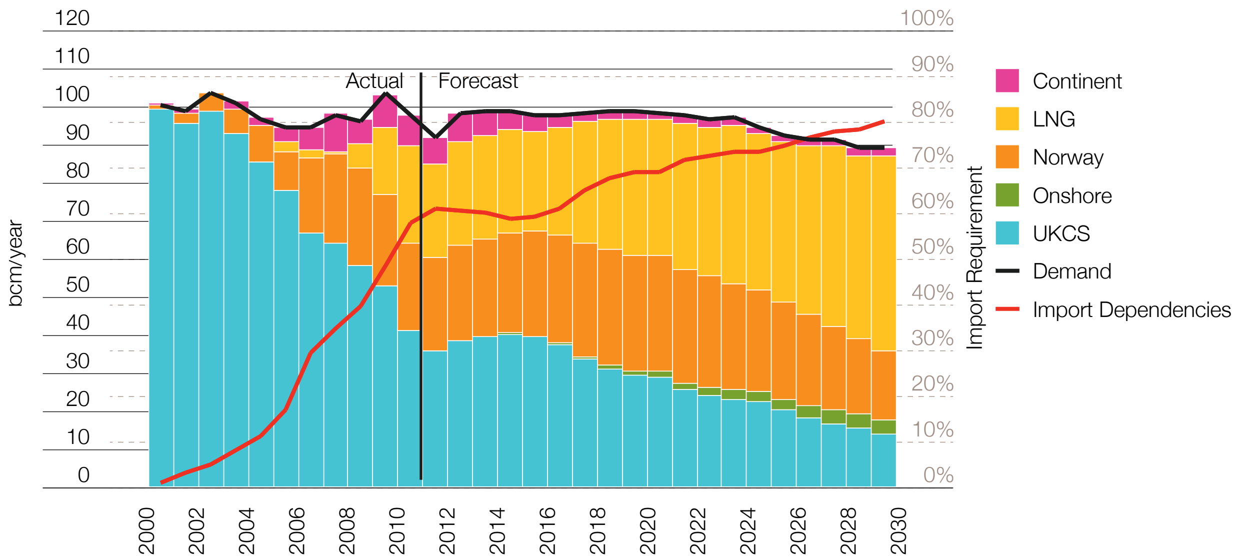


Figure 45 shows the annual gas supply forecast for **Gone Green**. It predicts a balanced view of the gas supply mix, with slightly lower levels of gas from UKCS, Norway and LNG than that outlined in **Slow Progression**. The focus is on flexible storage driven by market requirements. In **Gone Green** there is no new seasonal gas storage development.

Figure 45.
Annual Gas Supply: Gone Green

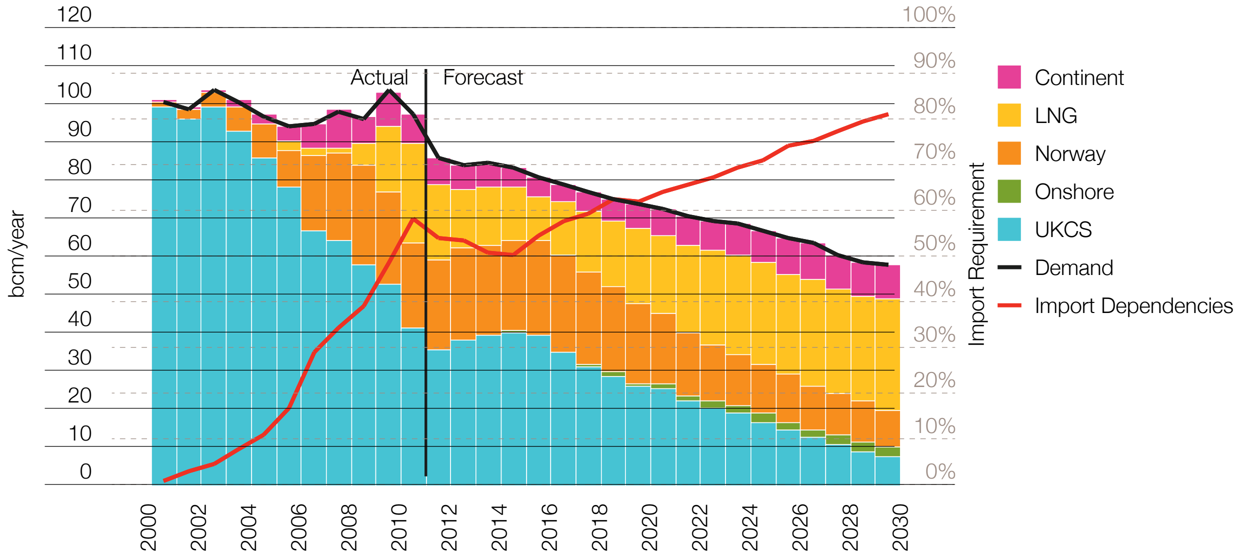
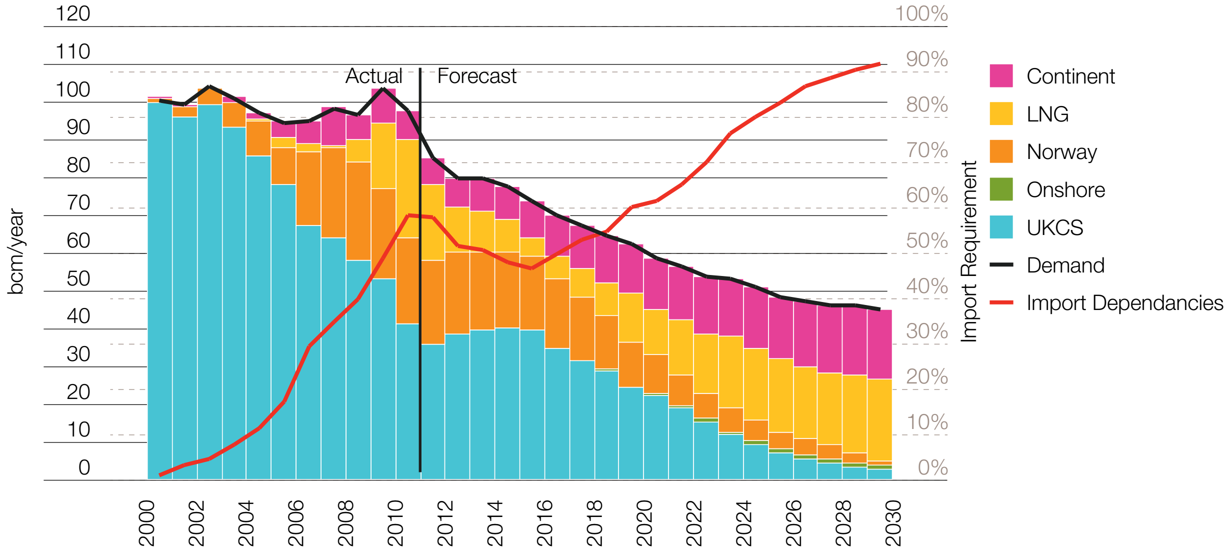


Figure 46 (overleaf) shows the annual gas supply forecast for **Accelerated Growth**. It predicts lower levels of gas supply from UKCS and Norway, due to lower gas demand and lower exports. LNG supplies are tight due to lack of new production facilities. Higher Continental imports are expected, particular at periods of high demand. Only existing and under construction storage sites are operational. Continental and LNG terminals provide flexible supplies to the market as an alternative to new storage.

