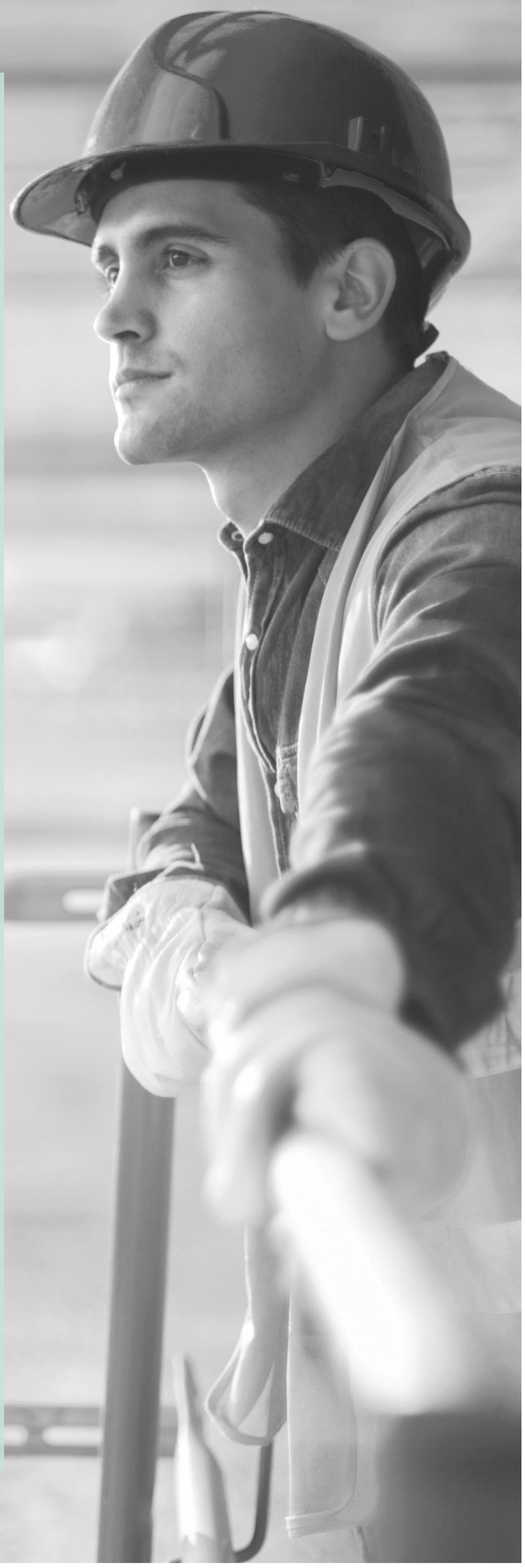
Local Low Carbon Accelerator

Delivering jobs and growth through local green infrastructure projects

Sharing learnings with local and combined authorities

Contents



Executive summary

Local green infrastructure projects can deliver cleaner, more prosperous, and liveable communities as part of the transition to 'net zero' emissions of greenhouse gases.

Local and combined authorities are uniquely positioned to deliver the local energy transition, which is anticipated to deliver substantial benefits such as reduced energy bills, improved air quality, jobs and growth. However, effective delivery will require unprecedented levels of public-private collaboration to deploy green infrastructure at scale.

The Local Low Carbon Accelerator (LLCA) has worked with three local and combined authorities to demonstrate replicable models that accelerate deployment of energy efficiency home retrofits, zero emission buses, and zero emission vehicle infrastructure. Through this work, the LLCA aimed to demonstrate how local and combined authorities can, and must, collaborate with the private sector to develop the ground-breaking solutions that could overcome the challenges faced in delivering local green infrastructure projects across the nation.

In this report, the LLCA shares lessons learnt with all local and combined authorities nationwide looking to catalyse the delivery of local green infrastructure.

Liverpool City Region Combined Authority	West Midlands Combined Authority	Leeds City Council
In Liverpool: collaboratively identifying and assessing suitable financing options to support a transition to a regional zero emission bus system	**In the West Midlands: providing cross-sector perspectives and challenge on the region's infrastructure strategy for zero emission vehicles**	**In Leeds: supporting the design of a local authority-led city-wide retrofit programme, starting with the 'able to pay' market as a proof of concept**

Key outcomes

Liverpool City Region Combined Authority	West Midlands Combined Authority	Leeds City Council
• **Developed total cost of ownership analysis, indicating that electric buses are likely to be more financeable than hydrogen buses over a 15-year period** • **Identification and suitability testing of financing models suggested 'infrastructure-as-a-service' solution could shift some ownership risks**	• **Collectively identified 13 low regret action levers to influence the pace and scale of delivery across zero emission vehicle infrastructure segments** • **Categorised full spectrum of surface transport infrastructure segments from market-led to public-led delivery based on commercial attractiveness**	• **Initiated the design of a blueprint for a one-stop-shop retrofit delivery model** • **Developed a granular database of local housing stock, income levels and tenancy status to inform the design of a scalable retrofit scheme** ***Proof of concept learnings to be shared at a later date***

Key learnings for local and combined authorities

Liverpool City Region Combined Authority	West Midlands Combined Authority	Leeds City Council
• Identify the most cost-effective zero emission bus technology by conducting a total cost of ownership analysis, • Understand the impact of zero emission bus technology choice on ownership and management options across the full suite of network assets, and • Work with various potential financiers to identify most appropriate financing solutions.	• Establish a dedicated convening capability that enables cross-sector partnership across energy, transport and built environment, • Understand where infrastructure can be delivered by the market, and how local and combined authorities can improve commercial attractiveness, and • Channel limited resources towards priority interventions and navigate uncertainty by making low regret investments.	• Draw on communities and private sector knowledge to build a detailed understanding of building stock in the region, • Start small to build local confidence in the delivery model, before taking an iterative and innovative approach to scale up, • Design a delivery model that provides a single point of contact for the customer journey, and • Seek local community buy-in as a signal to mobilise suppliers.

In addition to the technical and delivery insights, the LLCA has identified five building blocks that local and combined authorities are likely to need in place to deliver local green infrastructure at scale and pace. Establishing these building blocks would enable coherent and technically informed approaches to energy transition, while also harnessing the power of private sector capital and delivery needed to decarbonise cities and regions across the country.

At a high level, these building blocks are:

Local and regional capability and capacity to design and drive delivery of local green infrastructure

Expert advice and delivery best practices that are tailored and accessible to the local area

Harnessing the private sector's ability to deliver infrastructure where possible

Financing solutions and innovation to create bankable projects

Resilient local skills market to design, deliver and maintain local green infrastructure

These building blocks are also reflected in further detail in the cross-cutting recommendations for policymakers, set out in the report published in November 2022: 'Delivering jobs and growth through local green infrastructure projects: Summary for Whitehall policymakers'.

The LLCA will showcase the outcomes delivered by each of the three projects and share the learnings with other interested local and combined authorities through an event series this year.

Words from the LLCA partner organisations

'The net zero transition has the opportunity to drive regeneration of cities and communities across the country.'
***Charlie Nunn**, Executive Director and Group Chief Executive, Lloyds Banking Group*

'If we can accelerate local and regional infrastructure projects, we can drive forward our collective ambition to create a low-carbon economy across the UK'
***Ben Wilson**, Chief Strategy and External Affairs Officer, National Grid*

'The energy transition needs locally-driven action at pace and scale as well as businesses, communities and regional government pulling together in one clear direction.'
***David Bunch**, Country Chair, Shell UK*

'We must speed up the roll out of green infrastructure to bring cheap, clean power to everyone, wherever they live. This project shows that when business and Local Government work together we can move fast, create jobs and boost local economies.'
***Greg Jackson,** Founder and CEO, Octopus Energy*

Words from the local and regional leaders

'The accelerated progress made by bringing together public-private expertise to tackle how we might decarbonise our bus fleet has demonstrated how powerful cross-sector partnerships can be in facilitating an affordable, deliverable and future-proofed transition to net zero, helping to inform our future plans.'
***Richard McGuckin**, Executive Director Place, Liverpool City Region Combined Authority*

'We can only achieve a just energy transition by working collaboratively and this work showcases the importance of planning energy and transport infrastructure together, to overcome system barriers and achieve our vision.'
***Laura Shoaf CBE**, Chief Executive, West Midlands Combined Authority*

'Leeds City Council is delighted to be part of the LLCA, clearly demonstrating the value of public-private collaboration to tackle the thorniest policy problems, allowing us to collectively design a new way to make housing retrofit happen at scale and at pace.'
***Tom Riordan CBE**, Chief Executive, Leeds City Council*

Introduction

What do local green infrastructure projects do and how do we deliver them?

Green infrastructure projects in local areas can deliver cleaner, more prosperous, and liveable communities as part of the net zero energy transition. This transition could include 240,000 jobs decarbonising the heat and buildings sector by 2035[1], and 72,000 jobs producing zero emission vehicles by 2050[2]. The investment required for home retrofit and low carbon heat, and road transport, is estimated at £100-135bn[3] and £140bn[4] respectively by 2035, and would reduce the UK's current greenhouse gas emissions by almost 30% by 2035[5].

Local and combined authorities are best positioned to deliver a place specific approach that meets the needs of local communities and geographies. However, coordinated and locally-driven action is a significant challenge that will need unprecedented levels of public-private collaboration, and without which there could be a real risk of failure. Local and combined authorities will need to convene stakeholders across the public and private sectors and coordinate deployment.

How can public-private collaboration help?

Four members of the Prime Minister's Business Council – Lloyds Banking Group, Octopus Energy, Shell UK and National Grid – formed the LLCA to demonstrate replicable models for how the private sector could collaborate with local government to accelerate the local transition to net zero while maximising public value for money[(a,b)].

Surface transport and the built environment have been prioritised for action as they account for nearly two thirds of UK energy use[6] and 53% of total greenhouse gas emissions[7] and present the greatest opportunity to unlock private investment.

In 2022, the LLCA worked with Leeds City Council (LCC), Liverpool City Region Combined Authority (LCRCA), and West Midlands Combined Authority (WMCA) on three projects covering energy efficiency home retrofits, zero emission bus deployment, and strategy for zero emission vehicle infrastructure.

How does this report help you?

This report sets out the replicable learnings that all local and combined authorities could draw on to deliver similar projects. The LLCA also identifies five cross-cutting building blocks that enable local and combined authorities to accelerate their own local energy transition.

The building blocks are presented in more detail, along with how central government can support this transition, in the accompanying report, 'Delivering jobs and growth through local green infrastructure projects: Summary for Whitehall policymakers', launched last year.

Bus decarbonisation

The LLCA worked with LCRCA to identify suitable financing options for a zero emission bus franchising model as a case study to develop replicable solutions to accelerate adoption.

