In association with:

Innovate UK

pwc

OTLEY ENERGY

UNIVERSITY OF LEEDS

Accelerating Net Zero Delivery

Unlocking the benefits of climate action in UK city-regions

Final: Supplementary evidence

March 2022

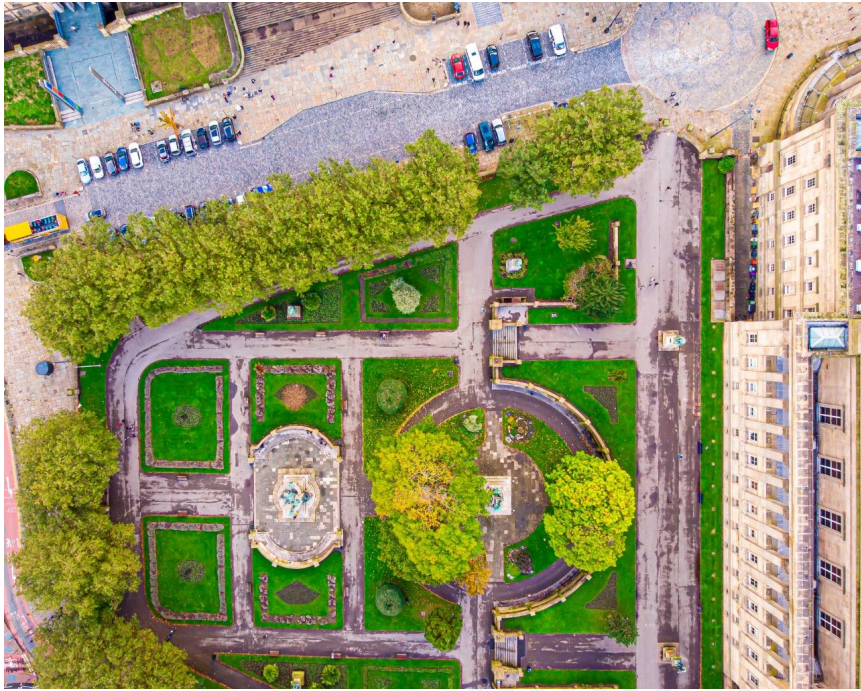
Document Purpose

PwC, together with Otley Energy and the University of Leeds, were commissioned by Innovate UK to explore the strategic and economic potential of local climate action to deliver Net Zero. Focusing specifically on the role of heat & buildings and surface transport*, the study sets out the basis of an Accelerated Delivery Framework which could inform the Government's execution of the UK Net Zero Strategy.

Our overall report is made up of three parts:

- **Summary report -** this is our overall narrative supported with extracts of evidence and high level recommendations
- **Supplementary evidence - this document** - this contains detailed findings and is split into 5 sections covering economics, blockers, city readiness and case studies. It is not meant to be read as one narrative but as detailed supporting evidence for each of these sections of the main report
- **Technical appendix**: economic modelling methodology.

This section provides supplementary evidence.



*Referred to as 'buildings' and 'transport' respectively, throughout this report

Acknowledgements: the Steering Group

In order to deliver quality findings we tested our ideas and consulted extensively. We would like to thank the Steering Group with responsibility for oversight of the project and who are listed in full below, as well as all of the participants in workshops, interviews and individuals and organisations.

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Contents

1

Economic Modelling: Approach and Methodology

This section explains our approach to and methodology for analysing the costs and benefits of decarbonisation in cities

This document provides details of the approach and methodology to the economic modelling of the costs and benefits of decarbonisation in cities.

The document is structured as follows:

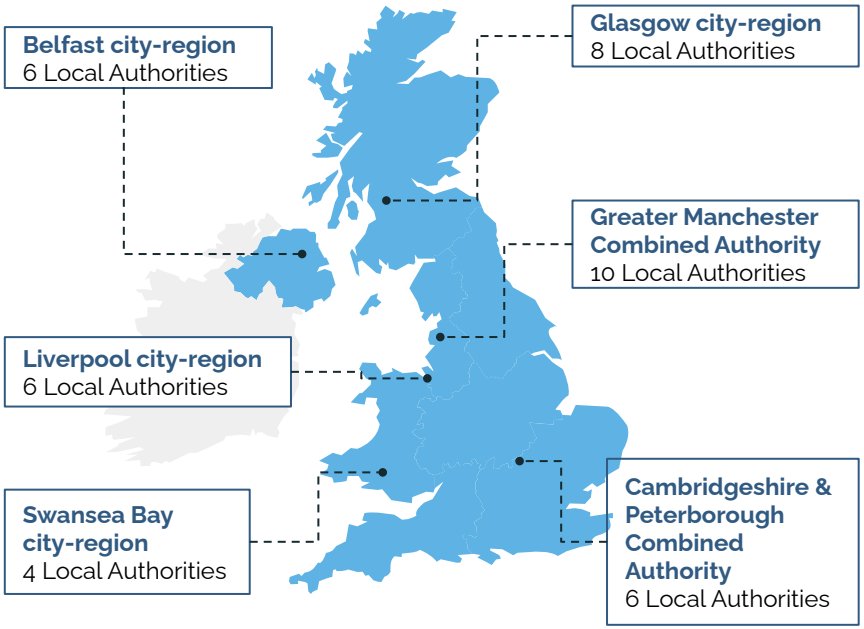
- An overview of the different models, their relationship to each other and the key outputs that are generated
- A summary of what the modelling includes and excludes
- An overview of the scope of the economic modelling, the approach adopted and the key features and assumptions
- Details of the geographic scope of the modelling
- An explanation of the low carbon measures considered for heat & buildings, and (surface) transport
- An explanation of the types of costs and benefits included in the modelling
- A description of the different scenarios which have been modelled
- A glossary of the key concepts and terms used in the analysis

A further technical annex provides more detail on each of the economic models focusing on:

- The basis of each model
- The key data inputs
- The key assumptions

Place: This analysis is focused on six UK city-regions

The modeling covers six UK city-regions:



This analysis focuses on six city-regions from across the UK to reflect different decarbonisation challenges.

The city-regions were selected using the following criteria:

- Coverage of a broad range of UK nations and regions
- Contain a diverse mix of urban typologies i.e. city core, suburbia, towns, peri-urban etc
- Have a political mandate such as a city-deal or combined authority
- Do not contain atypical levels of heavy or extractive industries (as these have different decarbonisation pathways)
- Limited existing analysis so that this study can add more value to the evidence base.

Results for the six city-regions were also scaled to reflect the urban population outside London. The 'Non-London Urban UK' covers 40 million people (70% of the UK)* and allows consideration of the aggregate costs and benefits to the UK's urban population of place-specific decarbonisation.

*London was excluded because its transport system is not comparable to other places e.g. rail use is more than seven times that of most other UK cities.

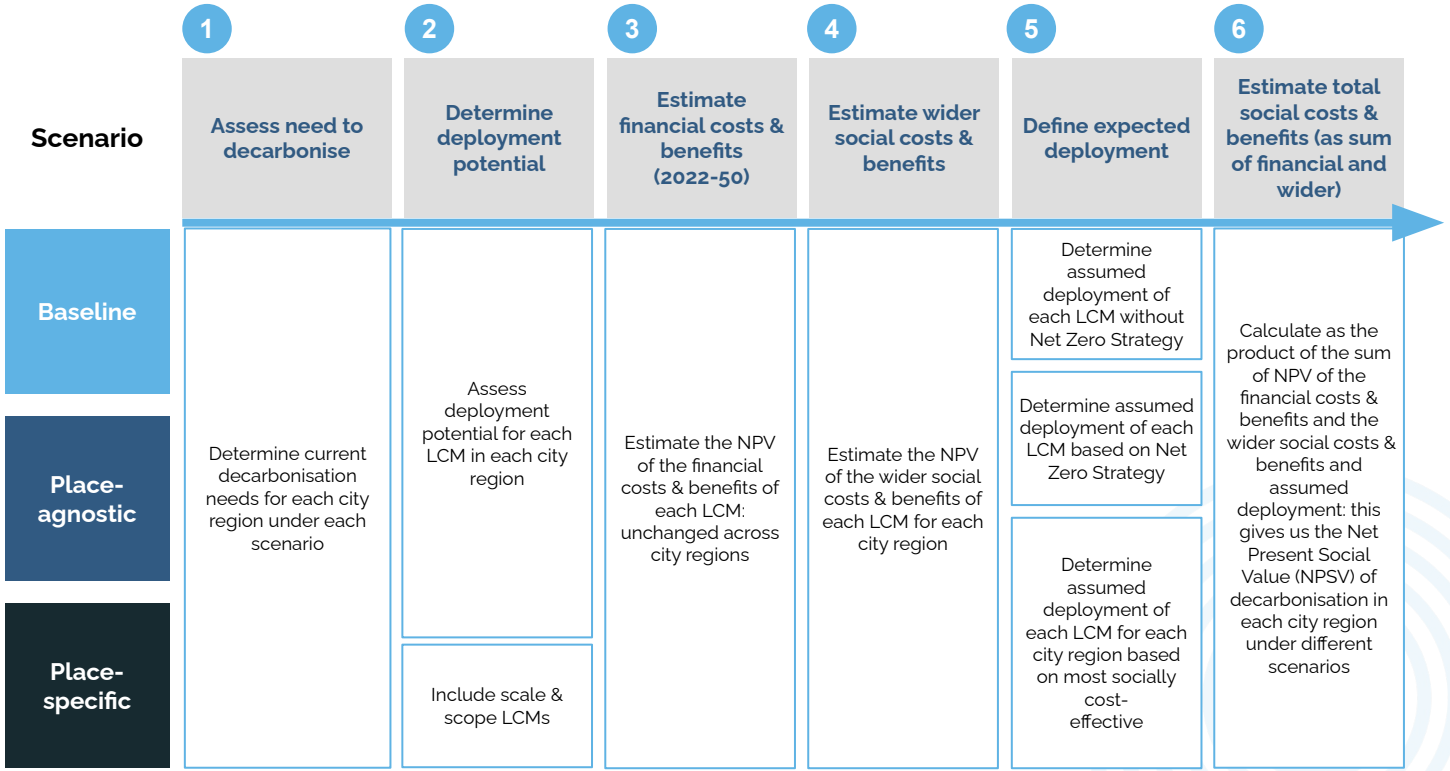
Our approach is based on six steps which enable the total costs and benefits of different combinations of Low Carbon Measures to be assessed