Gas supply

Figure 46.
Annual Gas Supply: Accelerated Growth

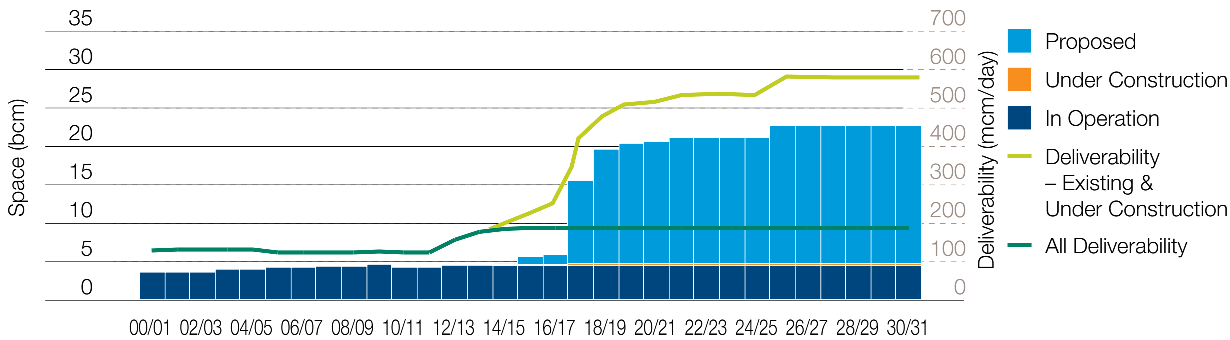


While the annual position looks manageable, the peak is expected to become increasing challenging due to the options for peak supply (more storage, LNG, Continental imports, possible Norwegian swing) and day-to-day and within-day variation in demand caused through the intermittency effects of increase renewable electricity generation. The exact nature of future gas demand and supply behaviour is still uncertain but under most scenarios the gas network is required to be very flexible. In most instances, gas is supplied via a global market that determines where the gas flows. By having diversified sources of gas supply the uncertainty can be managed through flexible supply options e.g. storage or LNG. While this diversity is of great benefit to security of supply, it requires the gas network to be flexible enough to accommodate very different supply and demand flow patterns and will increasingly be required to respond very rapidly as those patterns change.

4.4.6
Gas supply: Storage projects

To assess peak supply, the contribution from storage combined with UKCS and all imports at maximum supply / capacity needs to be assessed. As in previous years, the storage position is dominated by the potential for new storage projects that could be built over the next few years. Most of these projects are proposed rather than under construction. Those under construction are facilities with high injection and withdrawal rates relative to their space. This enables them to operate relatively flexibly and cycle within winter. Figure 47 shows the current status of UK storage projects in terms of space and deliverability.

Figure 47.
Storage Projects



The chart shows that the contributions from storage projects under construction or recently completed add modest space but provide a considerable surge in term of deliverability.

Opportunities for further new storage exist, for example, to manage the increased demand variation brought about by more wind generation or to provide cover for supply losses. Due to increased supply concentration at entry terminals and the length of the supply chain, these are expected to increase and have a potential greater impact.

For the three demand scenarios the development of further storage is shown in Figure 48 and Figure 49.

For **Slow Progression** new seasonal storage developments are assumed to meet market needs and provide some cover for the high import requirements. For **Gone Green**, further flexible storage is assumed to be developed by market players. This is primarily needed to provide some of the anticipated flexible gas supply to gas-fired power stations that are needed for intermittent power generation bought about by more wind generation. For **Accelerated Growth** little or no new gas storage is considered as flexible supplies are assumed from underutilised import sources that are used as an alternative to further new storage. This includes the possibility of Norwegian or LNG imports providing peak gas or access to Continental storage via IUK or BBL.

Figure 48.
Storage Forecast (Space)

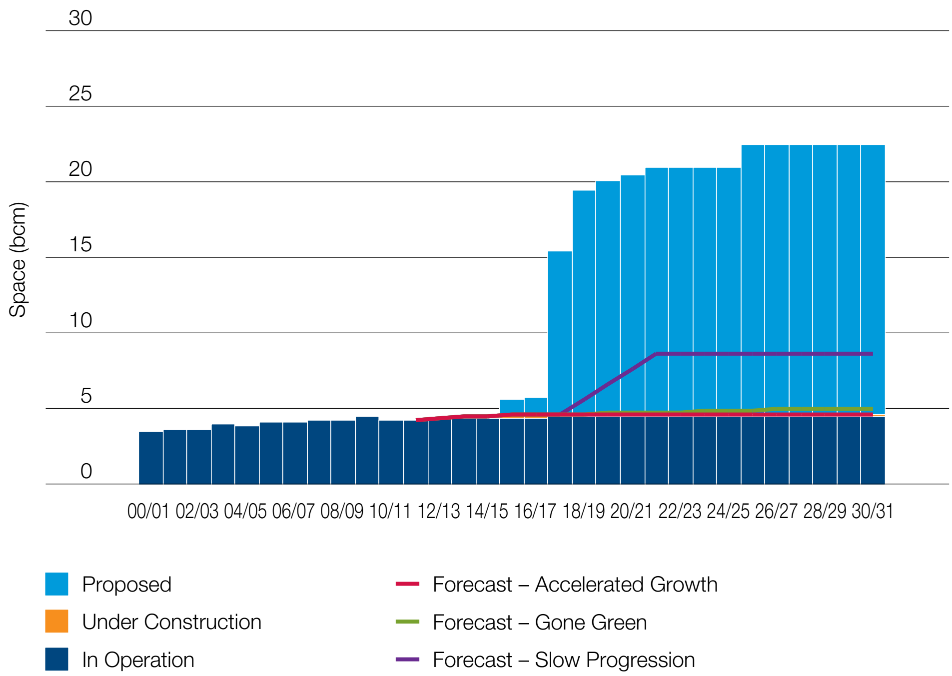
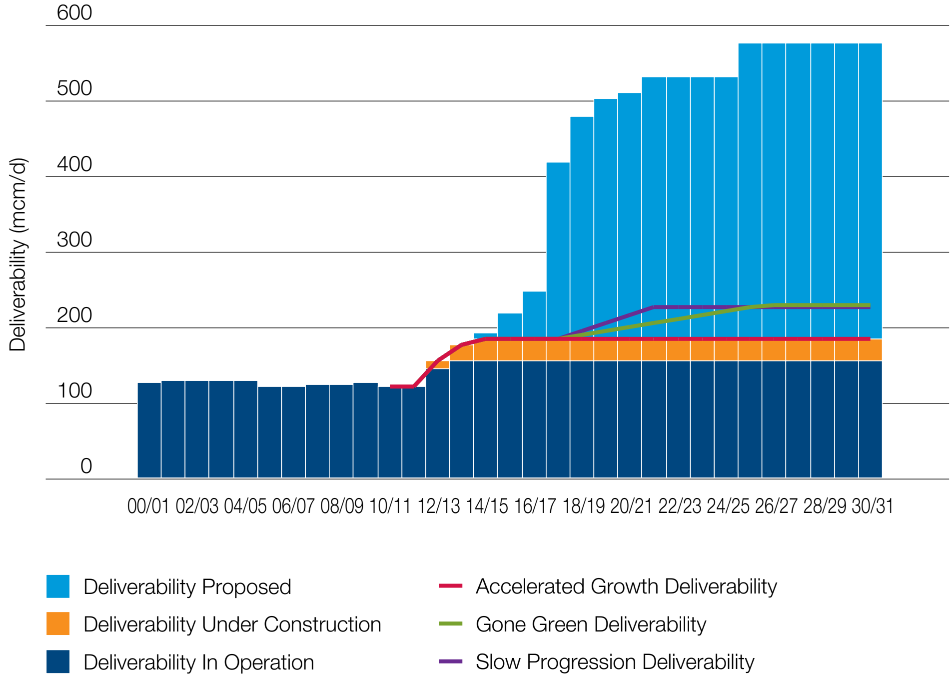