Infrastructure for zero emission vehicles

The LLCA supported WMCA to develop its strategy for zero emission vehicle infrastructure, providing a case study on planning for locally-led, system wide transport decarbonisation.

Energy efficiency

The LLCA worked with LCC to initiate design of a tenure agnostic city-wide retrofit scheme, starting with 500-1,000 able-to-pay owner-occupied and private rental homes, as a case study to examine replicable delivery and policy solutions.

Notes: (a) The LLCA partner organisations (Lloyds Banking Group, Octopus Energy, Shell UK and National Grid) financially contributed to the publication of this report.
(b) The recommendations outlined in this report are not all relevant and/or applicable to the LLCA partner organisations.

Turning the corner for zero emission bus fleets in Liverpool

Key Outcomes

- **Developed total cost of ownership analysis, indicating that electric buses are likely to be more financeable than hydrogen buses over a 15-year period**
- **Identification and suitability testing of financing models suggested 'infrastructure-as-a-service' solutions could remove some ownership risks from the authority**

Liverpool's vision for a decarbonised bus system and its challenges

LCRCA aims to reform its bus system to improve services and deliver economic and environmental benefits of reduced congestion, improved air quality, and access to services across income groups. LCRCA's preference is to pursue a franchising model over enhanced partnerships (see the National Bus Strategy[8]), with an aim of establishing a London-style bus system. As part of this bus reform, LCRCA is planning to replace their 1,200 buses (mostly diesel) with zero emission buses (ZEBs) through a phased approach over a period of 15 years[9, 10].

Over £500m of Government support has been provided for the uptake of ZEBs until 2024[11], but penetration remains low, with only 3% of the 31,400 buses in England classified as zero emission[12, 13] (see Figure 1). Bus owners and operators, including LCRCA, are facing challenges to ZEB procurement, including technology risks, cost uncertainties, and financing requirements. An estimated £7.5bn could be required for purchasing ZEBs in the UK out to 2035[14] (see Figure 2), with only £0.5bn of this financing covered by existing government support. Collaboration with the private sector will be essential to addressing these challenges.

The LLCA and the UK Infrastructure Bank (UKIB) supported LCRCA to identify suitable financing options to overcome the challenges of franchising and ZEB procurement, mitigate the unique technology risks, and manage economic uncertainties associated with the longer-term transition to a ZEB fleet. This section outlines the key considerations for other authorities looking to identify ZEB financing solutions in their region.

Figure 1: Number of public service buses in England by fuel type, 2022 (thousands)[12, 13]

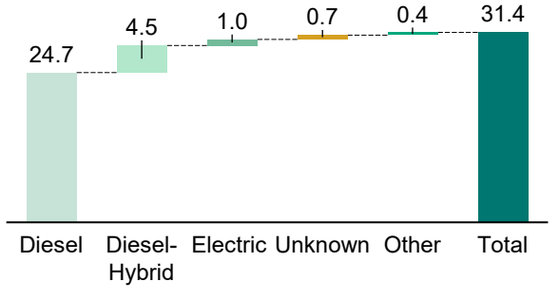
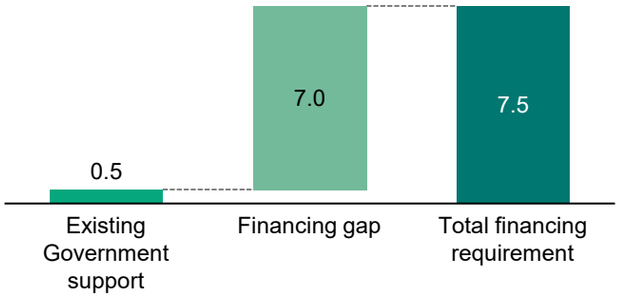


Figure 2: Estimated financing gap to purchase ZEBs in the UK by 2035, based on an estimated requirement of £7.5bn and £0.5bn of existing Government support (£ billion)[15]



How did collaboration with LLCA help accelerate the delivery of ZEBs in Liverpool?

The LLCA worked closely with LCRCA through a series of workshops, providing finance, energy, and transport expertise to support in the identification of suitable financing options for the ZEB transition in Liverpool and discuss the impact of each ZEB technology pathway.

A total cost of ownership (TCO) analysis of different bus technologies revealed that, over a 15-year period, electric buses are likely to be cheaper and more financeable than hydrogen buses. The LLCA also provided analysis of the impact of technology choices on the planning and management of network assets, guidance on the implications of technology choice and financing models on asset ownership, and support in identifying suitable financing models.

Through this work, the LLCA helped identify financing options that could be used by the combined authority to support the procurement of ZEBs. Six financing models were identified, including public loans, finance lease, operating lease, green bond, corporate debt and infrastructure-as-a-service. These could be flexibly adopted by LCRCA depending on the number and technology of the ZEBs that may be introduced as part of franchising, as well as the authority's appetite for asset ownership and risk.

These financing options can accelerate ZEB uptake in the region by attracting and leveraging public and private finance, and creating strong demand signals for key ZEB technologies. The TCO analysis and advisory support on network and energy infrastructure management and best practices will also feed into the region's long-term bus, transport, and energy infrastructure planning and investment decisions.

LLCA learnings: How to find the right delivery pathway for ZEBs

The work highlights the importance of public-private collaboration to comprehensively design new bus financing models for a ZEB system transition. An authority seeking to go on a similar journey will need to determine the right ZEB technology mix, asset ownership options, and associated financing implications for their region. There are three main learnings from this bus financing work for local and combined authorities:

Finding 1

Conduct total cost of ownership analysis to determine the most cost-effective ZEB technology for your region

Transitioning to a ZEB system is a complex and long-term process. The ZEB technology (or mix of technologies) selected for a particular regional bus network has significant implications on the overall cost of the transition, the infrastructure planning and investment decisions, and the ultimate financing model required to deliver this transition.

There are two main zero emission technologies that were considered: battery electric buses and hydrogen fuel cells buses. More details on these technologies can be found in Annex A. The LLCA developed a TCO calculator for LCRCA to facilitate the comparison between the two. This calculator provided an overview of the total cost of owning a particular type of bus over a given timeframe. Capital and operational costs of the bus and respective infrastructure were considered, providing a comprehensive overview of the total costs of each technology pathway. An overview of the LLCA's TCO key considerations and assumptions can be found in Annex B.

The TCO analysis found that, over a 15-year period, electric buses are likely to be cheaper and more financeable than hydrogen buses due to lower purchase, fuel, and maintenance costs. However, for certain operational situations (e.g. very long distance bus routes, or highly constrained depots) hydrogen buses may still be a viable option as they could align better with existing operations. The UK Government recently green-lit the HyNet industrial decarbonisation project in the North West, providing LCRCA with the future ability to leverage place-based advantage to procure green hydrogen at a potentially lower cost.

Replicable learning: Utilise the framework and key inputs from the TCO calculator developed for LCRCA for conducting a similar lifetime cost comparison. Engage with your bus network operators, and other local private sector partners, to input robust regional assumptions into your TCO model.

Finding 2

Understand the full breadth of impact of ZEB technology choice on asset ownership and operations

There are multiple physical assets to consider when planning an effective ZEB transformation, beyond the core bus fleet. These include depots, refuelling/charging infrastructure, and information systems, all of which have been traditionally owned and operated by the bus operator. Under a franchised bus system, local and combined authorities can choose whether to own these assets. Each ownership option presents different risks for the authority and the asset operator; therefore each needs to be considered by the authority depending on their appetite for ownership, which will in turn impact the financing solution required.

The LLCA supported LCRCA in understanding the implications of different ownership models on financing options, as well as the impact of a given technology choice on future depot ownership and management. The increased flexibility and versatility of ZEB assets (e.g. batteries providing grid services, bus depots providing public charging services, etc.) allows for different asset ownership structures, opening up several opportunities and potential for partnerships. These impact the way depots are managed, where they are located, and the size of the grid connection.

Replicable learning: When designing ZEB transition, it is important to consider the whole ecosystem of assets that supports the bus network, in order to make decisions that optimise outcomes for the authority, its partners and residents.

Finding 3

Collaborate with various potential financiers to identify financing solutions that suit your preferred delivery model

There is still a significant financing challenge to purchase new ZEB assets and infrastructure once suitable technology pathway and ownership options have been selected. The bus sector has stressed the need for available, accessible, and affordable financing models to navigate the challenges of transitioning to a ZEB fleet[16]. This is compounded by issues such as the technology uncertainty risk associated with ZEBs and their residual value.

The LLCA and UKIB provided financing expertise to help LCRCA identify the most suitable financing solutions for their ZEB fleet, based on their technology choice, and appetite for asset ownership and risk. The LLCA analysed the solutions, which ranged from fully public sector financed to fully privately financed. A summary of the analysis can be found in Annex C. This analysis identified the most appropriate solutions that LCRCA could use to finance ZEBs.

Replicable learning: The list of financing options considered during the work with LCRCA could act as a starting point that can be adapted for your regional requirements, as well as using the assessment criteria for determining the suitability of the options.

Charging up infrastructure for zero emission vehicles in West Midlands

Key Outcomes

- **Collectively identified 13 low regret action levers to influence the pace and scale of delivery across zero emission vehicle infrastructure segments**
- **Categorised full spectrum of surface transport infrastructure segments from market-led to public-led delivery based on commercial attractiveness**

Why is a regional zero emission vehicle infrastructure strategy so important?

Surface transport decarbonisation is a central part of the West Midlands' five year carbon reduction plan. Progress has been made across the nation, driven particularly by the Government's phase out target for new internal combustion engine vehicles by 2040 (2030 for cars and vans). Industry forecasts expect zero emission vehicles to make up c.70% of the UK's car fleet in 2040 (see Figure 3), but more needs to be done across the vehicle segments.

The West Midlands is an early mover, already deploying new charging and hydrogen refuelling infrastructure in various locations. This includes a market-leading project of ten Electric Vehicle (EV) Charging Area Transit Stations, super-stations aimed at serving trucks, vans, and cars to put 90% of the region within easy reach of rapid charge points[17]. However there is significant variation in levels of provision across the nation, as shown in Figure 4.

WMCA recognised that limited cross-sector collaboration was creating siloed and inefficient deployment. Local transport infrastructure strategy should bring together regional transport system planners, the energy system, the private sector and other energy users, and consider the needs of residents, businesses, fleets and visitors. Finding complementary opportunities will help deliver future-proof infrastructure, maximise community benefits and rationalise investment required.

The region's Infrastructure for Zero Emission Vehicle (IZEV) strategy is being developed by Energy Capital, the WMCA's energy strategy hub. The strategy setting approach is bringing an energy-focused lens to transport infrastructure planning, while integrating regional transport and spatial planning strategies. This approach has recognised that zero emission vehicle transition must be underpinned by a high level of coordination across many sectors and departments within the authority.