Our analysis of the costs and benefits of each place adopting a place-specific set of low carbon measures follows six steps.

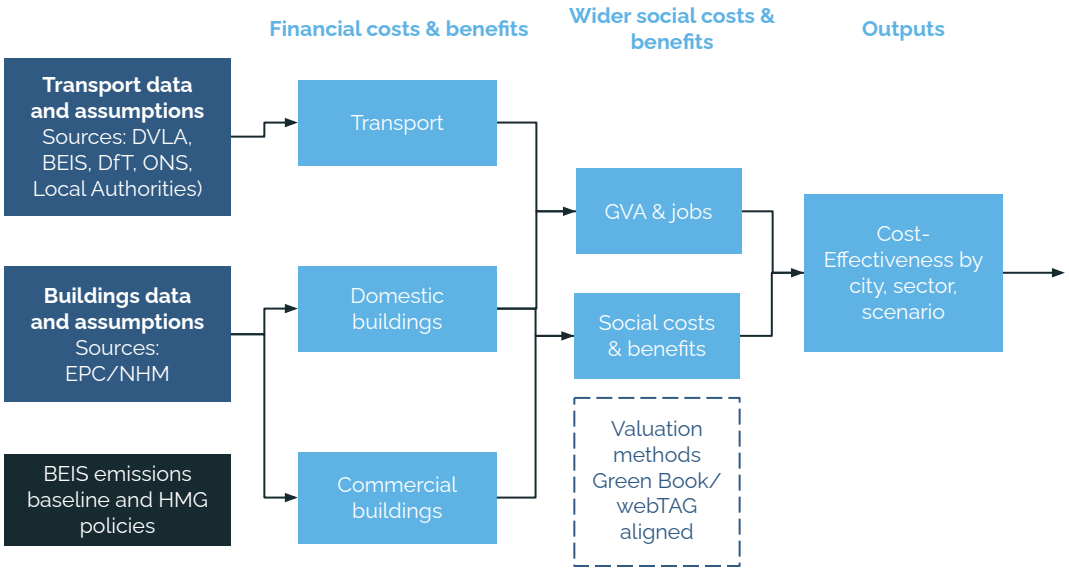
We assess the costs and benefits of deploying different combinations of low carbon measures in six city regions under different scenarios (all based on the same level of decarbonisation - consistent with the ambition in the Net Zero Strategy).

The costs and benefits included are:

- The financial costs and benefits (energy savings)
- The wider social costs and benefits (such as improved health)



We have integrated multiple models to analyse the costs, benefits and effectiveness of decarbonisation options



Key outputs

Impact of uptake of low carbon measures up to 2050 on:

- Carbon emissions
- Capital costs
- Other costs and savings (e.g. maintenance, road repairs)
- Energy savings
- Social social costs & benefits, for example:
  - Warmer homes → improved health
  - Cleaner air → improved health
  - More active lifestyles → improved health
  - Less congestion → productivity
  - GHG emissions reduced → avoided future costs
  - GVA and jobs supported

These outputs can be analysed:

- Nationally
- City-region by city-region
- Sector by sector
- Low carbon measure by low carbon measure

* 'Non-London Urban UK', see Key Definitions

Note: Our approach builds on established data sources e.g. PCAN models, ONS

"Low Carbon Measures": 500+ technology and behaviour changes which can decarbonise heat & buildings and transport

Our analysis focuses on how heat & buildings and transport, including distributed energy generation, can be decarbonised. Current policy and delivery efforts have succeeded in decarbonising electricity supply and parts of industry, with emissions decreasing by 65% between 2009 and 2019.[1] Although urban heat & buildings and surface transport account for over a third of total UK emissions, progress on decarbonisation in these areas has been slow to date (8% and 1% respectively over the same period). Hence, this analysis focus on these two sectors.

There is a consensus that changes in behaviour and/or greater adoption of low carbon technologies is needed to meet Net Zero targets. This transformation involves comprehensive and coordinated action by individuals, households, business, utilities, infrastructure and all parts of government. Our analysis considers over 500 technologies and behaviour changes which are available at scale today. These are referred to as "low carbon measures" and grouped into the 13 categories shown in the table.

Our analysis does not consider measures that are not widely available today, such as hydrogen transport or heating.

Table 1: Categories of Low Carbon Measure for heat & buildings and transport

Sector	Category
Buildings	Insulation
	Energy efficiency
	Heating efficiency
	Low carbon heat
	Behaviour change
	Microgeneration
Transport	Car trips to buses
	Car trips to cycling
	Car trips to walking
	More efficient logistics
	Electrification of private transport
	Electrification of bus network
	Electrification of freight

[1] Climate Change Committee (2021), Progress in reducing emissions 2021; Report to Parliament

The options for decarbonising domestic and public and commercial buildings are broadly similar

Energy consumption in buildings accounts for around 18% of the UK's total carbon emissions: seven categories of low carbon measure were considered across domestic, public and commercial buildings.

Domestic buildings

We model seven categories of low carbon measures for decarbonising bungalows, converted flats, houses (detached, semi-detached, end of terrace, mid-terrace) and purpose built flats (high rise and low rise):

- **Energy efficiency**: Upgrading gas ovens and appliances to energy efficient alternatives, gas hobs and ovens to induction alternatives, analogue to digital TVs, filament light bulbs to low energy lighting
- **Insulation**: Installing insulation (cavity wall, external wall, floor, internal wall, loft), draught-proofing, top up loft, triple glazing
- **Heating efficiency**: Upgrading storage tanks and conventional boilers to gas combi-boilers, tank insulation, thermostats, radiator valves
- **Low carbon heat**: Replacing storage tanks and conventional boilers with heat pumps, use of solar thermal
- **Microgeneration**: Solar PV
- **Scale and scope domestic Measures**: Whole house / apartment retrofit, district heating network
- **Behaviour change**: Lowering thermostats, reducing heating for washing machines, reducing household heating by 10C, reducing standby consumption, turning unnecessary lighting off

Public and commercial buildings

We model six categories of measure of low carbon measures for decarbonising offices, retail space, industrial/warehouse units, community centres, education and healthcare spaces, and hotels:

- **Energy efficiency**: Increasing energy efficiency of lightbulbs, daylight and movement sensors, increasing efficiency of technology (e.g. variable speed pumps, chillers)
- **Heating efficiency**: Upgrading boilers to 95% efficiency, using heating controls, heat recovery, increasing efficiency of technology (e.g. DC drive fan coils, chilled beams)
- **Low carbon heat**: Installing solar thermal or replacing gas boilers with air source heat pumps
- **Insulation**: Increasing air tightness, replacing single with double glazing, external shading, improving insulation
- **Microgeneration**: Solar PV, installing a wind turbine
- **Scale and scope commercial Measures**: Area based commercial PV installation, area-based commercial retrofit scheme.

The options for decarbonising surface transport are based on the principles of "Avoid, Shift and Improve"

Surface transport contributes to 22% of the UK's total carbon emissions. On average, every person in the UK makes 2,000 trips per annum of which 55% are in petrol or diesel cars. Heavy and light commercial vehicles travelling through our cities contribute 32% of transport emissions and have wider implications for our roads and the quality of the air we breathe.

Our analysis focuses on intra-city transport most prevalent in towns and cities across the UK:

- Cars and taxis
- Heavy and light commercial vehicles
- Buses and coaches.

The options for decarbonising these forms of transport are assessed using the **A**void, **S**hift, and **I**mprove framework. The modelling focuses mainly on Shift and Improve - total trip levels are assumed not to fall markedly (e.g. in a mass working from home scenario). However, we do consider the impact of avoidance of some freight mileage, by improving logistical efficiencies.