Figure 49.
Storage Forecast (Deliverability)



4.4.7
Gas supply: Peak day

The following three charts show the peak supply forecasts for Slow Progression, Gone Green and Accelerated Growth. These charts potentially overstate the role of imports as all imports are shown at capacity. The storage contribution is also potentially overstated as storage is shown at maximum deliverability. For many storage sites maximum deliverability may be restricted to just a few days and in the winter storage stocks may be depleted in advance of any peak day.

Figure 50.
2012 Peak Day Gas Supply: Slow Progression

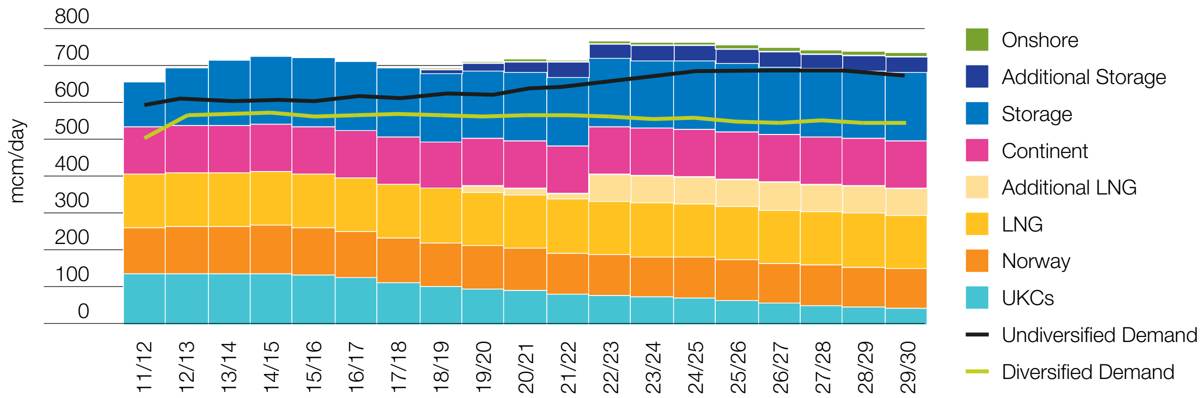


Figure 51.
2012 Peak Day Gas Supply: Gone Green

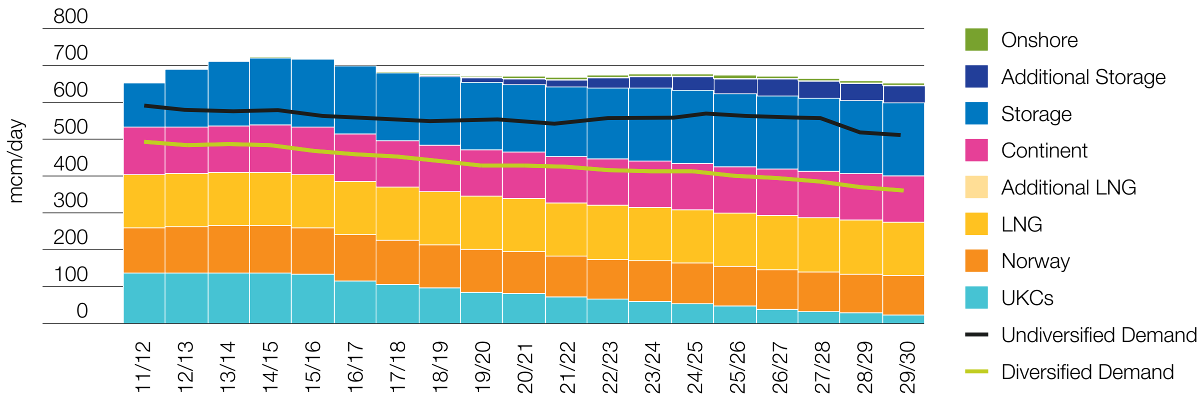
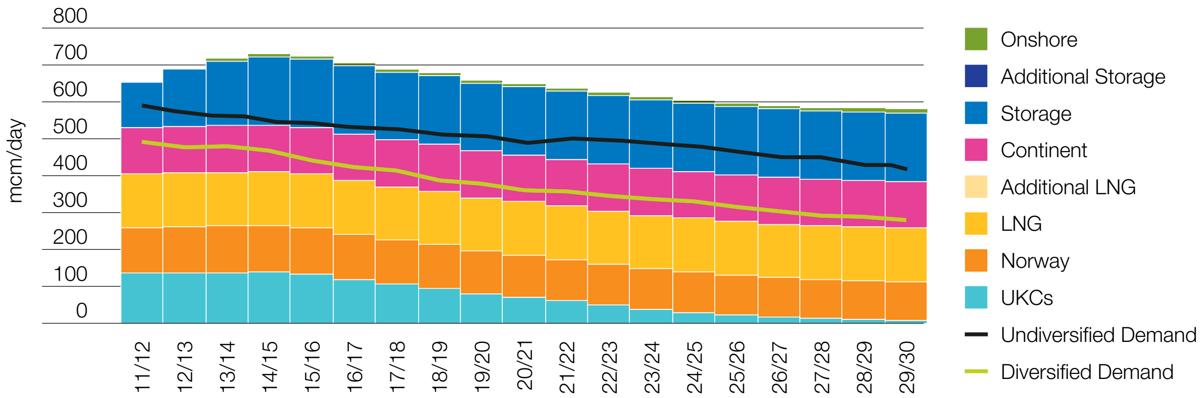


Figure 52.
2012 Peak Day Gas Supply: Accelerated Growth



4.5
Progress towards targets

We have used the DECC 2050 Calculator to calculate total emissions of greenhouse gases and assess the fraction of total energy requirement met by renewable sources.

The Calculator gives totals for all greenhouse gases covered in the Climate Change Act and an aggregate in tones of carbon dioxide equivalent (CO_2e). The one slight drawback is that results are only calculated for every fifth year, starting from 2010, which means that assessment of progress against the carbon budgets, which cover five-year periods from 2012 to 2027 involves interpolation between calculated values.