The trailblazer devolution deal recently announced will provide further autonomy to the WMCA to establish itself as a leader in transport innovation and decarbonisation in the UK.

Figure 3: UK passenger vehicle fleet outlook, 2020-40[18]

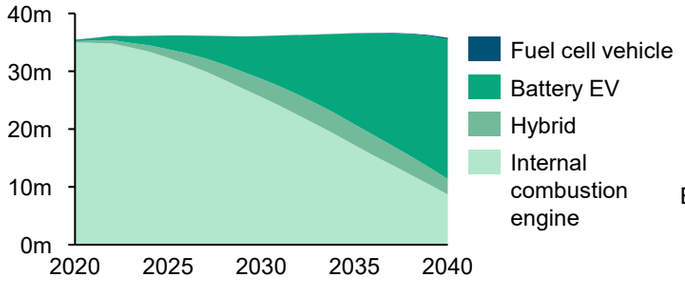
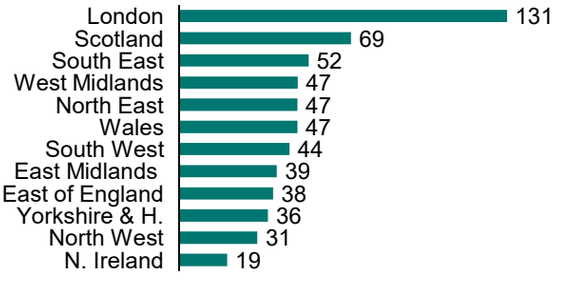


Figure 4: Public chargers per 100k population, 2022[19]



How did collaboration with LLCA help the development of the IZEV strategy in the West Midlands?

The IZEV strategy aims to support coordinated implementation of key infrastructure across the transport and energy systems and the built environment. This will enable a cost-effective and fair transition to zero emission networks. Activities will be coordinated between transport, energy and spatial planning, to leverage public investment and enhance market conditions.

The LLCA provided experts in energy network operation, technology, and charging infrastructure to support WMCA in finalising their strategy. Bringing together these diverse perspectives provided challenge to the drafted strategy and the WMCA's vision of the future transport system. Deep dive sessions were conducted to explore the strategic considerations for selected infrastructure segments and nascent technologies, for example the role of hydrogen in surface transport and the technology choices surrounding zero emission freight and buses.

To prioritise low regret interventions, current and expected levels of market provision across ZEV infrastructure segments were discussed. The LLCA identified market barriers and assessed what role the combined authority could play in unblocking these to attract the private sector or where limited public funding could address market gaps. As a result, the LLCA identified 13 actions levers available to WMCA and other local and combined authorities to act as a starting point for IZEV strategy development (see Annex E, Figure E.2). These action levers include: considering green infrastructure uses for WMCA-owned or accessible land, and facilitating demand-led planning and early understanding of grid requirements.

LLCA learnings: how to develop a strategy for zero emission vehicle infrastructure

The support that the LLCA has provided to the WMCA has highlighted the importance of cross-sector collaboration across the energy and transport systems and the built environment to future-proof the infrastructure needed to decarbonise surface transport. There are three main learnings to share with other local and combined authorities looking to progress transition:

Finding 1

Set up dedicated capability that convenes key actors across departments and sectors

Cost-effective decarbonisation of the surface transport system, and reaching net zero regionally, requires a synchronised place-based approach underpinned by a high level of cross-sector collaboration. Local and combined authorities are best placed to do this as they understand the local needs, are responsible for various planning processes and can convene stakeholders to ensure decisions create future-proof and efficient systems for local communities and businesses.

WMCA set up Energy Capital, a dedicated partnership between the public and private sector, to create a single point of responsibility for delivering a coordinated energy strategy across the region. Energy Capital bridges the energy, transport, and buildings sectors, and considers the infrastructure and planning needs across the three systems.

The LLCA enhanced the diverse set of stakeholders, contributing to the development of the IZEV strategy by bringing in private sector expertise and expanding the dialogue. This level of collaboration identified new insights and opportunities from information sharing, for instance the value in combining WMCA's spatial land ownership data with National Grid's network capacity maps to identify optimal locations for new charging infrastructure.

Replicable learning: Establishing a hub like Energy Capital that brings together public and private sector voices to coordinate regional energy strategy enables authorities to more comprehensively understand how major decisions in transport infrastructure could impact the energy systems and the built environment, and vice versa.

Finding 2

Understand how to further unlock and maximise market-led delivery

The Government's Electric Vehicle Charging Infrastructure Strategy signalled a vision for a market-led rollout for most charge points, whilst fostering competition to provide innovative solutions at the lowest possible cost[20]. In practice, some locations are commercially attractive for the private sector while others will require intervention from the public sector.

LLCA supported WMCA in assessing the degree of market-led charging/refuelling infrastructure rollout across different locations and vehicle segments. Types of infrastructure, such as on-street charging, charging and hydrogen refuelling hubs, and depot charging, were mapped onto a spectrum of market-led to public-led delivery, based on current and expected level of market provision.

This process helped WMCA identify the specific challenges facing market-led delivery of heavier and specialised vehicle infrastructure, and the rollout of chargers along motorways, remote locations and on-street. The role that local government could play in better enabling market delivery was assessed.

Common delivery barriers impacting the pace of market-led delivery were articulated, such as land availability and lengthy planning permission periods. This helped identify areas where WMCA could be well-placed to ease these barriers, as well as coordinate accelerated delivery in segments that are already commercially attractive. See Annex E for more information.

Replicable learning: By mapping potential levels of market provision across all surface transport segments, local and combined authorities can identify market delivery barriers that they could take or coordinate practical steps to overcome.

Finding 3

Direct finite public resources to address market failures and low regret investments

The scale of the challenge to decarbonise the whole transport system and consider the wider energy system needs is huge, even with some areas being led by the private sector. Local and combined authorities have finite resources and capacity to act, driving the need for careful allocation of these resources to achieve a just transition across this transport system.

The LLCA helped WMCA to identify priority interventions in infrastructure segments that are expected to have insufficient levels of provision if relying on private-led delivery alone. The types of intervention was determined through collaboration with transport, energy and built environment experts to ensure that considerations were given to the interactions between the three systems.

These interventions were assessed for their attractiveness and ability for WMCA to deliver. Attractiveness was based on the anticipated level of impact on WMCA's energy transition objectives. Ability to deliver was based on alignment with WMCA's remit, as well as expected time and resource commitments. Actions with both high attractiveness and ease of delivery by WMCA were determined to be low regret actions. See Annex E for more information.

Replicable learning: Use the framework used in WMCA to undertake a similar exercise to prioritise allocation of scarce public resources, assessing based on impact attractiveness and local government's ability to deliver.

Moving the dial on energy efficiency across Leeds

Key Outcomes

- **Initiated design of a blueprint for a one-stop-shop retrofit delivery model targeting the 'able to pay' customer segment**
- **Developed a granular database of local housing stock, income levels and tenancy status to inform the design of a scalable retrofit scheme**
- **LCC will continue to share scheme development learnings**

Leeds has the ambition to deliver home energy efficiency improvements at scale

Like many other cities in the UK, Leeds City Council (LCC) is keen to deliver home energy efficiency improvements at scale, having made progress in retrofitting a range of private and social housing schemes at a smaller scale. The environmental, economic, and social benefits associated with decarbonising the heat and building sector are vast. This transition has the potential to support 240,000 jobs by 2035[1], reduce the UK's carbon emissions by 14% by 2050[21] from the residential sector alone, and bring an end to the 9,700 average excess winter deaths from cold and damp homes[22].

Despite the benefits, the rate of retrofit installations across the UK remains very low over the past decade (see Figure 5). Demand for energy efficiency remains subdued amongst households, as many are unable to pay for retrofit measures, and those with the ability to pay are deterred by disruption concerns.

A different scale of delivery is needed to retrofit the c.220,000 homes in Leeds[23], and the 19 million homes across the UK that currently fall below Energy Performance Certificate (EPC) Band C[24]. More needs to be done, and both local and central government have a key role to play to accelerate installations in neighbourhoods across the nation.

Figure 5: Number of insulation installations in the UK 2010-2021 by insulation type (millions/year)[25]

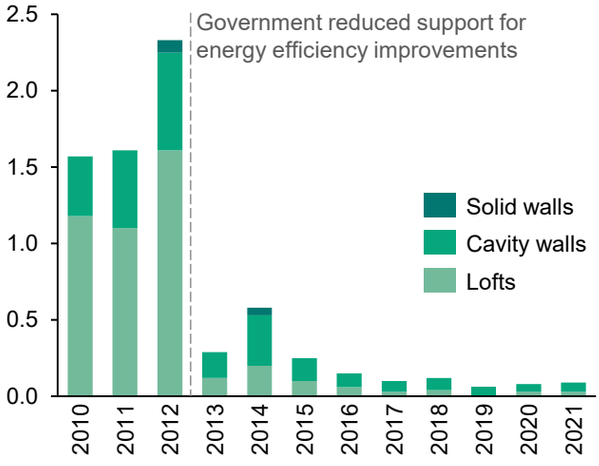
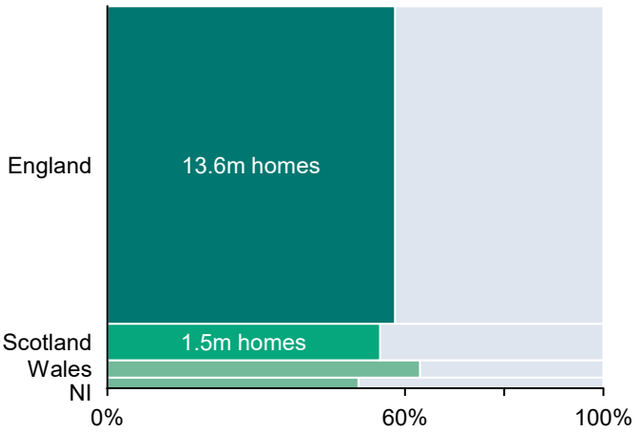


Figure 6: Share of UK homes below an EPC rating of C[26-31]



How did collaboration with LLCA help scale up retrofit in Leeds?

Collaboration between LCC and the LLCA led to the inception of the Leeds Retrofit Accelerator. This initiative is now working to develop a blueprint for a scale retrofit proof-of-concept for the 'able to pay' market, working with local specialist partners in customer design, data analysis, financial modelling and delivery models.

The blueprint focuses on a single neighbourhood, and contains a household targeting approach, customer offer and customer journey, financing offer, delivery model and engagement approach, along with a delivery plan. The current approach aims to encourage uptake by providing a simple, trusted and deliverable offer of a small range of retrofit measures, with financing, all of which would be coordinated by a single delivery vehicle.