Rail, metro and tram transport are not considered. These make up 2% of journeys in most UK cities, but 15% in London.[2]

Avoid - Improving the efficiency of the transport system, including integrated land-use planning and transport to reduce trip length

More efficient logistics - Improving logistics efficiency by better route planning or combining trips for multiple purposes

Shift - Moving from the most energy consuming urban transport modes towards more environmentally friendly modes

Car trips to walking - Walking generates no emissions so shifting to it reduces carbon emissions from trips otherwise taken by car

Car trips to cycling - Cycling generates no emissions so shifting to it reduces carbon emissions from trips otherwise taken by car

Car trips to buses - Buses generate emissions but lower energy consumption and higher occupancy mean emissions per passenger-km are lower than cars.

Improve - Enhancing the energy efficiency of transport modes, taking advantage of alternative energy use

Electrification of private petrol and diesel vehicles - Petrol and diesel vehicles generate emissions on every journey and electrification provides an opportunity for the energy used to be generated via renewable sources

Electrification of distribution vehicles (HGV, OGV1 and OGV2) - Electrifying vehicles typically run on petrol or diesel provides an opportunity for the energy used to be generated via renewable sources

Electrification of buses and coaches - Electrifying buses and coaches previously run on petrol or diesel provides an opportunity for some the energy used to be generated via renewable sources

[2] NTS9903: Average number of trips (trip rates) by main mode, region and Rural-Urban Classification: England, 2018/19

‘Scale and scope LCMs’: Low carbon measures that are large in scale and/or diverse in scope can offer cost advantages

Some low carbon measures are large in scale and/or diverse in scope. These measures can abate more CO2 per £ because of their economies of scale and/or scope

Large-scale measures can meet the needs of multiple people at the same time: A neighbourhood-wide installation of heat pumps could bulk-buy and employ retrofit engineers on long-term rates, so each heat pump installed would be cheaper than its individual equivalent.

Diverse measures work together to increase effectiveness: In a whole house retrofit, the heat pump works more cost-effectively alongside insulation and thermostats.

Given that each city-region is unique in terms of urban typology, flexibility in deployment of large-scale and / or diverse LCMs is required to deliver the greatest value for money in terms of emissions reduction and social value.

A place-specific scenario allows each city region to adopt the most socially cost-effective combination of low carbon measures, including those which are large in scale or diverse in scope.

Illustrative examples of low carbon measures which vary in terms of scale or scope

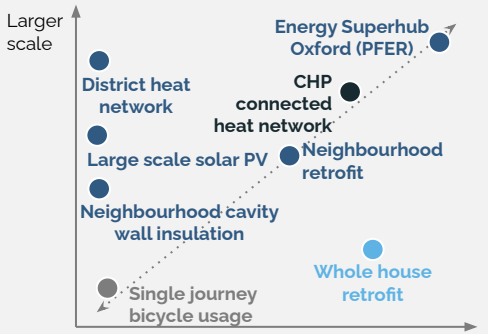


Table 2: List of ‘scale and scope’ low carbon measures modelled

	Economies of scale	Economies of scope
Domestic buildings		
District heat network	●	○
Low energy apartment retrofit	●	●
Whole house retrofit	○	●
Commercial and public buildings		
Area-based commercial retrofit scheme	●	●
Area-based PV installation	●	○
Transport		
Bike sharing scheme	●	○
Electric vehicle sharing scheme	●	○
Integrated logistics*	○	●

*See technical annex for further details

Our analysis estimates the financial costs and benefits of each Low Carbon Measure between 2022 and 2050 ...

Our modelling estimates the incremental cost of reducing a unit of carbon emissions.

The costs of a low carbon measure are the capital investment and all ongoing (changes in) operating costs (including labour).

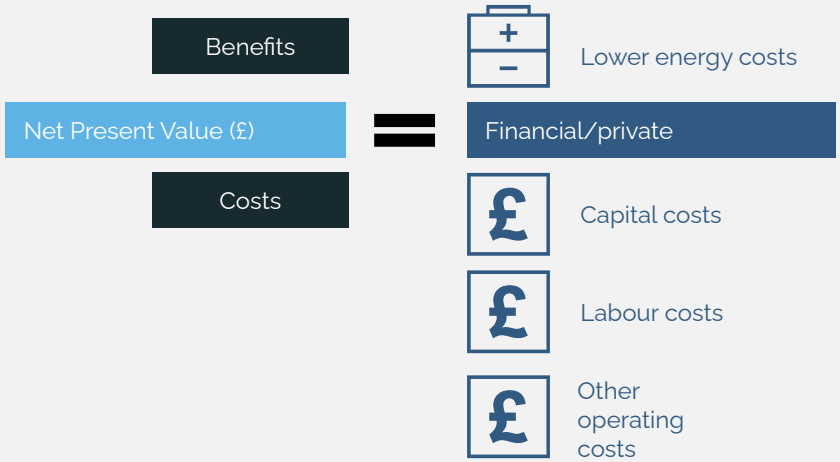
Benefits are estimated in terms of the reduction in energy costs and any change in operating cost. Both are estimated in terms of their Net Present Value (NPV). The calculation is as below:

Marginal abatement cost = − Net Present Value (£) ÷ Abatement of emissions (kgCO2e)

Excluded are:

- Enabling programmes costs to promote uptake of low carbon measures (e.g. setting up a local delivery framework, heat pump awareness schemes)
- Enabling infrastructure costs not directly aligned to low carbon measures e.g. new power plants, battery storage and smart grids
- Workforce and supply chains upskilling costs for delivery

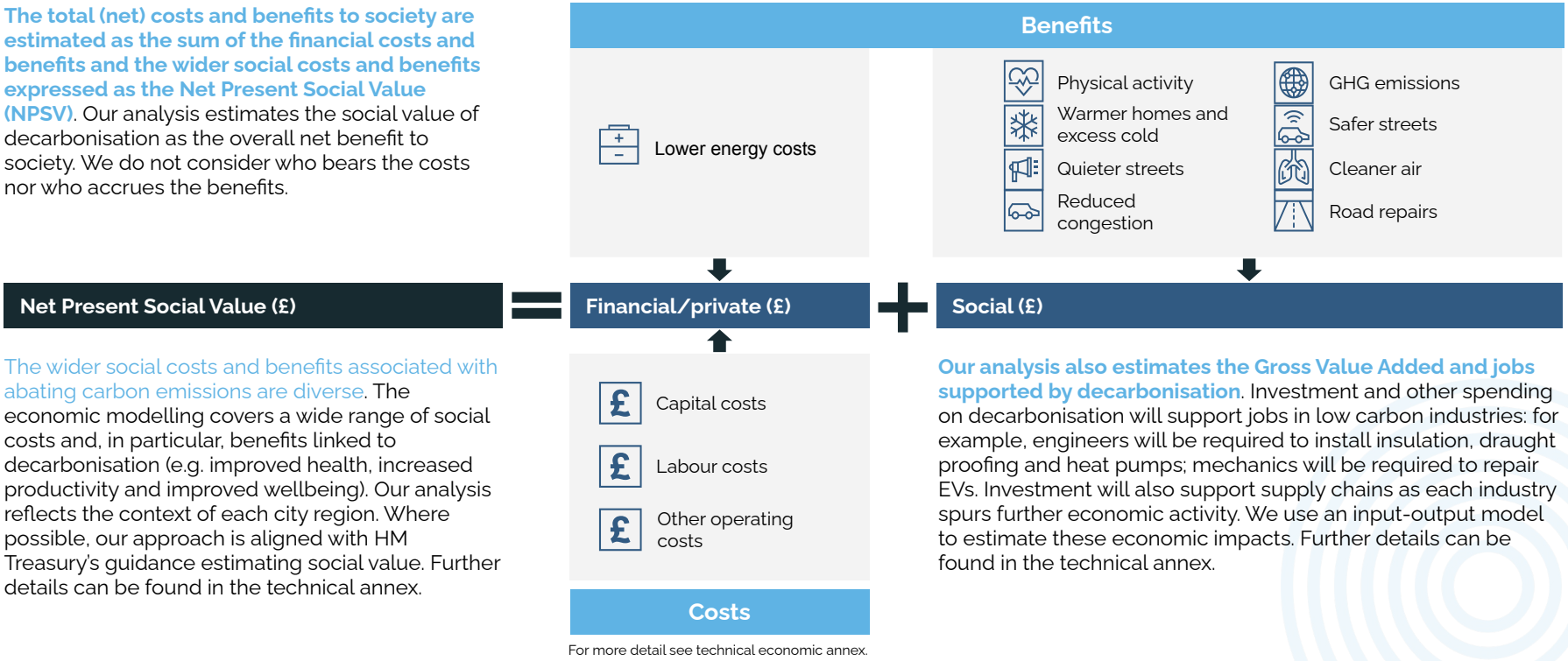
Our central estimates assume that real prices (e.g. of technologies and labour) remain unchanged over the assessment period (2022 to 2050). As the scale of the transition may create market imbalances, our analysis tests the sensitivity of our results to changes in key variables**.