We have used the Calculator to ensure that Gone Green meets the targets, and to assess how close Slow Progression comes to meeting the targets. In Accelerated Growth there is more rapid progress towards low carbon and renewable energy targets than in Gone Green and, given that Gone Green reaches the targets there was less need for detailed analysis of progress in Accelerated Growth.

Figure 53 shows the fraction of total energy met by renewable sources. Data for 2010 and 2011 are from DUKES[24]. Gone Green meets the 15% renewable energy target but in Slow Progression the 15% level will be reached some time between 2020 and 2025.

24 http://www.decc.gov.uk/assets/decc/11/stats/publications/dukes/5956-dukes-2012-chapter-6-renewable.pdf

Figure 53.
Progress towards renewable energy target: Slow Progression and Gone Green

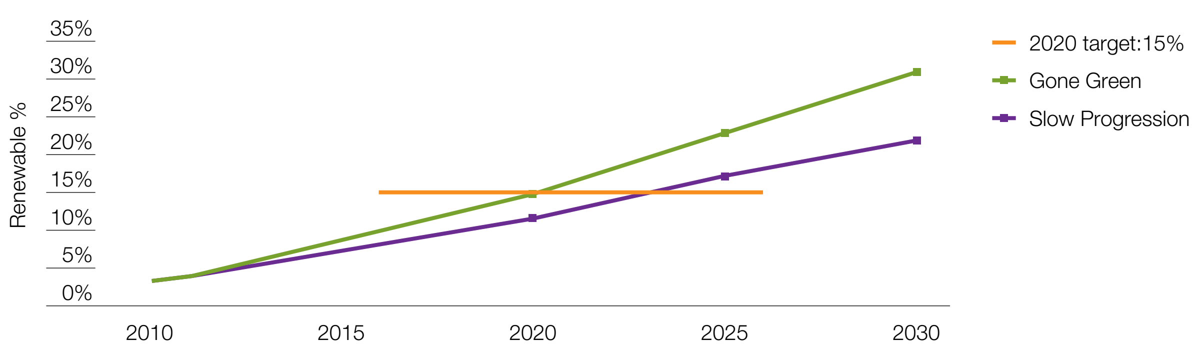


Figure 54.
Reduction in emissions of greenhouse gases

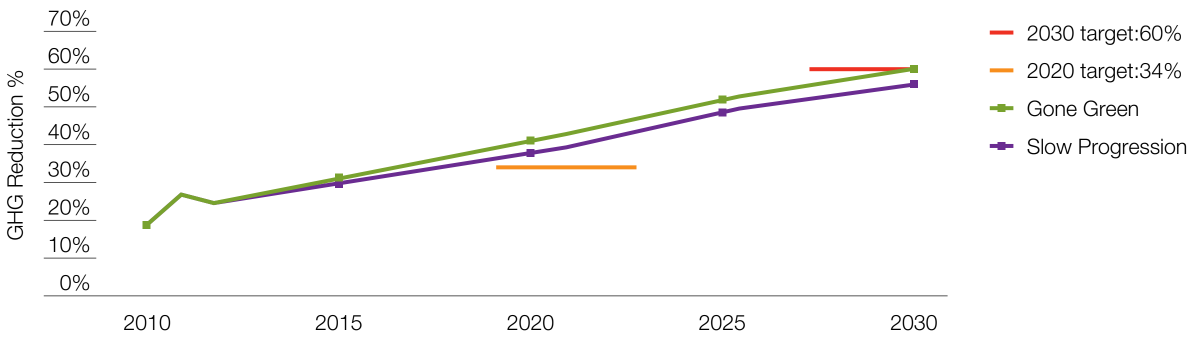


Figure 54 shows the reduction in total greenhouse gas (GHG) emissions compared with the 1990 baseline. Data for 2008 to 2010 are taken from the Annual Statements of Emissions[25] published as a requirement of the Climate Change Act. Note that the reduction was lower for 2010 (emissions were higher) than in 2009. In both **Gone Green** and Slow Progression reductions in emissions are greater than the 34% target for 2020. We could not produce a scenario in which the 2020 renewable target was met and the carbon reduction target was not exceeded, a problem we also faced in our 2011 scenarios. The reduction in total GHGs in **Gone Green** was 43%, but when emissions of CO_2 alone were considered the reduction was 39%, slightly less than our value from **Gone Green** 2011.

Gone Green just meets the indicative 60% reduction for 2030, but Slow Progression falls short at 56%.

25 http://www.decc.gov.uk/assets/decc/11/cutting-emissions/carbon-budgets/4743-annual-statement-emissions-for-2010.pdf

Chapter five
2030 to 2050

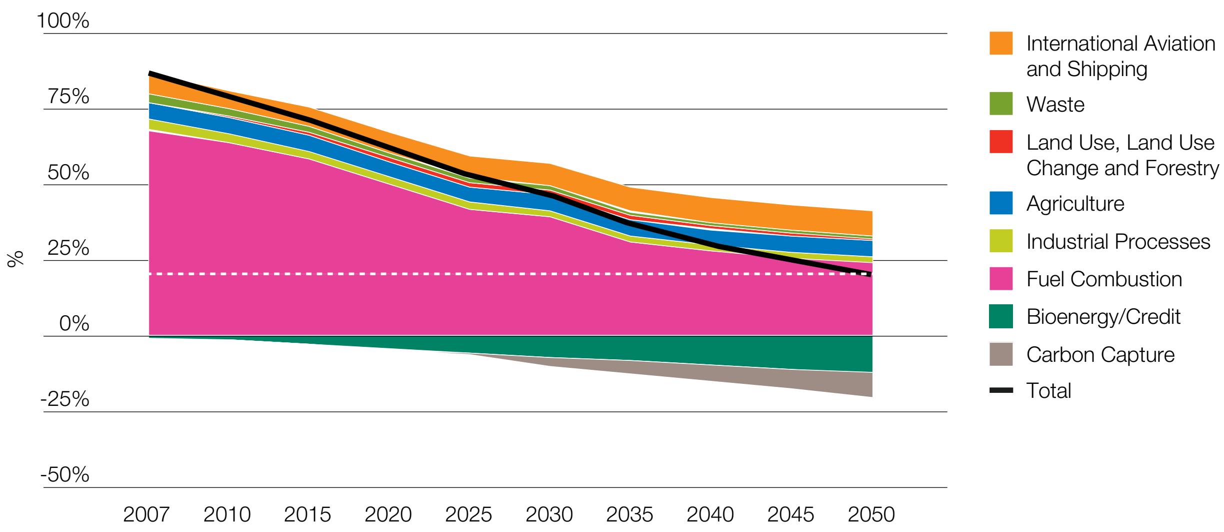
Beyond 2030 there are increasing uncertainties regarding technology developments and likely economic outlook. Gone Green, which hits the 2030 targets but does not exceed them, is the only scenario developed beyond 2030.