The long-term vision is to make the model replicable for other cities, as well as other neighbourhoods and customer groups in Leeds, with the city-based model scaling sustainably over time. Work is underway between LCC and their private sector partners, with learnings to be shared once the project moves into pilot implementation.

LLCA learnings: How to develop a retrofit delivery model and scale it up

The development of a home retrofit delivery model needs to be carefully tailored to the local communities it will serve. Local and combined authorities looking to develop their own delivery model will need to engage with all relevant stakeholders, including their residents, to fully understand the deployment challenges. There are four emerging learnings from the work undertaken so far for local and combined authorities:

Finding 1

Build a detailed understanding of the region's residents and building stock

The UK housing market comprises a large variety of house types with different tenancies (such as private rented and owner-occupied) and occupied by residents of all backgrounds, family structures, and financial situations. This is a barrier to mass market engagement and consumer uptake as it complicates marketing, financing, identification and delivery of the right retrofit solutions for individual homes.

LCC developed a granular database of their local housing stock, income levels and tenancy status, which has been influential in designing a realistic neighbourhood retrofit scheme with the potential to deliver at scale.

Replicable learning: Developing a detailed regional housing database enables optimal targeting of retrofit solutions to customer segments. Once established, these databases should be continually enhanced over time to facilitate scale retrofit to other segments.

Finding 2

Start small to build local confidence before taking an iterative approach to scale up retrofit over the longer term

Recent home energy efficiency efforts have been unable to reach the scale and impact needed. Short-term and narrowly focused funding pots, overwhelming choices and undeliverable schemes, have resulted in a scattergun approach.

LCC is using the initial experience gained from delivering domestic energy efficiency projects for council-owned and fuel poor homes to build senior buy-in for a different approach. An agile, iterative approach is in development to offer a limited yet flexible menu of options for a neighbourhood of similar homes in the 'able to pay' market. LCC and private sector partners are working on solutions to make finance available to consumers at the point of delivery, including property linked finance.

Replicable learning: Start with limited, targeted schemes, for example using Social Housing Decarbonisation funding, and create offers that can be iterated based on learnings and customer segment needs.

Finding 3

Create a delivery model that provides a single point of engagement and an end-to-end customer journey

The current retrofit landscape features a range of specialist providers and unclear financing. This makes it difficult for customers to navigate through to uptake and creates demand uncertainty for suppliers, preventing scaling.

De-risking retrofit for customers and suppliers is critical for scaled uptake and scaled delivery. Without a clear and trusted customer journey, including certainty around service and outcome, customers will not sign up and suppliers will not have a secure pipeline.

The LLCA worked with LCC to design a single delivery model to coordinate assured suppliers, deliver solutions, and provide financing to households, along a simple, end-to-end customer journey. LCC plans to target the most populous home types in a certain neighbourhood, with the intention to pivot and scale to eventually cover all homes in the city. See Annex G for more information on the customer journey.

Replicable learning: Assigning a single coordination point for consumers and suppliers provides delivery certainty and a streamlined experience. This will enable an increase in delivery knowledge, as well as consumer and supplier confidence.

Finding 4

Seek local community buy-in as a signal to mobilise suppliers and scale up delivery

The local retrofit supply chain currently lacks the incentive to scale as consumer demand is stifled by limited awareness and trust, as well as a lack of area-specific signals. This issue was seen with the Green Homes Grant which was undeliverable due to a scarcity in available suppliers. Sufficient provision is needed to mass-market customer uptake, with the aim that uptake will be driven and accelerate through word of mouth.

LCC is designing an incremental approach to build customer trust over time. In order to inform the design of local marketing campaigns and solutions that drive customer demand, financial modelling is being used to understand the 'tipping point' of customer buy-in that will be sufficient to mobilise suppliers and to initiate the delivery model. This exercise shows that fuel bill reductions vary significantly depending on the household and interventions installed[32]. See Annexes F and G for more information on LCC's modelling exercise and approach to customer engagement.

Replicable learning: Other local and combined authorities can look to use in-house or partner modelling capacity to identify the level of customer buy-in required to initiate supply in the delivery model.

The five building blocks at the heart of local green infrastructure

The LLCA's collaboration with LCRCA, WMCA and LCC has accelerated three projects and shone light on replicable learnings for other cities and regions in the UK. However, this work alone only represents a fraction of the public-private collaboration that could be needed to accelerate energy transition across the nation.

A step change in cross-sector collaboration, innovation and delivery is likely needed to deliver local green infrastructure across all sectors. In parallel to increasing project delivery, systemic delivery barriers need to be addressed to accelerate the regional energy transition at scale.

The LLCA has identified five building blocks to help overcome these barriers and accelerate the energy transition. Putting these building blocks in place across the country will require collective action from central government, local government, and the private sector. Once in place, they have the potential to expedite locally-led action across the nation.

Local and regional capability and capacity to design and drive delivery of local green infrastructure

A step change in local and regional capabilities is needed to broker, design and deliver energy and transport solutions in cities and regions across the UK. These capabilities involve the ability to develop cross-sector strategies and planning, lead negotiations, undertake necessary market-building, and, on occasion, undertake consumer engagement.

With the right capabilities in place, Local Area Energy Planning (LAEP) will be essential in aligning the planning and investment decisions between the organisations responsible for transport, energy, and built environment infrastructure planning. This should be developed regionally in collaboration with private and public stakeholders to ensure low cost, rapid deployment of green infrastructure projects.

Insights from WMCA: WMCA's Energy Capital has created a new level of regional capabilities to deliver a whole-systems energy strategy, including obtaining the needed investment and powers. The addition of a dedicated hub to bring stakeholders together has given the region new insights and transformed their approach to infrastructure delivery.

Recommendations for key stakeholders: There are options as to whether this capability is built within combined or local authorities, or potentially in specific arms-length regional bodies.

Each city and region, working with central government, will need to identify the right approach to building the required regional and local capability for their location, and the funding needed to enable this capability to be established with the right skilled professionals.

Primary actors: local and combined authorities, central government (DESNeZ, DfT, DLUHC)

Expert advice and delivery best practices that are tailored and accessible to the local area

Accessing informed advice, understanding best practices and collaborating cross-sector is essential to enable local and combined authorities to accelerate delivery. The harnessing and disseminating of expertise and learnings has the potential to bridge capability and capacity gaps for local and combined authorities, while avoiding duplicative efforts.

Insights from LCC: The collaboration between LCC and the LLCA demonstrated the value of expert advice and knowledge sharing. In the early design phase, LCC had to navigate complex challenges and trade-offs spanning specialist areas, including but not limited to finance, legal, customer landscape and journeys, and technical standards. Perspectives were sought from multiple sources, including law firms, consultants, UKIB, GFI, to help navigate these.

Recommendations for key stakeholders: The complexity of green infrastructure deployment means the answers are unlikely to come from a single source, but rather from both the public and private sectors at national and regional levels, including existing bodies such as the Net Zero Hubs and Core Cities UK, who all have a role to play in coordinating and providing advice.

In addition to this, central government plays a key role in ensuring the provision of coherent cross-departmental guidance and frameworks for risk, financing and deal-making.

Primary actors: local and combined authorities, central government (DESNeZ, DfT, DLUHC), private sector

Harnessing the private sector's ability to deliver infrastructure where possible

Local government has finite resources so the private sector will play a crucial role in deployment of the infrastructure needed to achieve local energy transition at scale and at pace. Local and combined authorities should collaborate with businesses to understand and overcome barriers to make market-led delivery more feasible and commercially attractive. This could include identifying what levers local government have to accelerate delivery, such as easing planning permissions. Limited public resources should fulfil market gaps and ensure equitable rollout of infrastructure.

Local government, together with the private sector, also need to articulate the long-term market signals needed from central government to build market confidence. This has been demonstrated by the positive impact of target setting and supporting policy on increasing adoption of zero emission cars and vans; similar interventions are needed in other sectors.

Insight from WMCA: With back-stop regulation in place for zero emission vehicles, WMCA can leverage the supportive policy environment to stimulate private sector led delivery and drive a coordinated and equitable infrastructure rollout. An assessment of the infrastructure segments that are primed to be delivered by the private sector have allowed the combined authority to more efficiently target public intervention.

Recommendations for key stakeholders:

Local and combined authorities facilitate open dialogue with the private sector on what is needed to amplify market provision across all green infrastructure requirements.

Local government and the private sector should support central government in creating appropriate market signals, which could take the form of backstop regulation, fiscal policy and funding certainty.

Primary actor: local and combined authorities, central government (HMT, DESNeZ, DfT, DLUHC), private sector

Financing solutions and innovation to create bankable projects

Green infrastructure projects including energy efficiency, ZEBs, and EV infrastructure are generally subject to high upfront costs, long payback periods, and may have unattractive risk-return profiles for the private sector over the short to medium term. Uncertainty and risk associated with nascent technologies are also limiting private investment.

A stronger pipeline of investable projects can be fostered through greater engagement with the technical assistance function of UKIB, as well as more collaboration with the private sector and industries bodies such as the Net Zero Hubs and Green Finance Institute. It is essential that more combined and local authorities leverage these resources to understand and mitigate technology and delivery risks, replicate industry best practices, and develop more robust business cases.

Insight from LCRCA: LCRCA saw the benefits of bringing in private sector expertise, and drawing support from institutions like UKIB, to navigate the complexities of the bus transition and create accessible and affordable financing models that mitigate technology risks and attract private finance. The LLCA supported LCRCA to identify suitable financing options for ZEB procurement and understand the impact of ZEB technology choices.

Recommendations for key stakeholders: Local and combined authorities should collaborate with the private sector to utilise their financing expertise and engage with institutions like the UKIB.

Primary actors: local and combined authorities, UKIB, finance sector

Resilient local skills market to design, deliver and maintain local green infrastructure

Infrastructure projects are already experiencing costly delays due to a shortage of skilled workers. Changes in standards and regulations can contribute to delivery bottlenecks. Where possible, local infrastructure projects should be delivered by local businesses. Central government action is also needed to provide signals and support all other sectors and bodies to deliver curriculum and training programmes.

Insight from LCC: The shortage of retrofit coordinators and experienced architects in Leeds has been exacerbated by the rigid application of PAS 2035. This has created additional administrative burden which discourages prospective labour.

Recommendations for key stakeholders: The uncertainty and magnitude of the green skills gap means that all sectors have a role to significant part to play. Local and combined authorities need to ensure that appropriate reskilling programmes are available to address local skills gaps.