* Net Present Value, see Key Definitions
**For more detail see technical economic annex

...as well as the wider social costs and benefits in each city region

The total (net) costs and benefits to society are estimated as the sum of the financial costs and benefits and the wider social costs and benefits expressed as the Net Present Social Value (NPSV). Our analysis estimates the social value of decarbonisation as the overall net benefit to society. We do not consider who bears the costs nor who accrues the benefits.



For more detail see technical economic annex.

The wider social costs and benefits associated with abating carbon emissions are diverse. The economic modelling covers a wide range of social costs and, in particular, benefits linked to decarbonisation (e.g. improved health, increased productivity and improved wellbeing). Our analysis reflects the context of each city region. Where possible, our approach is aligned with HM Treasury's guidance estimating social value. Further details can be found in the technical annex.

Our analysis also estimates the Gross Value Added and jobs supported by decarbonisation. Investment and other spending on decarbonisation will support jobs in low carbon industries: for example, engineers will be required to install insulation, draught proofing and heat pumps; mechanics will be required to repair EVs. Investment will also support supply chains as each industry spurs further economic activity. We use an input-output model to estimate these economic impacts. Further details can be found in the technical annex.

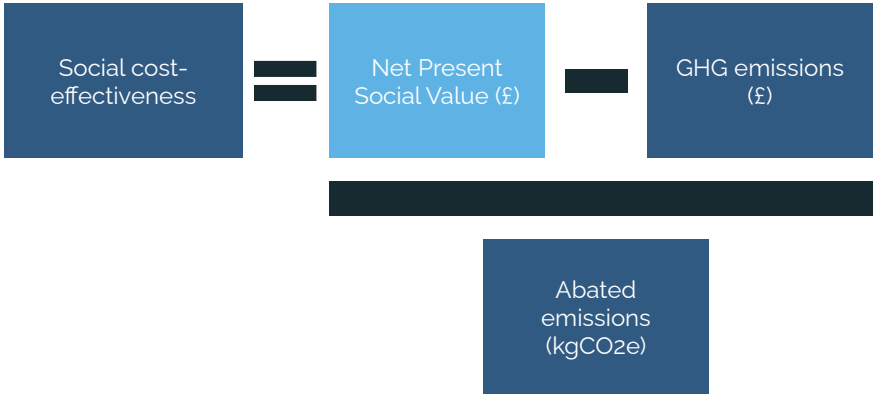
A key element of the economic modelling is the assessment of the social cost-effectiveness of different low carbon measures

Analysis of the costs and benefits of different approaches to decarbonisation is based on estimating the social cost-effectiveness of different low carbon measures in different places. An integral part of our analysis is the relative cost-effectiveness of different low carbon measures in different places in abating carbon emissions.

The cost-effectiveness of a low carbon measure is defined as as:

> The NPSV of a low carbon measure is the present value of its capital and operating costs, energy savings and wider social costs and benefits (excluding GHG emissions*) divided by the amount of carbon abated

As part of our scenario analysis, the low carbon measures are ranked in terms of their relative cost-effectiveness.



*The value of the GHG emission reduction benefit is removed from NPSV in the assessment of cost-effectiveness to avoid it being on both sides of the equation

It is important to be clear what the economic modelling includes, and excludes, as well as distinctive features and underlying assumptions and limitations of scope

	Financial costs and savings	Wider social costs and benefits
What we modelled (1) Established carbon abatement technologies (2) Diverse city-regions with various urban typologies (3) Emissions reductions in line with Sixth Carbon Budget	**Buildings** • Cost of installing low carbon measures • Energy savings from more efficient measures **Transport** • Costs of EVs (cars/buses/freight) • Cost of building linked infrastructure, e.g. bus/bike lanes, charging infrastructure • Operational costs of new bus services • Maintenance costs of vehicles and bikes • Net difference in fuel vs electricity and maintenance costs by different transport modes	**Benefits** • Improved air quality • Reduced noise pollution • Increased home warmth and fewer winter deaths • Physical health benefits from active travel • Safer streets (fewer accidents) and lower spend on road repairs • Improved journey times and journey quality • Reduced GHG emissions • Local GVA and jobs **Costs** - some of these benefits could also be costs, but all are *net* benefits, e.g. more buses but fewer cars → more / fewer accidents
What we excluded	• Other sectors, such as energy production, waste, industry, agriculture or land use • Impact of any changes in prices/wages • Cost of enabling programmes to promote uptake of low carbon measures • Enabling infrastructure not directly aligned to measures e.g. smart grids, battery storage • Policy costs (e.g. to implement the Delivery Framework) • Skills & supply chain development	• Embodied carbon (and other externalities) in low carbon measures, biodiversity/natural capital • Any first mover/agglomeration effects (e.g. linked to international competitiveness) • Any indirect, longer term impacts on urban form which result from deployment of low carbon measures (e.g decreased journey times). • Distributional considerations (e.g between public and private sector, sectors, households etc.)

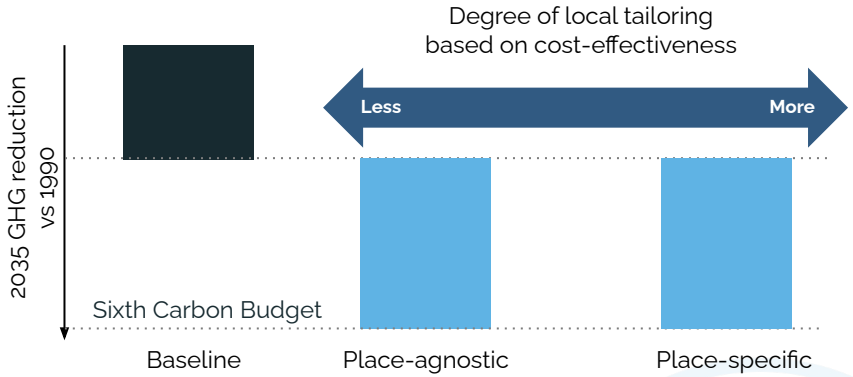
Notes: (1) All of the costs are 'net' - i.e. we do not consider the total cost of an EV or heat pump but the additional cost vs an ICE car or gas boiler replacement. (2) These cost modelling approach is comparable to that considered in the Net Zero Strategy, i.e. *"in-year capital expenditure requirements, excluding financing costs, and do not cover operational costs or savings, or policy costs". (p327)*

Our analysis considers the cost-effectiveness of different combinations of Low Carbon Measures under four scenarios

Our analysis focuses on how the overall costs and benefits of different combinations of low carbon measures vary depending on how the combinations are selected. Three scenarios were developed:

- **Baseline** - uses BEIS' current forecasts of GHG emissions from heat & buildings and transport, updated to reflect pre-Net Zero Strategy policy commitments.
- **Place-agnostic** - adds low carbon measures to the baseline in line with the deployment paths set out for heat & buildings and surface transport in the Net Zero Strategy (e.g. additional heat pumps, insulation, increased cycling, electric buses). Assumes uniform adoption of LCMs based on deployment potential, rather than local choice - this is not stipulated in the NZS.
- **Place-specific** - achieves the same reduction in carbon emissions as the place-agnostic scenario but allows each city region to adopt the most socially cost-effective combination of low carbon measures, including those which are large in scale or diverse in scope (e.g. whole house retrofit).

Figure 1: Carbon reduction is the same under both scenarios



Note: The place-agnostic and place-specific scenarios represent different ends of a spectrum which reflects the degree of local tailoring based on cost-effectiveness. No scenario is indicative of current government policy and none should be considered a 'realistic' scenario. However, the gap between the different costs and benefits that arise under each scenario demonstrates the size of the prize, and highlights the importance of the Delivery Framework to address issues related to technical feasibility, availability, awareness and consumer preferences.

Place-agnostic scenario

Under the place-agnostic scenario, each city-region is assumed to adopt low carbon measures roughly in line with the deployment paths set out for heat & buildings and surface transport in the Net Zero Strategy (e.g. additional heat pumps, insulation, increased cycling, electric buses). The pattern of adoption is assumed to be proportionately the same across city regions, based on their local characteristics, which the NZS does not stipulate.

The level of carbon abatement by 2035 under this scenario aligns to the Sixth Carbon Budget and is the same as the place-specific scenario.