CO_2 target

A reduction in overall greenhouse gas emissions by 2050 of 80% on 1990 levels was established in the Climate Change Act. Emissions reductions need to come from all main sectors of energy usage; Heat, Transport and Electricity all emit more emissions alone than would be allowed for all three sectors in 2050. This is in keeping with the philosophy behind the development of **Gone Green** out to 2030. We have continued a balanced approach, with progress towards targets required in all sectors but without needing extreme effort in any one sector. Figure 55 shows emissions in broad end-use categories[26] expressed as a percentage of the base year (1990). The solid line shows that the net emissions reach the target of 20% of base year by 2050.

[26] The categories are those used in the DECC 2050 calculator and are based on those recommended by the International Panel on Climate Change (IPCC)

Figure 55.
Greenhouse gas emissions as a percentage of the base year



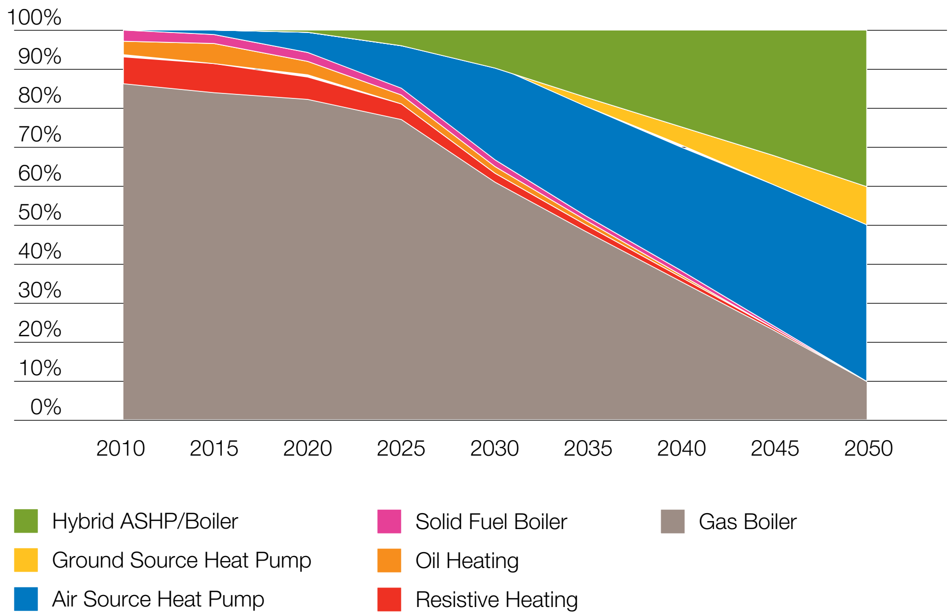
Background

In the **Gone Green** scenario the UK in 2050 has a thriving low carbon economy. Significant reductions have been made in fossil fuel use for electricity generation and supply and demand are balanced by a robust mix of dual fuel appliances, with smart grids and interconnection management enabling the UK to minimise greenhouse gas emissions without jeopardising affordability or security of supply. Significant reductions have been made in primary energy consumption due to improvements in insulation and in efficiency gains from greater electrification of transport and the increasing use of heat pumps and hybrid appliances for space and water heating.

Heat

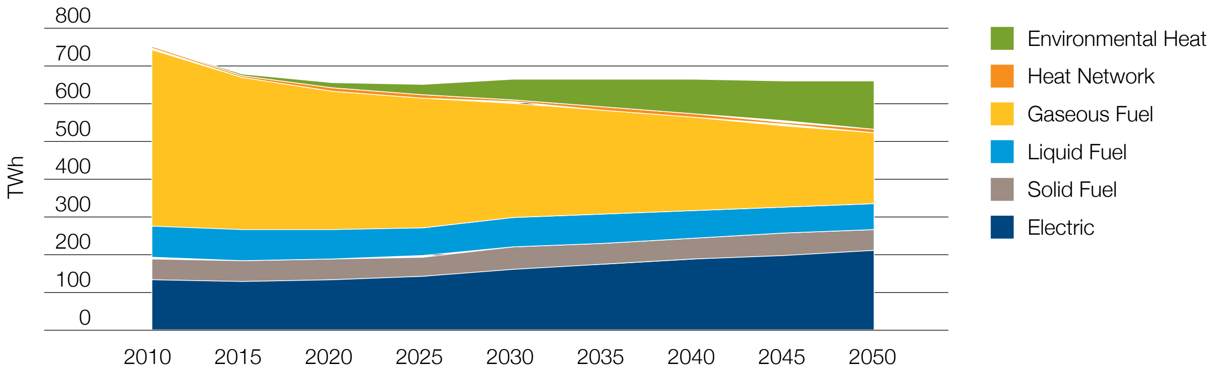
In domestic and commercial premises there are marginal improvements in energy efficiency between 2030 and 2050 with most of the more cost-effective refurbishments of the UK's buildings being done by 2030. Between 2030 and 2050 most efficiency gains are made by the changing way heat is supplied in buildings with a shift to heat pumps for well insulated new properties with hybrid heat pump and boiler systems being used in buildings in which the difference in seasonal heat requirements makes them less suited to be supplied by heat pumps alone. By 2030 the cost of ground source heat pumps has reduced to the point where they become an acceptable option for domestic heating. Note that gas boilers still make up some 10% of the mix in 2050, and that gas will also be used in the hybrid heat pump/ boiler systems.

Figure 56.
Breakdown of the domestic heating market



Industrial heat and processes however show a moderate increase in demand between 2030 and 2050, there is however a shift towards increasing use of CCS in heavy industry where there is significant clustering. There is also a shift towards increasing use of biofuels within the industrial sector. Figure 57 shows the total energy demand for heat across all sectors.

Figure 57.
Total energy demand for heating



Transport
By 2030 battery technology and charging locations for electric vehicles have developed sufficiently for a major shift in passenger vehicle transport towards electrification. Plug in hybrid electric vehicles are the choice of the majority of consumers, with pure electric vehicles used more as second cars and for urban driving. Figure 58 shows the distribution of vehicle types in the personal car sector. Road freight is primarily carried by hybrid vehicles. There is also a minor shift towards rail and cycling for shorter journeys. Figure 59 shows the total energy demand for transport.