Primary actors: local and combined authorities, central government (HMT, DESNeZ, DfE), private sector

Acronyms and abbreviations

Abbreviation	Definition
DESNeZ	Department for Energy Security and Net Zero
DfE	Department for Education
DfT	Department for Transport
DLUHC	Department for Levelling Up, Housing and Communities
EPC	Energy performance certificate
EV	Electric vehicle
HMT	HM Treasury
IZEV	Infrastructure for Zero Emission Vehicles
LAEP	Local area energy planning
LCC	Leeds City Council
LCRCA	Liverpool City Region Combined Authority
LLCA	Local Low Carbon Accelerator
PV	Photovoltaics
TCO	Total cost of ownership
UKIB	UK Infrastructure Bank
WMCA	West Midlands Combined Authority
ZEB	Zero emission bus
ZEV	Zero emission vehicle

Endnotes

No.	Source
1	HM Government, *Heat and Buildings Strategy*, 2021
2	Department for Transport, *Decarbonising Transport: A Better, Greener Britain*, 2021
3	Estimated based on the additional capital cost to improve residential building fabric efficiency and install low carbon heating solutions by 2035. The cost to improve building efficiency is based on DESNeZ's published estimate of £35-65 bn to improve all homes to EPC rating of 'C' by 2035, and a projected £68 bn investment calculated from EEIG's estimate of an annual £5.2 bn investment required for fabric efficiency for 13 years. This range is consistent with the Climate Change Committee's estimate of £45 billion for building efficiency improvements by 2035. The additional capital investment for low carbon heating was taken from the Climate Change Committee's estimate of £67 bn by 2035. Fabric efficiency estimates from: *Government response to BEIS Select Committee's recommendations*, 2019; EEIG, *Making energy efficiency a public and private infrastructure investment*, 2019; Climate Change Committee, *The Sixth Carbon Budget: The UK's Path to Net Zero*, 2021. Low carbon heating estimates from Climate Change Committee, *The Sixth Carbon Budget – Dataset,* 2021
4	Based on the additional capital investment for cars, vans, HGVs, rail, and public transport required in the Climate Change Committee's Sixth Carbon Budget: Balanced Net Zero Pathway. Taken from Climate Change Committee, *The Sixth Carbon Budget - Dataset*, 2021
5	Calculated based on an estimated 120 $MtCO_2e$ abatement from surface transport (cars, vans, HGVs, rail, public transport) and residential buildings (existing home fabric efficiency and low carbon heat) projected in the Climate Change Committee's Sixth Carbon Budget: Balanced Net Zero Pathway in 2035, compared to the UK's 2020 greenhouse gas emissions of 405 $MtCO_2e$. Carbon abatement taken from: Climate Change Committee, *The Sixth Carbon Budget - Dataset*, 2021. UK emissions taken from: DESNeZ, *2020 UK Greenhouse Gas Emissions, Final Figures*, 2022
6	DESNeZ, *Energy Consumption in the UK (ECUK): Final Energy Consumption Tables*, 2021
7	Climate Change Committee, *The Sixth Carbon Budget: The UK's Path to Net Zero*, 2020
8	Department for Transport, *Bus Back Better: National Bus Strategy for England,* 2021
9	Liverpool City Region Combined Authority, *Liverpool City Region: Bus Service Improvement Plan*, 2021
10	Liverpool City Region, *Liverpool City Region Bus Strategy: Appendix One*, 2016
11	UK Parliament Committees, *Written evidence submitted by the Department for Transport (BUS0061)*, 2022
12	Department for Transport, *Table BUS0609: Percentage of buses used as Public Service Vehicles by emissions standards and fuel type by metropolitan area status and country: Great Britain*, 2021
13	Department for Transport, *Table BUS0602: Number of buses by metropolitan area status and country: Great Britain*, 2021
14	Calculated based on the cost of a new ZEB of £357,000 multiplied by a total of 21,140 new ZEBs in the UK by 2035. This only considers the cost of new vehicles and does not consider the cost of ZEB infrastructure or replacement costs. Bus cost estimates taken from Transport Scotland, *Zero Emission Bus Financing Ideas Pack*, 2021. ZEB Sales forecasts taken from BNEF, *Buses long-term outlook*, 2022
15	The financing gap was calculated by subtracting the announced Government support of £525m (see endnote 23) from the estimated £7.5bn required to purchase ZEBs between now and 2035 (see endnote 26)
16	Transport Scotland, *Zero Emission Bus Financing Ideas Pack*, 2021
17	National Records of Scotland, *Households and Dwellings in Scotland*, 2022
18	BNEF, Long-Term Electric Vehicle Outlook, 2022

No.	Source
19	Department for Transport, *Electric vehicle charging device statistics: January 2023*, 2023
20	Department for Transport, *Taking charge: the electric vehicle infrastructure strategy*, 2022
21	Calculated based on an estimated 58 $MtCO_2e$ abatement from residential buildings (existing home fabric efficiency and low carbon heat) projected in the Climate Change Committee's Sixth Carbon Budget: Balanced Net Zero Pathway in 2035, compared to the UK's 2020 greenhouse gas emissions of 405 $MtCO_2e$. Carbon abatement taken from: Climate Change Committee, *The Sixth Carbon Budget - Dataset*, 2021. UK emissions taken from: DESNeZ, *2020 UK Greenhouse Gas Emissions, Final Figures*, 2022
22	E3G, *Cold homes and excess winter deaths: a preventable public health epidemic*, 2018
23	Calculated based on 61% of homes in Leeds having an EPC rating of D or below, and 341,467 dwellings recorded in Leeds in the 2021 Census. EPC data taken from: ONS, *Energy efficiency of Housing, England and Wales, local authority districts*, 2021 ; Leeds household data taken from: Gov UK, *UK Census,* 2021.
24	DESNeZ, *Energy efficiency: building towards net zero*, 2019
25	DESNeZ, *Number of measures installed through ECO and under the Green Deal Framework*, 2022
26	ONS, *Age of the property is the biggest single factor in energy efficiency of homes*, 2022
27	Scottish Government, *Scottish house condition survey: 2019 key findings*, 2020
28	Northern Ireland Housing Executive, *Housing Condition Survey*, 2016
29	ONS, *Household and resident characteristics*, *England and Wales*, 2021
30	National Records of Scotland, *Households and Dwellings in Scotland*, 2022
31	Department for communities, *The Northern Ireland Housing Statistics*, 2017
32	Analysis delivered to LCC as part of the LLCA sub-group work
33	Wrightbus, *Electroliner most efficient double-deck battery-electric bus*, 2022
34	Confederation of Passenger Transport, *Ending the Sale of New Non Zero Emission Buses*, 2022
35	NREL, *Fuel Cell Buses in U.S. Transit Fleets: Current Status 2020*, 2020
36	European Bank for Reconstruction and Development, *Going electric: A pathway to zero-emission buses*, 2021
37	Stagecoach, *Road map to zero*, 2022
38	Elecdrive.com, *Wrightbus presents electric & fuel cell single-decker buses*, 2021
39	UK Parliament Committees, *Written evidence submitted by the Go-Ahead Group (EVP0108),* 2021
40	National Grid, *2021 guide on electric vehicle charging for local authorities*, 2021
41	Element Energy, *Analysis to provide costs, efficiencies and roll-out trajectories for zero emission HGVs, buses and coaches*, 2020
42	Hydrogen Council, *Path to hydrogen competitiveness: A cost perspective*, 2020
43	International Transport Forum, *Policy Priorities for Decarbonising Urban Passenger Transport*, 2018
44	Analysis delivered to LCRCA as part of the LLCA sub-group work
45	Analysis delivered to WMCA as part of the LLCA sub-group work

Annex A: Zero emission bus technology considerations

In agreement with LCRCA, two ZEB technologies were considered in scope: battery electric and hydrogen fuel cell buses. Table A.1 summarises some of the key environmental, financial and technical features of electric and hydrogen buses.

Table A.1: Key technology considerations for battery electric and hydrogen fuel cell buses (developed from sources 33 – 43)

Criteria		Battery electric buses	Hydrogen fuel cell buses
Emissions and air quality	**Carbon emissions savings**	Can save more than 80% of carbon emissions (well-to-wheel) compared to Euro VI diesel buses[33, 27].	Can save more than 50% of carbon emissions (well-to-wheel) compared to Euro VI diesel buses (assuming green hydrogen is used).
	Air quality	Zero emission at tailpipe; particulates still produced.	Zero emission at tailpipe; particulates still produced.
Total cost of ownership	**Current upfront capital costs**	Current upfront capital cost of electric buses can be twice the purchase cost of diesel buses.	The capital cost of hydrogen buses is higher than the cost of both diesel and electric buses.
	Running costs	The LLCA calculations indicate that operational costs are lower for electric buses than for diesel buses, due to the higher efficiency and cheap cost of electricity.	The LLCA calculations indicate that operational costs for hydrogen buses are higher than either electric and diesel buses, due to the higher fuel and maintenance costs.
	Infrastructure costs	Infrastructure costs depend on the number, power and charging pattern of the charge points deployed and the potential need for a grid upgrade. The LLCA calculations show infrastructure costs per bus are roughly similar for electric and hydrogen buses.	Infrastructure costs depend on the hydrogen delivery method and the size of the hydrogen dispensing and storage facilities at depots. A grid upgrade may also be required. The LLCA calculations show infrastructure costs per bus are roughly similar for electric and hydrogen buses.
Operational considerations	**Range**	New single-decker models are expected to have 250-300 miles of range (less for double-decker buses). Extra vehicles may be needed on certain routes, given range and charging times.	Similar range to diesel buses, with new 650-mile models announced. This means there is likely no need for extra vehicles (and thus drivers) to cover longer routes.
	Lifetime	The lifetime of a bus is expected to be 14-15 years, although the battery may need to be replaced every 7-10 years.	The lifetime of a hydrogen bus is expected to be aligned with an electric bus, although bus operators expect this to be lower. The fuel cell could possibly last 4-10 years[34, 35].
	Charging / refuelling time	Depending on the power of the charge point chosen, it may take up to several hours to recharge an electric bus.	The bus refuelling process involved is similar to diesel, with roughly the same time (less than 10 minutes).
	Infrastructure footprint and layout	Depots will likely need redesign and ground works to install charge points, possibly resulting in extra space requirements.	Space is required for hydrogen storage and dispensing facilities which will need to comply with HSE regulations. More substantial depot redesign may be required if hydrogen is produced on site.
Ability to finance	**Current technology risk**	Battery electric buses are relatively well established with a moderate level of technology risk[36].	Hydrogen buses have a higher level of technological risk than battery electric buses[37].

Preferred technology option

Annex B: Total cost of ownership analysis for zero emission buses

Total cost of ownership considerations

A total cost of ownership (TCO) analysis can provide an economic comparison between different bus and infrastructure technology options by looking at the lifecycle costs of each technology over a given timeframe (e.g. the length of the franchise contract or the operational life of the bus). A TCO should include capital, operational and maintenance costs of the bus and infrastructure to provide a comprehensive overview of the total costs of different bus technologies.