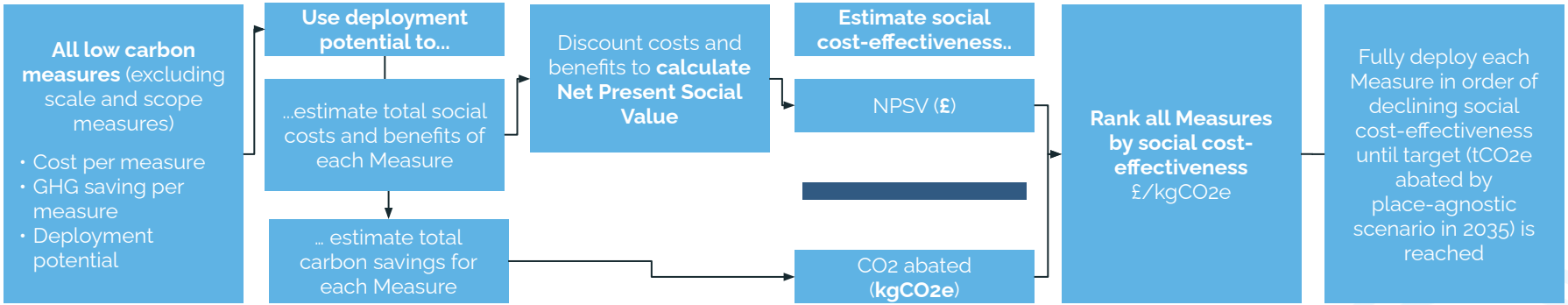
Table 3: Deployment levels of low carbon measures under the place-agnostic scenario

Sector	Category of Low Carbon Measure	Unit	Increase in deployment vs baseline
Public and commercial buildings	Energy efficiency	% floorspace with new Measures	6%
	Heating efficiency	% floorspace with new Measures	86%
	Low carbon heat	% floorspace with new Measures	23%
	Insulation	% floorspace with new Measures	1.4%
Domestic buildings	Insulation	New Measures per home	1.2
	Low carbon heat	New Measures per home	0.26
	District Heat Networks	New Measures per home	0.03
Transport	Car trips to cycling	Trips shifted	2%
	Car trips to buses	Trips shifted	17%
	Car trips to walking	Trips shifted	10%
	Electrification of private transport	Trips improved	14%
	Electrification of bus network	Trips improved	46%
	Electrification of freight	Trips improved	37%

Place-specific scenario

Under the **place-specific scenario**, each low carbon measure is ranked in terms of its social cost-effectiveness (NPSV). Each city region is assumed to deploy the most socially cost-effective low carbon measure until the required level of carbon abatement is achieved. The financial costs and benefits of an individual low carbon measure (e.g. an installed heat pump) do not differ by place*, but both the social costs and benefits and the deployment potential do.

Figure 2: How the model deploys low carbon measures in each city under the place-specific scenario



The approach to the **place-specific scenario** assumes city-regions to be able to deploy scale and scope low carbon measures where the potential exists to adopt them and they are socially cost-effective. In each place, each low carbon measure is deployed in rank order until the target level of carbon abatement is reached.

As a result of this process, under the place-specific scenario, each city will have a different deployment profile from the place-agnostic scenario (previous page) or from each other..

*In transport, there is some variance but it is minimal compared to differences in deployment potential

Glossary

Term	Definition
Low carbon measures (LCMs)	Individual measures that reduce emissions via changes in technology - such as switching to an EV, or installing insulation - or behaviour - such as lowering thermostats or walking.
Place-agnostic scenario	Deployment of LCMs uniformly across places (e.g. all places contribute a proportionate share of the UK target of installing 600,00 heat pumps a year) to a level consistent with the 6th carbon budget targets for buildings and transport
Place-specific scenario	Deployment of LCMs in a way that meets the 6th carbon budget targets by allowing each place to adopt the most socially cost-effective combination of measures (e.g. a city with older buildings may focus first on insulation and glazing)
Carbon emissions	Emissions of carbon or other GHGs expressed as CO_2 equivalent (CO_2e)
Costs	Capital investment in low carbon measures (e.g. heat pumps, EVs, bikes) and costs of operating them (e.g. repairs, bus drivers) or enabling them (e.g. bus lanes, bike lanes, charging infrastructure).
Energy savings	Financial savings from reduced energy or fuel usage
Net Present Value (NPV)	The sum of the stream of costs and energy savings that has been discounted to bring them to a present value
Wider social costs and benefits	The wider costs and benefits associated with decarbonisation that accrue to society but are not reflected in the financial costs and energy savings of adopting low carbon measures, e.g. avoided congestion, air pollution, improved health.
Net Present Social Value (NPSV)	The net present value of the sum of the stream of costs, energy savings and wider social costs and benefits after discounting
Financial cost-effectiveness	The NPV of the capital and operating costs and energy savings per unit of carbon emissions abated - this is a measure of the unit cost (or benefit) of abating carbon
(Social) cost-effectiveness	The NPSV of the capital and operating costs, energy savings and wider social costs and benefits per unit of carbon emissions abated - this is a measure of the social unit cost (or benefit) of abating carbon
Non-London Urban UK	All towns and cities outside London, including urban, suburban and peri-urban populations, as defined by two main criteria: population (i.e. areas forming settlements with populations of over 10,000) and accessibility, commutable distances equating broadly to areas within a 30 minute drive of a settlement. This accounts for 70% of the UK population.
Deployment potential	A measure of how feasible it is to deploy a low carbon measure in a given area. Limiting factors may be technical (first floor flats cannot have ground source heat pumps) or behavioural (the average person does not cycle more than 2.7 km per day).

2

Economic Findings

What this section contains

This section summarises the results of the economic modelling. The results demonstrate three key 'drivers' which together prove the key finding of section 2 of the summary report: **that the social cost-effectiveness of different portfolios of low carbon measures can be optimised for each city-region**.

Drivers

1. The **deployment potential** of low carbon measures varies between city-regions
2. The **cost of decarbonisation*** varies by low carbon measure
3. The **social costs & benefits** vary by low carbon measure and between city-regions

Key finding

The **social cost-effectiveness** of different portfolios of low carbon measures can be optimised for each city-region

The results will be presented across four sections:

- **2.1** Overview of the place-agnostic scenario, and how it is (and is not) related to the government's strategy for getting to Net Zero in buildings transport
- **2.2** Three drivers: analysis of the economics of low carbon measures in city-regions
- **2.3** Scenarios: how to maximise the cost effectiveness of portfolios of low carbon measures
- **2.4** Cities: The potential benefits of choosing the most cost-effective portfolio in each city-region

Linked to this is a series of data points which supplement chapter 3 of the summary report: Blockers to the adoption of low carbon measures. Some measures are blocked for financial or economic reasons. The analysis sheds light on these through a series of case studies and sensitivity analyses

*Cost of decarbonisation refers to marginal abatement cost - see key definitions

2.1

Modelling Net Zero: The Place-Agnostic Scenario

Under the place-agnostic scenario, all cities deploy a similar mix of low carbon measures in the transport and buildings sectors

In developing the place-agnostic scenario, we took the projected baseline emissions of city-regions across the UK for heat & buildings and transport and added low carbon measures such as additional heat pumps, increased insulation and more active travel based on the deployment paths set out in the Net Zero Strategy.

Key point: The modelling is based on the Net Zero Strategy but should not be considered an accurate representation of it because:

1. We only consider two sectors, and within those, we exclude aviation, shipping (transport) and new-builds (buildings)
2. We only consider the 70% of the UK population that live in towns and cities outside of London

Table 4 shows what this looks like for our major low carbon measure categories for the average city*: these numbers represent the increase of each category deployed in the place-agnostic scenario versus the baseline by 2035. If successful this deployment would represent a significant shift in the way we live and move around cities. For example, by 2035, 55% of all urban journeys would be by bike or foot, and ~11m heat pumps would be deployed.

Table 4: Deployment of low carbon measures by category under the place-agnostic scenario (change from baseline scenario), in UK towns and cities*

Sector	Category of Low Carbon Measure	Unit	Increase in deployment vs baseline
Public and commercial buildings	Energy efficiency	m^2 with new Measures	6%
	Heating efficiency	m^2 with new Measures	86%
	Low carbon heat	m^2 with new Measures	23%
	Insulation	m^2 with new Measures	1.4%
Domestic buildings	Insulation	New Measures per home**	1.2
	Low carbon heat	New Measures per home	0.26
	District Heat networks	New Measures per home	0.03
Transport	Car trips to cycling	Trips shifted	2%
	Car trips to buses	Trips shifted	17%
	Car trips to walking	Trips shifted	10%
	Electrification of private transport	Trips improved	14%
	Electrification of bus network	Trips improved	46%
	Electrification of freight	Trips improved	37%

*"Non-London Urban UK", see Key definitions; note that scale and scope public and commercial measures are not shown here
**The total number of LCMs deployed in each city divided by the number of homes, i.e. the average home will install 1.15 insulation Measures such as cavity wall, loft, draught-proofing