Figure 58.
Breakdown of vehicle types in the personal car sector

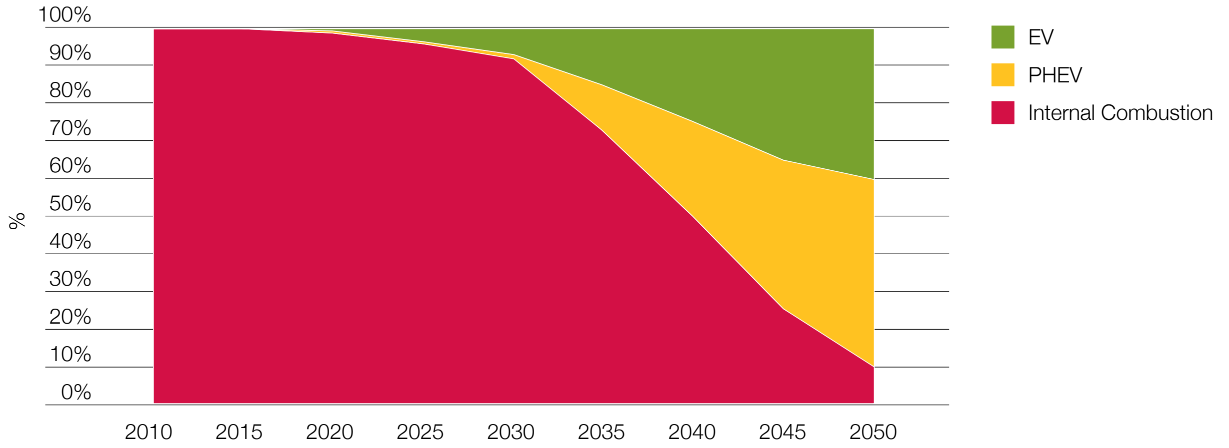
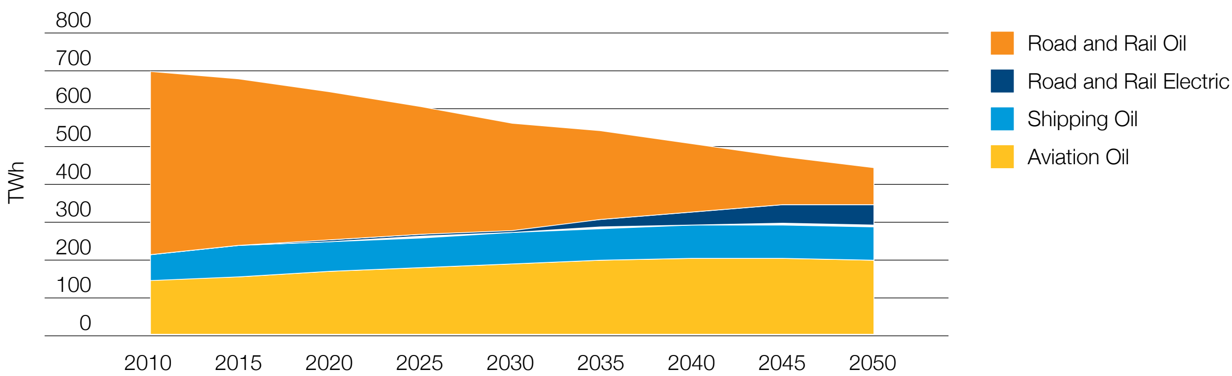


Figure 59.
Total energy demand for transport

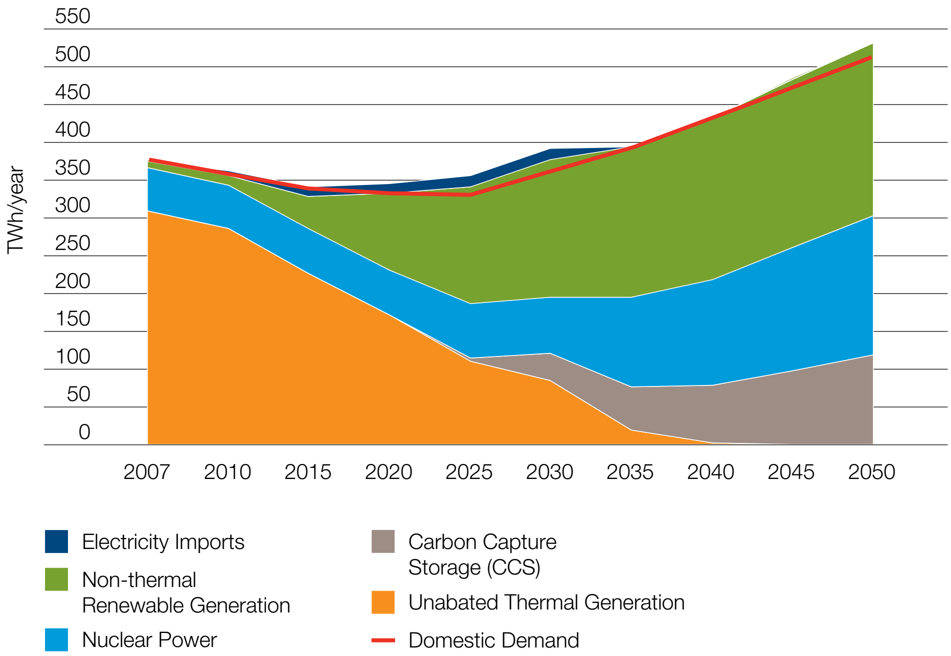


Electricity

Electricity demand for appliances and lighting decreases between 2030 and 2050, however this decrease is offset by the increasing use of heat pumps and electric vehicles for heating and transport. Electricity demand tops 500TWh annum by 2050.

Electricity supply is largely low-carbon by 2030, by which time wind generation technology is mature. Growth in low and zero carbon generation is from next generation nuclear reactors and Carbon Capture and Storage (CCS) power stations running off coal, biomass and gas. Figure 60 shows total UK electricity demand and generation. Note that there is no unabated thermal generation by 2050; biomass is burned only in plant fitted with CCS.

Figure 60.
UK Electricity demand and generation



Appendix 1
Axioms

This table shows the full set of axioms used in our forecasts

2012 axioms			
	Slow Progression	**Gone Green**	**Accelerated Growth**
Targets	Pressure for EU 2020 renewable targets and UK 2050 carbon targets to be abandoned grows	Targets met. Scenario based on meeting targets. Balanced approach across all market sectors, no trading. No change to EU and UK policies	2020 targets met early
Economy / Econometric forecasts	Economic hardship across Europe, scarcity of finance, impact on consumer bills. Affordability of meeting targets compels change. Low GDP assumptions	Modest GDP assumptions in medium term, historical average from 2017 onwards	Sustained economic growth across Europe. High GDP assumptions
Energy Efficiency	Lower drive for energy efficiency – Green Deal domestic energy efficiency improvements are limited	Drive for energy efficiency – Green Deal domestic energy efficiency improvements are significant	Push for legislated energy efficiency. Significant take up of LED lighting. Green Deal domestic energy efficiency improvements very significant
Fuel Prices	In most / all instances below any central forecast. Gas generation cheaper than coal	In most / all instances around any central forecast	In most / all instances well above any central forecast. Coal generation cheaper than gas
Offshore Wind	Slow progress. Round 3 mainly post 2020	Round 3 delivers for 2020. Supply chain maintained post 2020	Round 3 levelised cost towards £100 / MWh or lower. Rapid build up
Wave & Tidal	Minimal deployment by 2030	Limited build up of capacity, mainly post 2020	Stronger build up of capacity with larger lagoon projects
Biomass	Limited new build due to subsidy cost / fuel source restrictions	Stronger development by 2020, with focus on conversion	Stronger development with conversion and new build