The LLCA produced a simplified TCO calculator that includes the costs to purchase and operate a fleet of diesel internal combustion engine buses (ICE), battery electric buses (BE) or hydrogen (H2) buses, as described in Table B.1.

Table B.1: An overview of the capital and operating cost components of the LLCA's TCO analysis[44]

Components of LLCA TCO calculations			Description	ICE	BE	H_2
Capital costs and contributions	**Bus purchase costs**	Bus purchase costs	Initial purchase cost of the bus	✓	✓	✓
		Battery replacement cost	Cost incurred to replace the electric battery once within the lifecycle of the bus, if not covered by other warranty arrangements.		✓	✓
		Residual value of the bus	Depreciated value of the bus at the end of its use that the asset owner can cash in. This is the value associated with some of the key components (e.g. chassis), excluding the battery.	✓	✓	✓
		Residual value of the batteries	The residual value of the original and replacement battery when sold by the asset owner, assuming one replacement cycle per bus lifetime		✓	✓
	Infrastructure costs	Electric buses charge point costs	Cost associated with purchasing and installing electric vehicle charge points.		✓	
		Hydrogen refuelling infrastructure costs	Cost associated with installing hydrogen refuelling infrastructure at depots (e.g. storage and dispenser facilities).			✓
		Electricity grid upgrades and connection costs	Cost associated with connecting both electric and hydrogen infrastructure to the electricity grid and upgrading the electric infrastructure.		✓	✓

Table B.1: An overview of the capital and operating cost components of the LLCA's TCO analysis (cont.)[44]

Components of LLCA TCO calculations			Description	ICE	BE	H_2
Operational costs and contributions (yearly)	**Fuel costs**	Diesel costs	Cost incurred to purchase diesel fuel, determined by diesel cost, vehicle fuel consumption and efficiency.	✓		
		Electricity costs	Cost incurred to purchase electricity, determined by electricity costs and charging patterns, and battery consumption per km.		✓	
		Hydrogen costs	Cost incurred to produce and supply hydrogen, determined by the colour of the hydrogen used and the logistics of the supply.			✓
	Maintenance costs	Bus maintenance costs	Cost incurred to maintain the bus (e.g. spare parts, lubricants where needed, tires), determined by the drivetrain of the bus and the distance travelled.	✓	✓	✓
		Refuelling / recharging infrastructure maintenance costs	Cost incurred to maintain the refuelling infrastructure, determined by the drivetrain of the bus and the frequency of use of the infrastructure.		✓	✓
	Other operational expenses or contributions	Insurance	Cost associated with insurance policies covering the vehicle, determined by the drivetrain of the bus and its technology/safety features.	✓	✓	✓
		Bus Service Operators Grant	UK Government contribution to operational costs, determined by the volume of diesel fuel consumed, the distance travelled and the drivetrain of the bus.	✓	✓	✓
	Staffing costs	Driver costs	Costs incurred to pay drivers.	✓	✓	✓

Key additional technical assumptions and sensitivity analysis

The TCO was estimated over a 15-year period for diesel, electric and hydrogen buses deployed along a sample daily distance of 250km within the LCR. Although all the factors outlined in Table E.1 affect the overall TCO/km of the bus technology chosen, some factors disproportionately impact the differential between technology options. A sensitivity analysis was conducted to test the impact of the assumptions around these factors. This was done by varying the values of:

- Upfront bus capital cost
- Battery price
- Battery residual value and replacement costs
- Battery electricity consumption
- Diesel and electricity prices
- Hydrogen production and distribution costs

An additional consideration was included on the affect of the daily distance travelled by buses in LCRCA, due to its impact on peak vehicle requirements (PVR) for the different technologies.

The results of the sensitivity analysis were considered alongside the baseline results to determine the overall suitability of the different ZEB technologies on a cost basis.

Annex C: Financing options analysis for zero emission buses

The LLCA provided sector expertise to support LCRCA identify suitable financing options for their envisioned bus reform, based on their technology choice, and appetite for asset ownership and risk. A shortlist of potential financing models was identified based on their applicability to LCRCA's existing plans. The shortlisted models were then assessed against a series of criteria to help LCRCA identify the most suitable options.

Shortlisted financing models

A series of workshops were held to identify a shortlist of potential financing models. The key conclusions included:

- The suitability of any financing models and the cost of finance will depend on the drivetrain chosen. Battery electric buses are likely to be easier to finance due to higher investor confidence in their residual value, but other considerations (e.g. distance of bus routes) may influence local and combined authorities or bus operators into choosing hydrogen buses.
- Each financing model will have implications on asset ownership, either positive (e.g. potentially higher chances of securing financing) or negative (e.g. LCRCA having to find ways to de-risk residual value).
- ZEBs, charging infrastructure, and depots could be financed independently or as part of a bundle, depending on the financing model chosen.
    - New 'infrastructure-as-a-service-models' could be an innovative mechanism to remove some ownership risks from the authority (but will need to be compared in terms of pricing).
    - Local and combined authorities should develop or acquire bus ownership/financing capability before entering into financing negotiations.
- Quantifying the financing needs and the sequencing of the investment in more detail will help identify whether more than one financial institution or investor may be needed.
- The LLCA view is that a mix of private and public funding may be a mechanism for adding private sector scrutiny to the initial tranches of ZEB acquisition if it is an area the authority has little experience in.
- Good asset management is vital, and the private sector could bring in expertise to help with this.

Based on the outcomes from these workshops, a shortlist of potential public and private financing models was identified by the LLCA as the most suitable for LCRCA's envisioned bus reform. These products are also expected to be useful for local and combined authorities looking to finance a ZEB transition. A summary of the shortlisted financing products is given in Table C.1.

Table C.1: Summary and description of the shortlisted financing mechanism

Financing model	Description
Public loans	Government can provide funding to support capital projects through different mechanisms, including the Public Works Loan Board (PWLB) and the UKIB.
Finance lease	The authority procures ZEBs which are financed by a financial institution and pays a regular lease payment to the lessor over the period of the lease. The ZEBs could be on-leased to bus operators or provided as part of franchising rounds. The lessee often has the material risks and benefits of ownership, including the ability or requirement to purchase the assets at the end of the lease term.
Operating lease	The authority takes out a lease from a financial institution and pays back a regular lease payment. The lease is used to purchase ZEBs which are on-leased to bus operators. Ownership of the assets sits with the leasing company and there is often the ability for the asset to be handed back to the lessor after a period of time.
Green bond	The authority issues bonds publicly or privately to raise funding that is used to purchase ZEBs (or other assets included in the stated purpose of the bond).
Corporate debt / asset loan	The local authority takes a long-term corporate loan with a financial institution to purchase ZEBs, with the procured ZEBs being provided as security for the loan.
Infrastructure-as-a-service	The local authority pays a service fee to an infrastructure services provider without any upfront capital investment. The provider then installs and maintains the charging or refuelling infrastructure.

Identifying a suitable financing product

The shortlisted products were assessed against ten criteria to support LCRCA in identifying a suitable financing solution. These criteria were selected to test each product's suitability further against LCRCA's envisioned bus technology mix, its suitability for wider asset ownership, complexity, cost of capital, and product scalability. Table C.2 provides a description of the ten criteria.

Table C.2: Description of the criteria used to identify a suitable financing product for LCRCA[44]

Criteria	Description
Source of financing	The source of financing for a given financing product. This can be either public, private, or a mixture of both, depending on the product chosen.
Asset value alignment	Whether a financing product is suitable for the quantum of investment required (e.g. if there is a minimum threshold for cost-effective funding). Consideration must also be given to whether an investment will require syndication across multiple lenders given the expected size.
Technology alignment	The suitability of a financing product for the chosen ZEB technology pathway (either battery electric and/or hydrogen) due to the different risks and concerns over residual value, technology risk, etc.
Possibility to bundle with infrastructure and depot financing	Whether other inter-related assets (infrastructure, depots, etc.) could be funded with the same financing product. This may be advantageous if the authority intends on taking these assets under public ownership in a franchising model.
Possibility to finance some bus components separately	Whether the financing product can be combined with part-financing components of the bus (primarily the battery) with different lenders. This can place the higher risk elements of the bus to lenders with a suitable risk appetite and/or competence to manage the asset, while affordably funding lower risk components (e.g. the bus chassis).
Requirement for residual value guarantee	Whether financiers may require local authorities (or manufacturers) to introduce a residual value guarantee to provide greater security for the end-of-life use of ZEBs and greater reassurance on the asset value over time. This is much more likely if there is a risk that the financing term with be shorter than the asset life.
Complexity for lender/lessor	An indication of the complexity of the financing product from the perspective of the lender/lessor. This can depend on factors including the source of funding, how established a product is, and the requirements of the local or combined authority.
Complexity for local or combined authority	A measure to test the complexity of the funding request process, or investment management for the local or combined authority. Highly complex financing products may require continued external support, reporting requirements (e.g. green bonds), and other administrative considerations.
Indicative cost of capital	An indication of the relative cost of capital compared to other financing products. This can depend on factors such as the source of financing, capital availability, financing timeline, and technology risks.
Scalability and replicability	Whether the financing product can be easily replicated to attract new lenders, increase funding volumes and extend agreements to future ZEB investment tranches.

Using this assessment, LCRCA can compare the suitability or performance of each product against the chosen criteria to identify which financing product best suits their requirements and vision for bus reform. An example of this assessment matrix is shown in Table C.3.

This assessment matrix and approach is also expected to be useful for other local or combined authorities adopting a similar approach to bus decarbonisation, where preferences for the different financing products may vary.

Table C.3: A summary of the assessment matrix used to support LCRCA identify suitable financing model options[44]

Criteria	PWLB funding	Finance lease	Operating lease	Green bond	Corporate debt/asset loan via an SPV	Infrastructure-as-a-service
Source of funding	Public only	Public and/or private	Public and/or private	Public and/or private	Public and/or private	Public and/or private
Asset value alignment	Suitable	Suitable but may require syndication	Suitable but may require syndication	Possibly suitable	Suitable	Suitable
Technology alignment	Flexible	Possible for hydrogen with corporate support	Possible for hydrogen with corporate support	Possible for hydrogen with corporate support	Flexible	Preference for electric buses
Possibility to bundle with infrastructure, energy supply and depot financing	Yes	Maybe	Maybe	Yes	Yes	Yes
Possibility to finance some bus components separately	Yes	Yes	Yes	Yes	Yes	Yes
Requirement for residual value guarantee	No	No	Likely	No	Likely	Unlikely
Complexity for lender/lessor	Low	Low to medium	Low to medium	Medium	Medium	Medium to high
Complexity for local authority	Medium	Medium if proactive asset management is adopted	Medium if proactive asset management is adopted	High	Medium	Low to medium
Indicative cost of capital	Low	Low	Medium	Low to medium	Low	Low to medium
Scalability and replicability	High	High	High	Low	High	Medium

Annex D: Overview of road transport ZEV infrastructure requirements

Local authorities will need to understand the current local infrastructure landscape to support deployment of zero emission vehicle infrastructure. This includes categories of vehicles that need to be supported, the likely future technology options, and the resulting segments of infrastructure that need to be addressed. Figure D.1 is a high level summary of infrastructure requirements for road transport ZEVs.