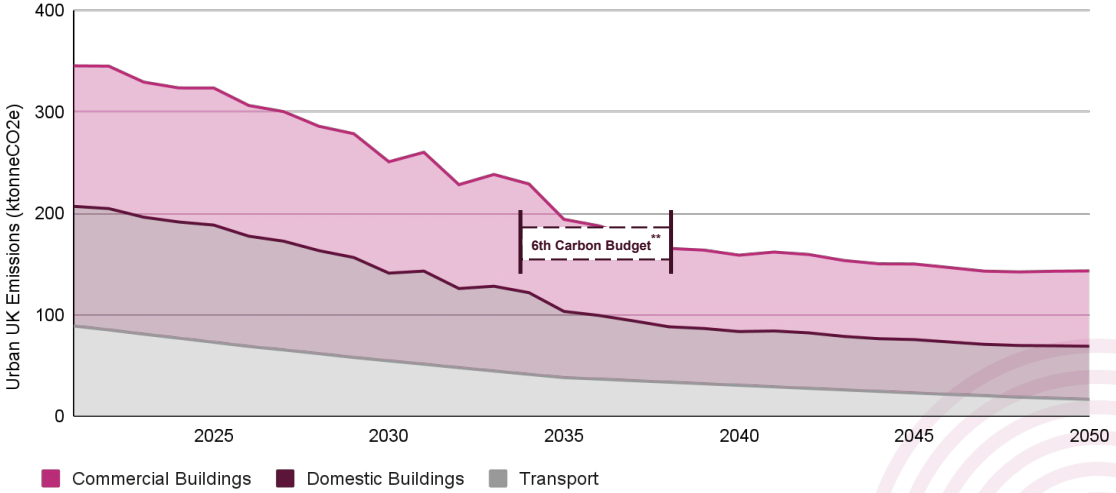
The abatement that would be achieved in these sectors would be in line with the Sixth Carbon Budget

The place-agnostic scenario aligns with the emissions targets set for heat & buildings and transport in the Net Zero Strategy. This provides a long term pathway for the UK to reduce emissions in line with the targets in the Sixth Carbon Budget (2033 - 2037), building towards Net Zero by 2050. The Net Zero Strategy recognises the need to "transform our cities and towns with greener, faster and more efficient transport" and also decarbonise the way we heat our buildings.

Using the deployment assumptions provided in the Net Zero Strategy, the model shows that towns and cities across **the UK can achieve their share of the Sixth Carbon Budget in 2037**.

We estimate the potential benefits of this transformation across UK towns and cities, and how these benefits vary depending on how far decarbonisation can be designed and delivered through integrated place-specific climate action.

Chart 1: Emissions from towns and cities across the UK under delivery of Net Zero Strategy vs Net Zero Strategy sectoral Sixth Carbon Budget for heat & buildings and transport*



*This is based on "Non-London Urban UK" which represents 70% of the population
**The box shows the targets for heat & buildings and transport in the Net Zero Strategy (pg.79) that will align with the Sixth Carbon budget target. The dotted lines represent the high and low ranges of these targets; the black lines, the budget years, 2033 - 2037

This would require significant investment which will be partly offset by significant associated energy savings

The place-agnostic scenario would require total investment of **£195 billion** between now and 2050 in transport and buildings, across the UK's towns and cities outside of London. If this is scaled up to include the whole of the UK, our results are broadly in line with the investment estimate in the Net Zero Strategy (£409 billion*).

We estimate that the cost of this investment would be partly offset by energy and operational savings of **£57 billion** - compared with ~£71 billion in the Net Zero Strategy**.

Table 5: Investment and energy savings from heat & buildings and surface transport in towns and cities across the UK under the place-agnostic scenario (2022 to 2050)

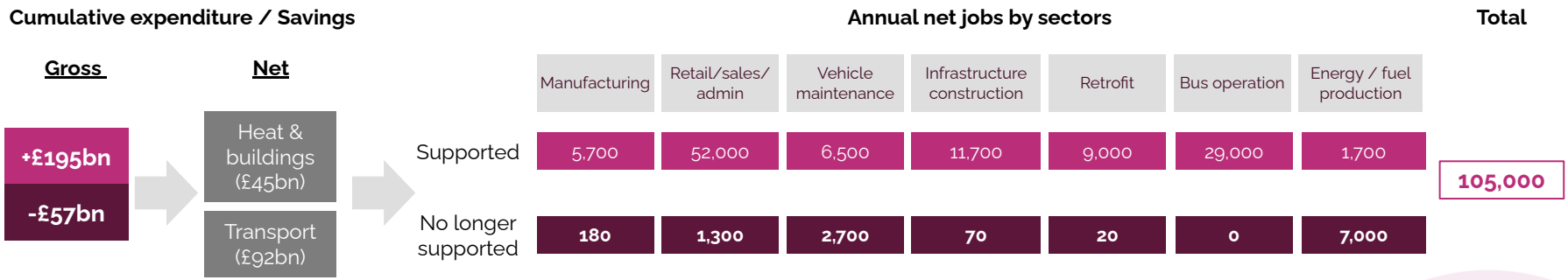
Category of Low Carbon Measure	Investment (£ billions)	Energy savings/costs (£ billions)
Transport		
Electrification of bus network	-£1.7	£5.6
Electrification of freight	£22.3	£6.5
Car trips to cycling	£0.3	£2.6
Car trips to buses	£96.7	£4.8
Electrification of private transport	£12.0	£7.1
Car trips to walking	£0.0***	£10.6
Heat & buildings (both domestic and public/commercial)		
Energy efficiency	£0.05	£1.2
Insulation	£50.4	£24.5
Heating efficiency	£1.4	£2.8
Low carbon heat	£13.1	-£7.6
District heating networks	£0.9	-£0.8
TOTAL	**£195**	**£57**

* Table 11, pg - note that the Net Zero Strategy figures include shipping, aviation and new buildings which our analysis exclude
** The Net Zero Strategy does not report sectoral resource savings, but allocating the total figure of £180 billion to transport and buildings on the same basis as investment (56%), and correcting for population (70%) = £71bn
*** We assume that walking is free

The investment will support jobs across the UK

This analysis finds that investment in the place-agnostic scenario would support an average of 105,000 net jobs per annum in UK towns and cities between 2022 and 2050. More jobs would be created in the next decade, reaching 235,000 by 2030 as investment peaks, before falling to 25,000 by 2050. By this point, it is assumed that both heat & buildings and transport are fully decarbonised though net jobs remain in public transport and maintenance.

Figure 1: GVA and job impacts - Place-agnostic scenario



This analysis uses cost and energy savings figures for each low carbon measure deployed in the place-agnostic scenario to model how many jobs would be supported and would lack support in each sector as a result of the change in expenditure. The analysis covers the UK as a whole; it does not apportion jobs to local areas. The results are subject to various uncertainties including future technology changes and, therefore, should be treated with caution.*

The Net Zero Strategy contains broadly similar estimates finding that, by 2030, 175,000 jobs will be supported in Heat & Buildings and 74,000 in Transport (249,000). These numbers are based on a different methodology: estimates made by different industry groups as part of the Green Jobs Taskforce, based on their assumptions about the UK's net zero transition - though prior to the publication of the Net Zero Strategy.

*We use input-output tables to estimate direct and indirect jobs based on local deployment of LCMs. Most home retrofits are likely to be carried out by local tradespeople - but not others - increased EVs will not lead to local manufacturing jobs except in places like Oxford and Sunderland where EV factories are located. Uncertain assumptions include the breakdown of costs across industries, the extent to which how much of each technology will be produced in the UK in future years, and the limitation of I-O models to incorporate changes to prices or economic structures over time. See technical annex for more information on methodology.

2.2

Three Drivers:
The Economics of Low Carbon Measures

The deployment potential of low carbon measures varies by city-region...

1

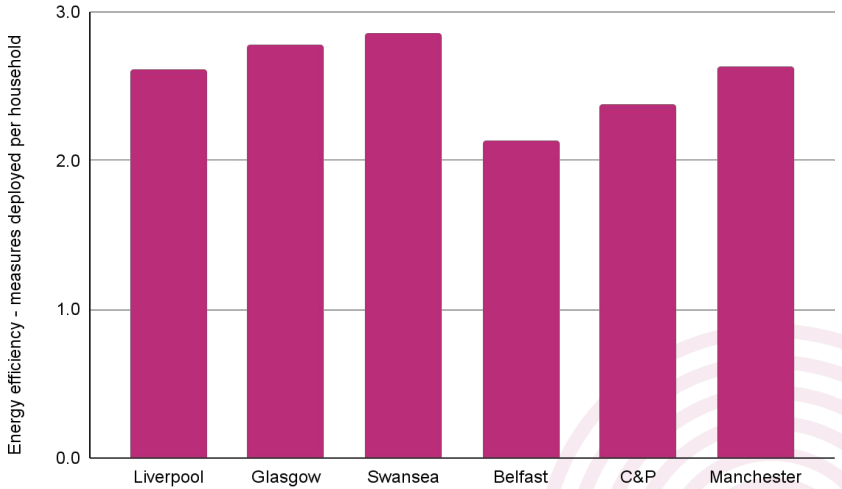
As discussed on page 30 of the summary report, opportunities to reduce emissions vary from place to place

The built environment varies across the UK, and therefore it follows that the 'deployment potential' - the number or scale of a low carbon measure that it is feasible to deploy in a given area - of each area differs. For example, in an area with a high proportion of new build properties, many homes will already have energy efficient appliances and will not be able to deploy this low carbon measure. The chart shows how this low carbon measure varies across the six cities studied.

Given that there are big differences in the costs and abatement capacity of different measures (see previous slides), limitations in deployment potential mean that not all city-regions will have the scope to pursue the same decarbonisation pathways at the same scale, and this may define the success of their chosen strategy in reducing emissions or costs.