Nuclear	Delayed (mid-2020s) Average additional 10-year AGR life extensions	Slight delay (early 2020s Average additional 7-year AGR extensions	Slight delay (2020) then strong deployment Average additional 5-year AGR extensions
CCGT	Significant new build over period	New build predominantly in period to mid-2020s. Some CCGT capacity with CCS after 2025	New build predominantly in period to 2020. Some CCGT capacity with CCS after 2020
Coal	Majority of plant closed by mid-2020s due to age and emissions legislation. – Different phasing of closures between scenarios.		
	No new build	Some new coal with CCS after 2025	Some new coal with CCS after 2020
CCS	Global pilot project in 2030 at earliest CCS coal not commercially viable, CCS gas demo plant in 2030s	Pilot project in 2025 with commercial deployment following (coal / gas)	CCS pilot project in 2020 – economically viable for gas, coal and biomass. Roll-out post 2020
Electricity Interconnection (+ imports / exports)	Limited new interconnection due to lower renewable energy source (RES) capacity (Market approach)	Increased interconnection with growing RES capacity	Significant new interconnection, laying foundation for Supergrid (Asset based approach)
Wind Intermittency (No specific values, but considered in developing generation scenarios)	Marginal gas and coal plants (and if required flexible new nuclear units) to provide cover for wind generation reductions (a different level required in each scenario). Surplus wind generation exported (different levels of interconnection assumed across the scenarios)		
Electricity demand	Annual energy consumption declines at a slower rate than Gone Green due to slower development in embedded generation and energy efficiency. Annual consumption continues to decline towards 2030. Peak demand broadly flat to 2020, with gradual decline thereafter	Gradual decline in annual consumption due to increasing level of embedded generation and energy efficiency gains. Energy consumption starts to increase from the middle of next decade. Peak demand broadly flat out to 2020, with gradual increase thereafter	Higher decline in annual consumption due to higher development in embedded generation, energy efficiency and the impact of TOU tariffs. Energy consumption picks up again towards the middle of the next decade due to increase charging from EVs and heat pumps. Peak demand broadly flat, out to 2020 then higher due to EVs and heat pumps

Appendix 1 continued
Axioms

Embedded generation	Current growth rates stall in all sectors. Limited re-planting of existing wind farms	Trend of embedded growth continues in wind, CHP and hydro. New technologies develop include marine	Robust growth in all sectors
CHP	Limited new CHP	Moderate CHP growth, some shift to renewable CHP (biofuels, waste)	Higher CHP growth, greater shift to renewable CHP
Micro generation (solar, hydro, wind)	Micro generation dominated by solar		
	Modest growth in all sectors. 2 GW installed in 2030	High growth in all sectors. 7 GW installed in 2030	Very high growth in all sectors. 19 GW installed in 2030
Smart meters and Time-of-Use-Tariffs (TOUT)	Smart meter replacement at current meter replacement rate. Completion towards the end of the next decade	Smart meter replacement / TOUT at a faster pace with replacement programme completion around 2022	Smart Meter replacement / TOUT implementation at Government target rate, i.e. completion by 2019
EVs	Modest growth 2020 ~280k 2030 ~670k	Strong growth 2020 ~630k 2030 ~3.2k	Robust growth 2020 ~1.4m 2030 ~7.1m
Heat Pumps	Modest growth 2020 ~350k 2030 ~750k	Strong growth 2020 ~1.5m 2030 ~9m	Robust growth 2020 ~2m 2030 ~13m (inc 3m gas heat pumps)
Consumers	Resistant to fund meeting targets	Acceptance of need to meet targets	Enthusiasm for low carbon agenda
	Domestic internal temperatures increase	Domestic internal temperatures do not change	Domestic internal temperatures continue to reduce
Green Investment Bank (No specific numbers, influences generation background etc.)	Limited uptake and funding	Medium uptake and funding	Strong uptake and funding

Domestic Gas Demand	Overall increases in demand with higher comfort levels and new house build exceeding reductions from low levels of energy efficiency	Demand reduces due to energy efficiency improvements followed later by the high penetration of heat pumps. Comfort levels assumed to remain the same as today. New build houses have low energy use and high use of heat pumps	Significant demand reduction due to energy efficiency improvements and lower comfort levels followed by very high penetration of heat pumps. New build houses have very low energy use and very high use of heat pumps
Power Generation Gas demand	High case (using SP gen. background, fuel prices, elec. demand etc.). Lower wind Load Factors	Lower case (uses GG gen. background, fuel prices, elec. demand etc.)	Low case (uses AG gen. background, fuel prices, elec. demand etc.). Higher wind LFs
NTS Industrial Gas Demand	High gas case. Low gas prices discourage significant demand reductions in this sector	Low gas case. Mid case gas prices and economic view encourage some demand reductions in this sector	Low gas case. Higher gas prices than GG have less effect than stronger economy leading to demands that are very slightly higher in the long term
NTS exports	High Moffat case based on high Irish gas demand High IUK utilisation	Moffat based on Irish model with Ireland hitting targets. IUK utilisation between SP and AG	Low Moffat case based on low Irish gas demand Low IUK utilisation
Gas Supply (UKCS)	Higher UKCS supply due to confidence in market. Though gas prices are lower in SP, they are still attractive for UKCS in a stable regime	Balanced / mid position	Lower UKCS due to lower gas demand, high carbon price and limited export opportunity
Gas Supply (Norway)	Higher Norwegian production and higher exports to UK due to demand certainty and possibly more contracts	Balanced / mid position	Lower Norwegian production and lower exports to UK due to a 'green' world