Table D.1: Overview of road transport ZEV vehicle types (excluding rail), leading technology types and maturity, and associated infrastructure requirements, within the West Midlands region

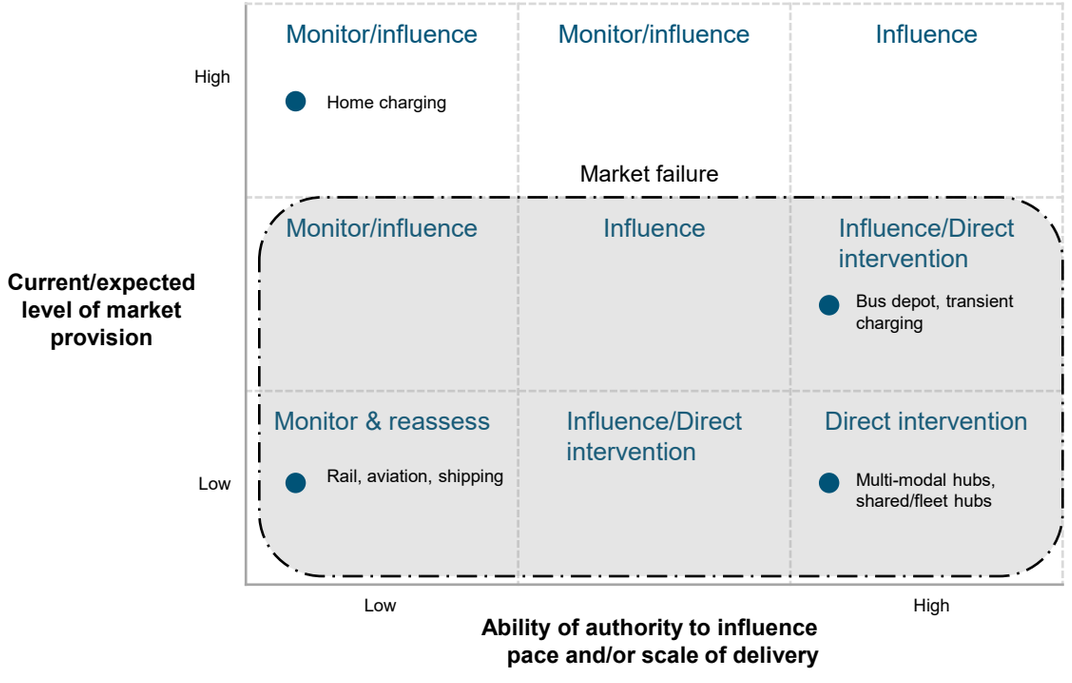
Category	Light vehicles	Buses and coaches	Freight and specialist	Micromobility
Main ZEV technology	Battery electric	Battery electric H_2 Hydrogen Biofuels	Battery electric H_2 Hydrogen Biofuels	Battery electric
Technology maturity				
Main point of use energy infrastructure requirements	**EV charging infrastructure** Home charging - private Home charging – shared dwellings Workplace Fleet depots & shared infra. On-street residential charging Destination charging Transient charging	**Depot-based refuelling** EV charge points H_2 H2 storage & refuelling equipment Biofuels storage & refuelling **Opportunity (en-route) charging** EV charge points, pantographs and wireless charging	**Depot-based refuelling** EV charge points H_2 H2 storage & refuelling equipment Biofuels storage & refuelling **Opportunity (en-route) charging** H_2 Freight rest areas with refuelling infra.	Low power demands serviced primarily by existing domestic/ commercial connections
	H_2 **Shared multi-use energy hubs**			
Upstream infrastructure requirements	H_2 **Electricity grid reinforcement** (for EV charging and electrolysis)			
		H_2 **Upstream production and transport** (inc. electrolysis)		

Annex E: Identifying the role of an authority in IZEV provision

The ZEV infrastructure landscape should be segmented to assess the role local and combined authorities should play in the provision of ZEV infrastructure, and to identify possible interventions.

The assessment of each segment would involve understanding the extent of current and expected market-led delivery, and how well placed the authority is to influence pace and scale of infrastructure delivery, in collaboration with the private sector. The outcome of this exercise can be visualised on a x-y grid as shown below:

Figure E.1: Visualisation of a ZEV infrastructure landscape to determine where and how a local or combined authority should play a role, with examples based on WMCA's ability to influence and expected market provision in the West Midlands[45]



For segments that have moderate-high levels of current or expected market provision, local and combined authorities should work with the private sector to understand; 1) are there any delivery barriers that could be unblocked to accelerate market-led delivery, and 2) whether the direction of the market-led delivery is in line with public interest.

For segments that have low-moderate levels of current or expected market provision, local and combined authorities should work with the private sector to understand potential interventions available to the authority. These interventions could be direct provision of infrastructure, delivered entirely by the public sector or in partnership with the private sector, or indirectly influence or incentive rollout by enhancing market conditions.

The LLCA identified 13 action levers available to WMCA and other local and combined authorities by conducting this exercise and consolidating the identified interventions. These action levers are outlined in Figure E.2, in line with the three priority pillars outlined below, and could act as a starting point for other local and combined authorities:[45]

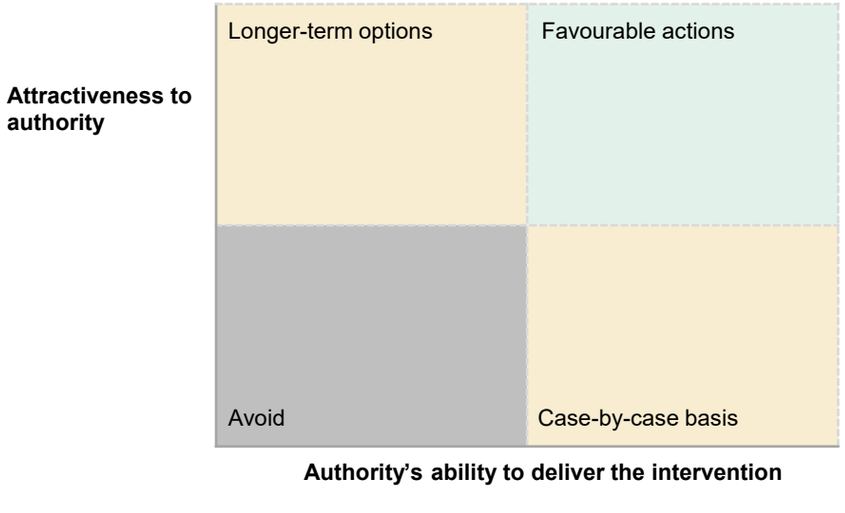
- Leveraging public investment: Helping stakeholders access the public funding they need to deliver green infrastructure projects.
- Enhancing market conditions – Supporting the development of earlier-stage markets by setting direction, acting to fill market gaps, de-risking investment, and providing targeted support.
- Coordinating infrastructure investment – Bringing together players across the region to develop a joint view of infrastructure requirements and to make optimal use of infrastructure assets.

Figure E.2: Key action levers available to WMCA to support the development of ZEV infrastructure[45]

Priority pillar		Key action levers identified for WMCA
Leveraging public investment	1	Educate and contextualise stakeholders on funding mechanisms and routes
	2	Work in partnership to leverage public investment
	3	Source long-term public funding for investment in critical market-making infrastructure projects
	4	Explore how investment could be channelled more effectively in the region through devolved funding and energy infrastructure planning powers
Enhancing market conditions	1	Support the definition of a vision for a future zero emission transport model
	2	Directly invest in or de-risk private sector investment in selected infrastructure projects to address identified gaps
	3	Consider green infrastructure uses for WMCA-owned or accessible land where feasible
	4	Encourage innovation and knowledge sharing in the region to support emerging technologies and new business models
	5	Coordinate targeted incentives to encourage positive consumer behaviours
Coordination of infrastructure investment	1	Convene local stakeholders to better map requirements and barriers, and to identify collaboration opportunities
	2	Facilitate demand-led planning and early understanding of grid requirements
	3	Drive consolidation of demand to maximise utilisation of energy assets across industrial, commercial and residential segments
	4	Facilitate consistent, optimised and accelerated planning processes in local authorities

Regardless of the nature of the intervention, a prioritisation exercise is needed to identify how best to channel the authority's resources. The diagram below presents the framework WMCA and LLCA used, as an example of how the prioritisation could be done, and how to identify low regret investments.

Figure E.3: An 'attractiveness' versus 'ability to deliver' framework for prioritising interventions[45]

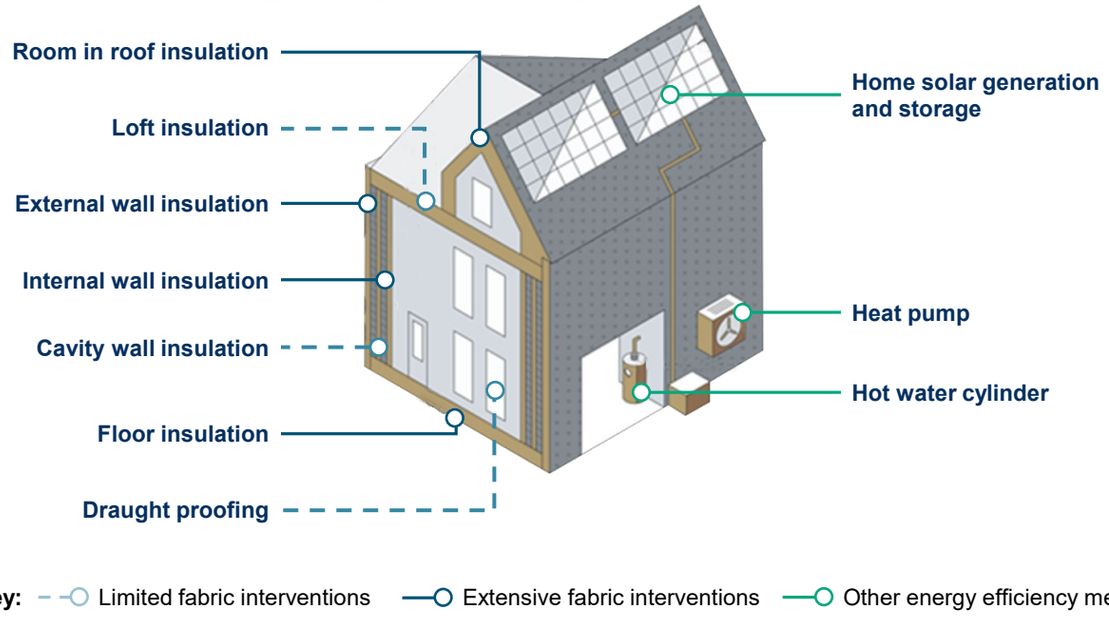


Annex F: Selecting priority energy efficiency measures

The successful uptake of retrofit schemes requires a set of interventions that are attractive to homeowners. There are lots of intervention measures that could be deployed, which can be overwhelming and ultimately a deterrent to the customer. The design of any scheme will need to consider which measures to provide, and in what combinations.