For example, energy efficiency measures have a low initial investment cost and offer long term savings that exceed their costs, so should require no government subsidy to encourage uptake. However, their emissions abatement potential is relatively low. For places like Swansea with higher deployment potential, energy efficiency measures represent a quick win, but still a very small proportion of total emissions.

Chart 2: The deployment potential of 'Energy efficiency' low carbon measures in the domestic buildings sector, per household



...and the deployment of 'scale and scope' measures is even more place-specific

1

The opportunity to deploy measures which are large in scale and/or diverse in scope depends on several local factors, for example, how much the population cycles (bike-sharing schemes) or the presence of surplus heat (heat networks: see below).This means that opportunities to deploy these economic low carbon measures varies between places.

As discussed on page 31 of the summary report, opportunities to deploy LCMs that are large scale or diverse in scope are highly place-specific

Case Study: District heat networks

A district heat network is a distribution system of insulated pipes that takes heat from a central source and delivers it to multiple households.

It is potentially large in scale. District heat networks benefit from economies of scale: the more households that are connected to a district heat network, the lower the average cost per household. This means that the cost-effectiveness and carbon-saving potential of these networks increases as they connect to more homes. A district heat network has the ability to replace several other low carbon measures, for example the installation of heat pumps in individual houses.

£130 / MWh air source heat pump **£92 / MWh** district heat network

The Net Zero Strategy has set ambitions for heat networks in the UK. Currently, heat networks supply 3% of heat demand in the UK. The ambition of the Net Zero Strategy is to increase this to 20% by 2050.

The marginal abatement cost of district heat networks can be highly place-specific and depends on:

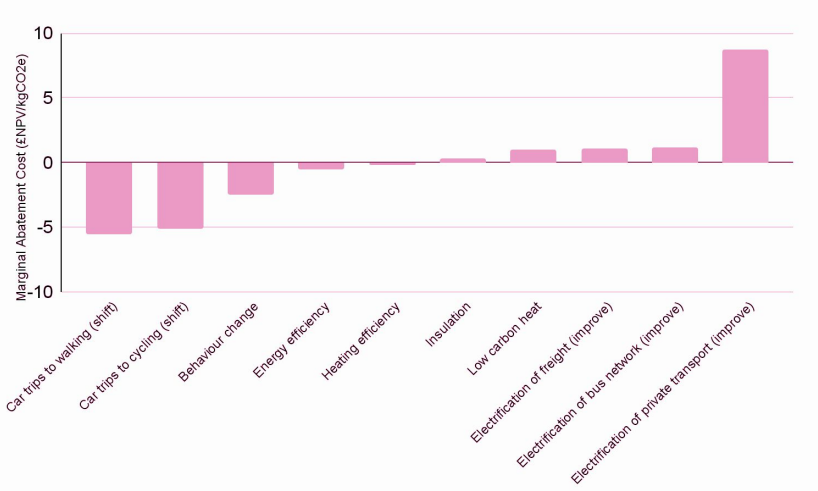
The size and location of the district heat network	Heat networks in areas of higher housing density have a lower investment cost per unit of heat.
The heat source for the district heat network	If the heat source is waste heat, then the incremental carbon emissions of the district heat network will be minimal. For example, the new energy centre for Bunhill Heat and Power Network in Islington, London extracts waste heat from the London Underground network.

There are significant variations in the marginal abatement cost of different low carbon measures...

2

Public and private investment is essential to transition to Net Zero. Decarbonising heat & buildings and transport will require investment in low carbon measures, and most of these will also give rise to potential savings in future energy costs. The sum of these costs and benefits divided by emissions abated is the marginal abatement cost (MAC).

Chart 3: MAC-curve for full-deployment of LCMs, by category



Reminder: Marginal abatement cost is a measure of the financial unit cost (or benefit) of abating each unit of CO2e.

Different low carbon measures have different marginal abatement costs. A negative marginal abatement cost means that energy savings more than offset the investment and operating cost because either the costs are low (zero in the case of walking) and/or the expected energy savings are high. Some low carbon measures have a negative marginal abatement cost but the opportunity to deploy them is limited. Equally, other low carbon measures such as heat pumps which do not pay for themselves may be integral to the long term goal of Net Zero as there are few other technologies deployable at similar cost and scale.

Box 1: Shifting journeys from cars to buses

Although public transport can offer cheaper travel for many commuters, the overall service is costly to run: bus systems have significant capital and operating costs which are usually subsidised by local government.

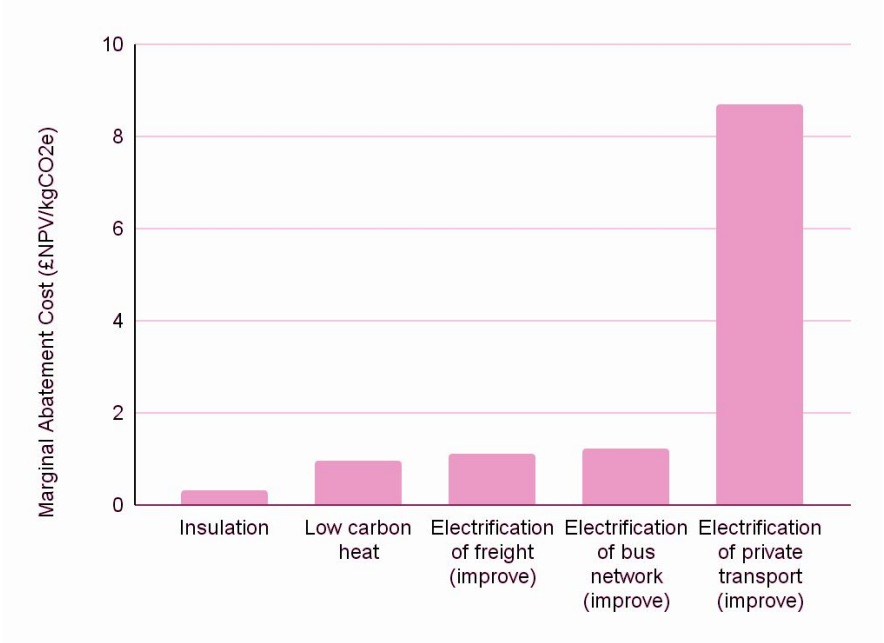
Although changing, diesel buses are still the most common type of bus in the UK and typically cost £250,000 per vehicle. In addition to the capital cost of the bus, infrastructure may be required (bus lanes, stops) and the operator also incurs operating costs. Many of these costs - such as maintenance and fuel - are lower per passenger than private vehicle use, but over 50% of opex is employee wages*. Because there are already so many cars already in use, this means that the marginal abatement cost of shifting journeys from petrol and diesel cars to buses is approximately 10 times higher than a switch to EVs.

*See CPT cost index

...and in some cases the energy savings gained from low carbon measures are less than the investment cost

2

Chart 4: Low carbon measures where the investment cost exceeds the expected energy savings (2022-2050)



The financial benefits of some low carbon measures exceed their costs. low carbon measures such as cycling to work rather than driving offer potential energy savings on fuel which exceed the initial cost of a bicycle and its accessories. Similarly, in homes, energy savings can be realised by switching to more energy efficient light bulbs.

Other low carbon measures do not reap returns yet. In some cases, the energy savings of low carbon measures are expected to be less than their costs. Where the costs of a low carbon measure exceed the expected benefits, this creates a potential blocker to their deployment.

Note: This analysis is based on reaching the Sixth Carbon Budget, or 78% reduction of 1990 emissions, but not Net Zero. The remaining 22% of emissions may be more costly to abate, but future changes in costs and technologies mean this is highly uncertain

The costs of some technologies, such as solar, have reduced rapidly and significantly over time as adoption has increased. If this trend continues, upfront investment costs will likely decrease to a point where they no longer exceed expected benefits.

As discussed in chapter 3 of the summary report, there are many reasons why low carbon measures are blocked, and a lack of financial payback is a key one

… but to meet emissions targets, all cities will have to deploy many measures where the costs outweigh the savings

2

In the decarbonisation of buildings, there are currently few available alternatives to heat pumps. While district heating, and electric and hydrogen boilers will all play a role, heat pumps are projected to be responsible for the largest proportion of emissions reductions: the Net Zero Strategy assumes rollout in between 7 and 11 million homes in the UK by 2035.

But due to both the installation cost and the running costs, replacing a gas boiler with a heat pump is currently a net loss for homeowners in almost all circumstances (see chart 6 on next page).

Some heat pumps are more loss-making than others. This analysis finds that while it is cheaper to install smaller heat pumps in smaller properties, the net savings (from using less gas)* will be less than that for larger properties. This means that on average, larger homes experience higher (though still negative) net present values.

In addition, different cities have a different mix of small and large homes, meaning that the aggregate return on investment of heat pumps varies by city (see chart). The data suggests that heat pumps are most economical in detached homes, which make up 37% of Swansea homes, vs 20% in Manchester.