Appendix 1 continued
Axioms

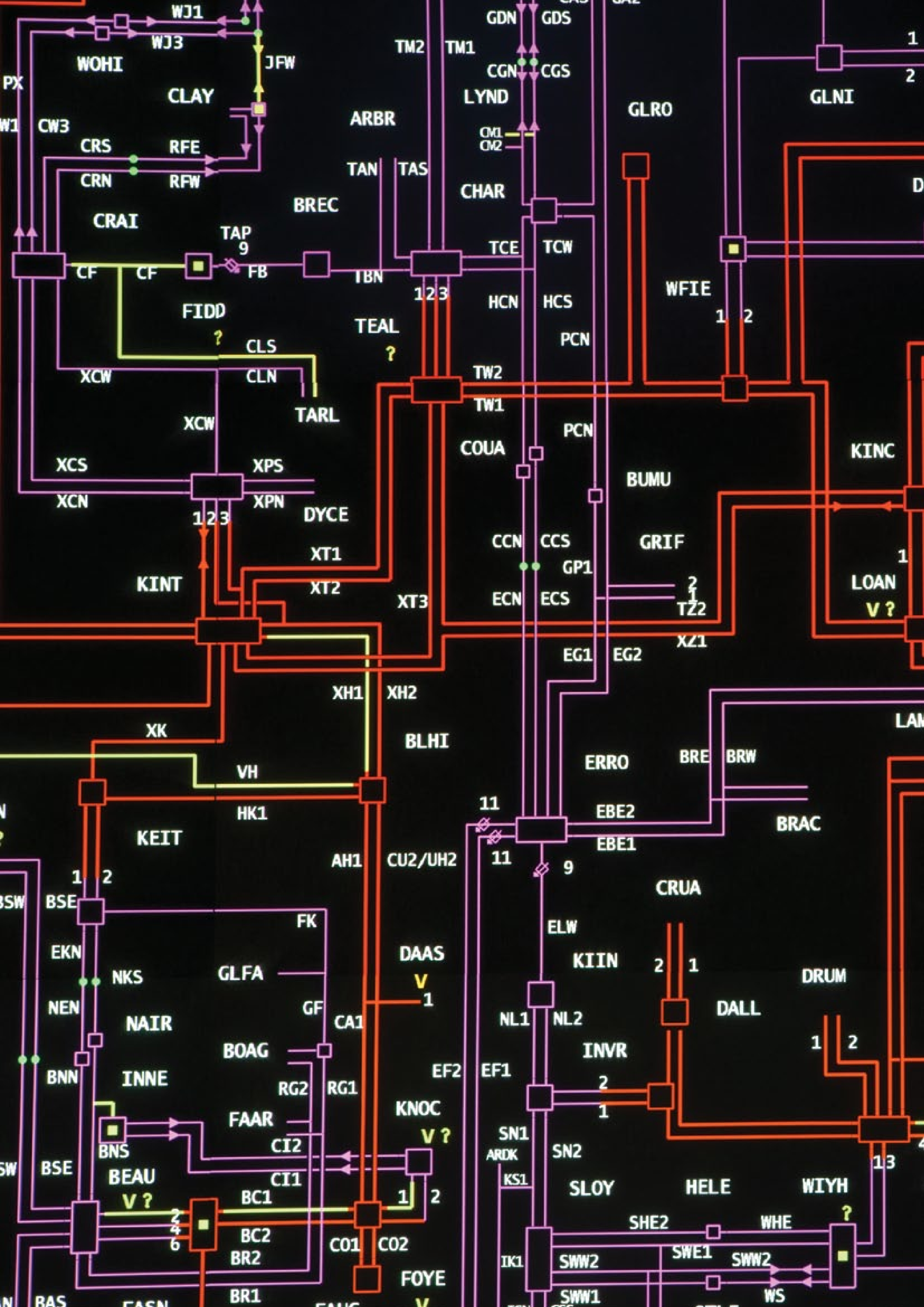
Gas Supply (LNG)	Plentiful world LNG from existing and new production. UK LNG terminals are base load, new LNG facilities needed	Balanced / mid position	Tight LNG market due to lack of new production facilities. UK LNG terminals provide flexible supplies
Gas Supply (Continent)	UK exports more due to supply availability and low prices, but potential imports at peak	Balanced / mid position	UK imports more particularly at high demands, use of Continental storage rather than new UK storage developments
Shale Gas, CBM & biogas	More shale and CBM, reduced biogas compared to GG	Some shale, CBM and biogas	No shale or CBM. More biogas compared to GG
Gas Storage	New seasonal development(s) to accommodate market needs (high imports)	No seasonal developments but new flexible storage Market led - greater flexibility, GG provides increased opportunities	Existing (and currently under construction) levels of gas storage. Continent (storage) and LNG terminals provide flexible supplies as an alternative to new storage
Biofuels (No specific biofuel forecast – included in other areas)	Biomass plant included in scenario generation backgrounds and embedded CHP forecast, biofuels in transport, biogas in gas supply etc.		
Irish Supplies	Corrib in 2015/16, no Shannon LNG, no new storage projects		

Appendix 2
Key facts

This table shows selected key facts from all three scenarios. Greater detail is available on the National Grid website at www.nationalgrid.com/uk/Gas/OperationalInfo/TBE/

	Slow Progression		**Gone Green**		**Accelerated Growth**	
	2020	**2030**	**2020**	**2030**	**2020**	**2030**
Electricity						
Peak Demand/GW	63.1	62.3	65.0	69.9	67.6	79.2
Annual energy/TWh	315	314	328	345	348	381
Capacity/GW	99.0	113.5	117.0	151.8	134.7	193.7
Offshore wind/GW	6.5	19.2	17.1	36.8	24.1	49.1
Onshore wind/GW	9.7	11.4	13.0	18.1	15.0	23.5
Biomass/GW	2.5	3.0	4.8	6.3	6.1	8.6
Solar PV/GW	0.9	1.9	2.5	5.8	6.6	16.1
Renewable capacity/GW	21.3	37.7	39.9	70.9	55.3	105.1
Nuclear capacity/GW	9.5	12.6	9.5	13.9	8.7	16.4
CCS capacity/GW	-	-	-	5.5	0.4	13.3
Low carbon capacity/GW	30.8	50.3	49.3	90.3	64.5	134.8
Interconnector/GW	5.2	6.6	6.6	8.6	6.6	11.6
Unabated coal capacity /GW	17.9	3.8	17.9	5.8	19.8	3.9
Unabated gas capacity /GW	36.1	43.9	33.2	36.0	32.0	29.2
Heat						
Domestic HP/Millions	0.4	0.7	1.4	8.8	2.0	12.8
Domestic HP electricity demand net change/TWh	-0.3	0.0	-2.0	3.2	-3.4	3.8
Domestic gas demand /TWh	358	387	279	197	225	103
Transport						
EVs						
Number/Millions	0.3	0.7	0.6	3.2	1.4	7.1
Electricity demand/TWh	1	5	2	19	4	40
Gas						
Annual demand	1,089	980	800	626	671	494
Renewable Energy %	12%	-	15%	-	>15%	-
GHG reduction	39%	56%	43%	60%	>43%	>60%

Notes



WJ1
WJ3
JFW
WOHI
PX
CLAY
CW3
CRS
RFE
CRN
RFW
CRAI
TAP
9
CF
CF
FB
FIDD
CLS
XCW
CLN
TARL
XCW
XCS
XPS
XCN
XPN
1 2 3
DYCE
KINT
XT1
XT2
XT3
XK
VH
HK1
KEIT
1
2
BSE
EKN
NKS
NEN
NAIR
BNN
INNE
BNS
BSE
BEAU
V ?
GLFA
BOAG
FAAR
FK
GF
CA1
RG2
RG1
CI2
CI1
BC1
BC2
BR2
BR1
BAS
TM2
TM1
ARBR
TAN
TAS
BREC
TBN
1 2 3
TEAL
TW2
TW1
COUA
XH1
XH2
BLHI
AH1
CU2/UH2
DAAS
V
1
EF2
EF1
KNOC
V ?
1
2
CO1
CO2
FOYE
GDN
GDS
CGN
CGS
LYND
CM1
CM2
CHAR
TCE
TCW
HCN
HCS
PCN
PCN
CCN
CCS
GP1
ECN
ECS
EG1
EG2
11
11
9
ELW
KIIN
NL1
NL2
INVR
SN1
ARDK
SN2
KS1
SLOY
IK1
SWW2
SWW1
GLRO
WFIE
1
2
BUMU
GRIF
2
1
TZ2
XZ1
ERRO
BRE
BRW
EBE2
EBE1
BRAC
CRUA
2
1
DALL
2
1
HELE
SHE2
SWE1
SWW2
GLNI
1
2
KINC
LOAN
V ?
LAM
DRUM
1
2
13
WIYH
WHE
WS

nationalgrid

National Grid plc
National Grid House,
Warwick Technology Park,
Gallows Hill, Warwick.
CV34 6DA United Kingdom
Registered in England and Wales
No. 4031152

www.nationalgrid.com