Providing a variety of retrofit interventions choices for customers could enhance uptake across the target demography. Even within a selected portfolio of homes based on common attributes, by property type, tenure and/or other socioeconomic characteristics, homeowners are likely to have differing needs, wants and individual priorities. Too much choice, however, could add design and delivery complexity. Local and combined authorities will have to balance customer choice with scheme deliverability.

Figure F.1: Illustration of the energy efficiency interventions being considered by LCC[32]



Prioritise retrofit intervention packages through conducting a payback assessment

One approach local and combined authorities could take to identify appropriate retrofit measure packages for a selected housing portfolio is by assessing the cost-effectiveness of a selection of measures. LCC has derived six different combination of retrofit measures (whole house, fabric and light touch retrofit interventions with or without solar photovoltaic and storage) and conducted a modelling exercise to explore the payback for households, based on housing archetypes within the selected portfolio of houses. They modelled investment required and annual bill reduction for each archetype carrying out each of the six retrofit measure packages.

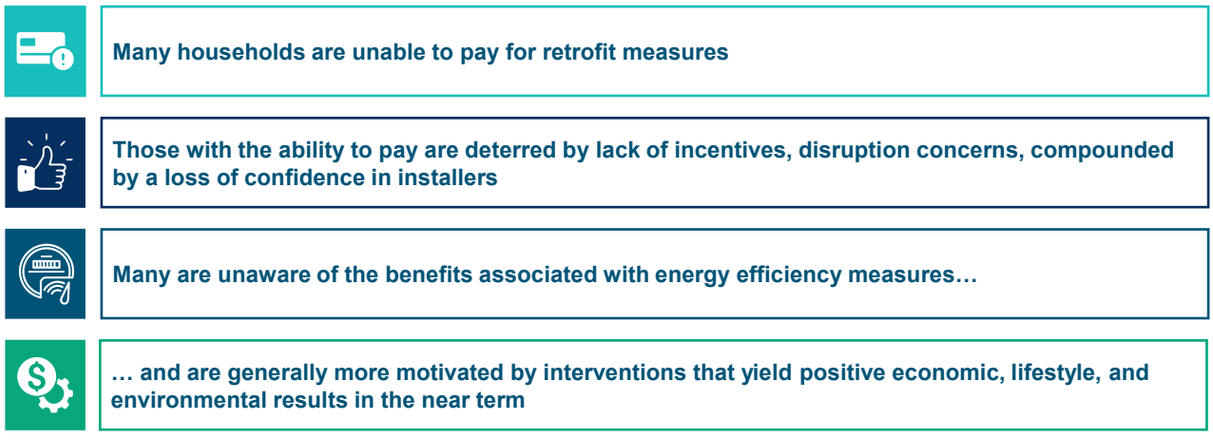
This modelling exercise indicated that only the light touch measures provide a full payback within an acceptable timeframe for most homeowners (20 years). Light touch measures represent an accessible market for initial scheme delivery, with modest absolute costs and material savings for households. Whole retrofit measures, with or without the installation of home solar generation and a storage system, are estimated to have significantly longer payback periods. Uptake will likely depend on a fall in costs or some level of funding/financial support. The payback periods for all measures are impacted by changes in energy prices which determine the annual fuel bill savings.

Annex G: Customer journey and engagement

Key themes of customer concern

Aside from the financing challenge, the uptake of retrofit is currently limited by a lack of awareness of economic, lifestyle and environmental benefits, the perceived disruptions from installation, and a lack of confidence in installers. To increase retrofit uptake, local and combined authorities need to understand the key concerns of its local communities and address these concerns through community engagement and delivery of an easy and hassle-free experience for the customer and end-user.

Figure G.1: key demand side challenges affecting the uptake of energy efficiency measures in Leeds[32]



Addressing key concerns through local community-based communication

LCC is exploring a peer-to-peer messaging approach to its engagement with local communities. The messaging is expected to set out the wide range of benefits resulting from scheme participation so it appeals to a wide audience who will have different motivating factors. The communications should also convey the aims and aspirations of the programme, delivered through punchy and memorable language.

Some of the core communication objectives of LCC are[32]:

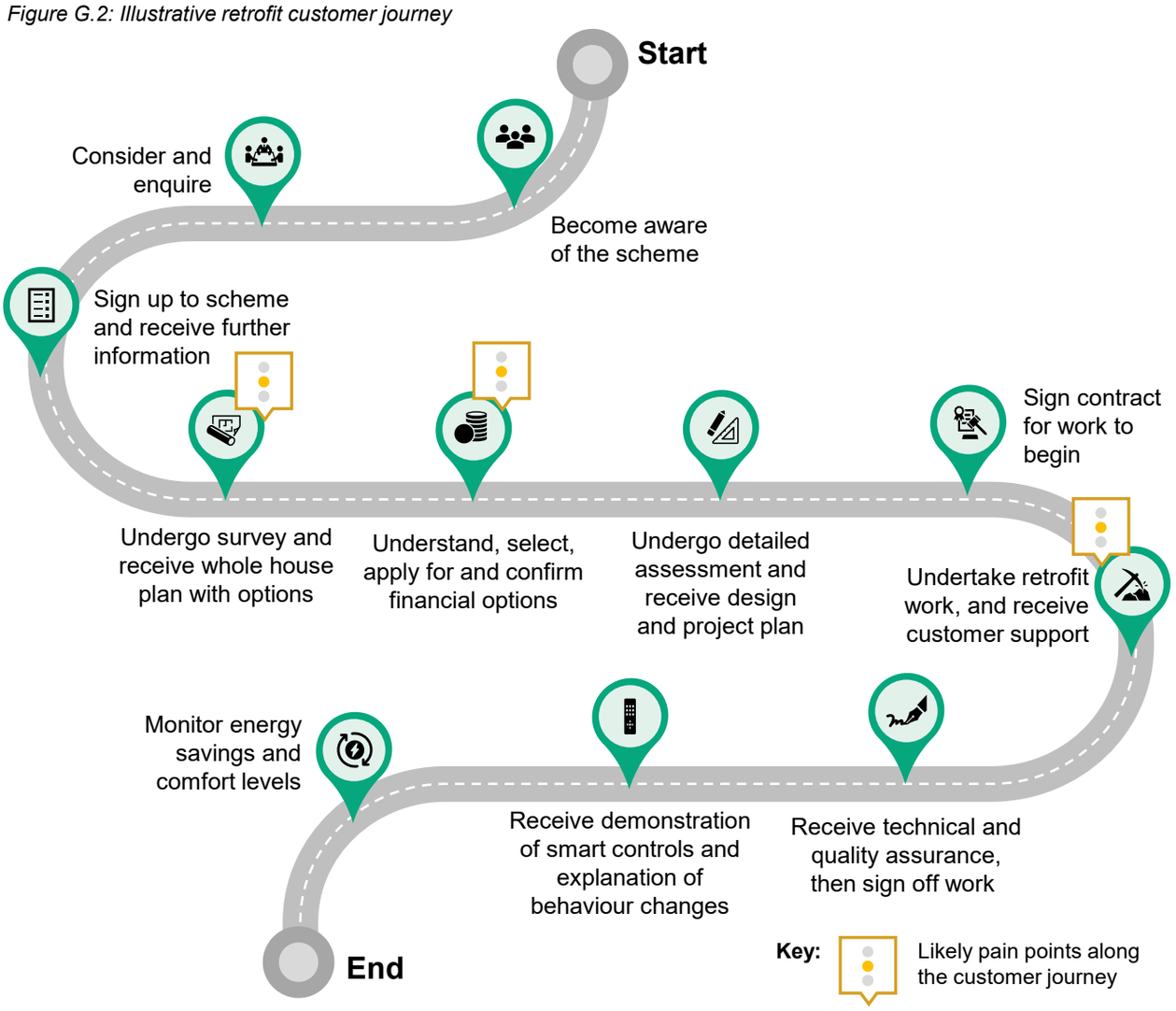
- **Clear messaging on the range of benefits from participation to appeal to a variety of motivating factors**, such as descriptions of a cosy home for the health and wellbeing conscious, carbon reduction for those concerned about their environmental footprint, and bill savings and future proofing resale value for the financially savvy.
- **Showcase the impact of house retrofit to secure the support of local advocates and ambassadors** through a series of case studies, with clear linkage to the city's broader climate ambition and net zero target.
- **Create a community liaison group to strengthen stakeholder relationships,** made up of local influencers and community groups to promote the programme, with tactics including local advertising and PR, alongside engagement with the local installer and supply chain to explain the aim and technologies involved in the programme.
- **Create an identity for the retrofit scheme**, such as a website, that would lead a consistent tone in communication with the wider community.

Customer journey design

Consumers want a frictionless journey regardless of building tenure or means. They need clear and impartial personal advice that outlines the right options to suit their needs through an easy, hassle-free process. The supply chain need to consistently execute high-quality work expediently to build certainty and trust with consumers.

Achieving the above requires a well designed and managed customer journey and experience. Figure G.2 demonstrates a typical journey for a domestic customer looking to retrofit their home.

Figure G.2: Illustrative retrofit customer journey



LCC has also identified five customer journey design principles, which will serve as guidelines in further design and finalisation of its customer journey and experience. These design principles are shown below.

Figure G.3: LCC's customer journey design principles

Understandable
Provides easy to understand and jargon-free information about the retrofit process and its benefits

Attractive
Communicates the benefits, relevance, and overall attractiveness of the offer successfully to the customer, improving uptake of the compelling offer.

Trusted
Gives customers confidence in the process through local authority involvement, quality assurance, a professional supply chain, and consumer protection

Supportive
Supports the customer throughout the journey with input from the scheme and gains confidence from neighbours who come along on the journey with them

Simple
Facilitates simple decision making, hassle-free processes and low-disruption delivery, allowing customers to move through each step with ease