Chart 5: Net cost of switching from gas boiler to heat pump across city regions (£m, NPV)

*.Based on long-run variable costs in 2021, see HMT Green Book guidance, tables 1-19

Note that there are also likely to be local differences in the cost of labour and parts in different city-regions which this analysis does not consider

Deep Dive: Cost of Energy
The cost of electricity is a major blocker to the decarbonisation of heat & buildings

2

Heat pumps are a long-established technology, but in the UK gas boilers dominate the market, with ~25m boilers vs 250k heat pumps. Consumer uptake is slowed by a lack of information and unfamiliarity - heat pumps are not a like-for-like replacement for boilers - but the main blocker preventing wide scale deployment is likely to be cost. As shown on the previous slide, this is due to (1) higher upfront capital costs and (2) higher energy costs

Heat pump cost: In all scenarios modeled, the price of heat pumps starts at between £9-17,000 more expensive than a gas boiler but, in keeping with projections in the NZS, this reaches parity by 2030 meaning that, all else equal, by this date, the typical homeowner would make a purchase decision based on the running costs of a heat pump vs a boiler alone*. It is assumed that significant heat pump rollout takes place from 2022, so there would still be an extra cost associated with heat pumps, but over 30 years this would average ~£4000 per household. However, if the price of heat pumps does not fall (scenario 1 on chart 6), the cost would be closer to £12 000.

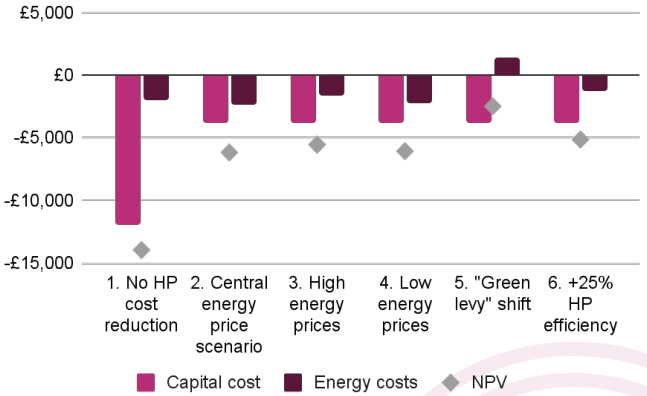
Energy costs: Heat pumps save gas and use electricity. But electricity is currently 5 times more expensive than gas per unit of energy. Because this ratio is projected to remain constant - i.e. electricity and gas prices are projected to rise or fall in tandem** - future energy shocks like the one experienced in late 2021 are not likely to alter the overall economics of a heat pump - as shown by scenarios 1-3 on chart 6.

However, changes that affect the cost of electricity *relative* to gas may have an impact. The price of energy is largely set by global markets, but the Government also adds taxes which are used to subsidise renewable energy, nuclear power and carbon abatement. These 'policy costs', or 'green levies', currently account for ~25% of the price of electricity but only ~2% of gas. Scenario 5 shows that if this burden was raised entirely by taxing gas - an option that has been considered by policy makers[3] - it would make heat pumps cheaper to run than boilers in all cities. However, the savings - typically less than £100 a year - would not be enough to cover the extra capital cost.

Innovation: Despite being a mature technology, it is possible that the large increase in demand for heat pumps over the coming years leads to product innovation that improves their energy efficiency. Scenario 6 shows that while a 25% increase in electrical efficiency would lead to a ~45% decrease in energy costs over the appraisal period, this would not have a significant impact on the trade-off with a boiler, since as would remain cheaper.

This is an example of a financial blocker to households and, to a lesser degree, a motivational blocker

Chart 6: The capital and running costs from 2022-2050 of replacing a boiler with a heat pump***



* The NZS also announced government subsidies for heat pumps but these are an intra-societal transfer, so are not modelled in this analysis
** BEIS projections (tables 1-19) of the long-run variable cost of energy. The retail price paid by households includes margins and other costs and is higher, but this does not alter the overall analysis.
*** In an end-terrace house, for illustration
[3] Financial Times, Sep 21

Deep Dive: Payback of different LCMs

LCMs have a significant range in upfront capital investment, with LCMs paying back more rapidly including draft proofing

2

Britain's housing stock is old and draughty and insulation provides a simple, long-lasting way to reduce emissions and energy costs. Installation can be intrusive, but once installed, no action is required, so most purchase decisions are likely to be made on financial grounds.

Installation costs range from £300 for loft insulation in a small house to £17 000 for the internal walls of larger homes. Energy savings also vary by property type but are rarely significant: payback periods range from one year to >50 years. Given that improving a property's energy efficiency has been found to have little effect on its price[4], there is limited incentive for the typical cash-constrained household to invest in insulation.

This creates a **market failure**: insulation does *eventually* have a positive NPV (50 years is an acceptable time horizon for government). It also has the added social benefits of reduced carbon emissions and warmer homes, both of which are of value to government. In theory, government could provide homeowners with a 0% loan, with repayments based on projected energy savings[5]. In practice government, and particularly local government, do have budget constraints: the place-agnostic scenario (based on the NZS) requires £50bn investment across UK towns and cities in insulation alone.

Innovation and prices: Today's electric vehicles have similar economics as insulation*: high upfront costs that are greater than the subsequent fuel savings. But while EV costs are likely to fall in the coming years as the technology improves, the price of insulation may instead rise.

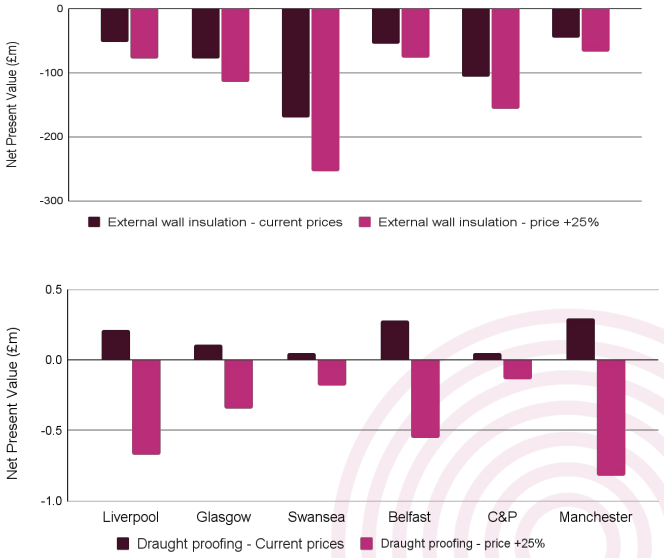
At the end of 2021, UK inflation reached a 10 year high of 4.2%, with construction prices up 23.5%[6]. The Construction Leadership Council estimates that the task of retrofitting the UK's 28 million homes will require a further 500,000 retrofit engineers[7]. If this supply remains unmet, it is likely that labour costs will rise

Chart 7 shows the impact of a 25% increase in buildings prices across six cities. This has a significant impact on the NPV of all measures and for some, such as draught proofing, it outweighs the energy savings.

This is an example of a financial blocker to households, which is also a market failure

Chart 7: Change in NPV for different types of insulation based on current and inflated buildings prices

(1) External wall insulation (2) Draught proofing measures



[4] FT adviser, Sep 2021 [5] Various such public and private mechanisms have been suggested - see Sorrell 2019 [6] BEIS, Sep 2021, Monthly Statistics of Building Materials and Components [7] CLC 2021 - Greening Our Existing Homes: National retrofit strategy * Although different investment criteria are made in respect to vehicles that also have a high utility value - it is more fun to own a car than to own insulation.

Scale and scope measures have even more favourable marginal abatement costs

2

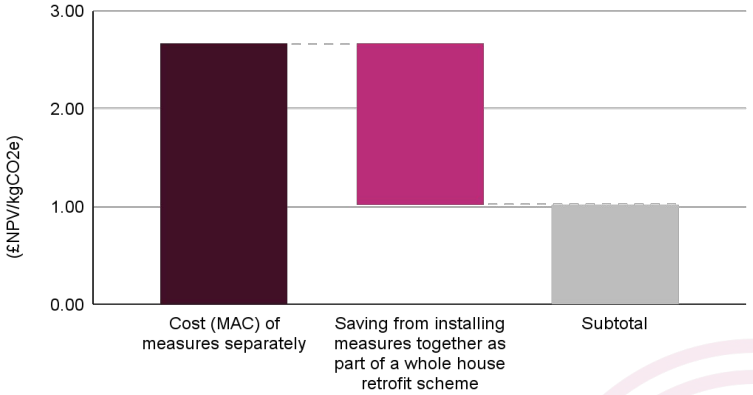
The unit cost of low carbon measures can be reduced through integrated delivery. In some cases, the unit cost of a low carbon measure can be reduced if economies of scale or scope can be realised. There are wide variety of low carbon measures that offer a lower marginal abatement cost when deployed at scale or when delivered alongside others. For example, large scale low carbon measures such as bicycle sharing schemes can meet the needs of multiple people at the same time and reduce the cost to their users.

Whole house retrofit is a comprehensive approach to making homes more energy efficient. The 'whole house' approach is diverse in scope as it combines the delivery of multiple low carbon measures to minimise disruption.

Whole house retrofit is an example of how a low carbon measure that is diverse in scope can decarbonise and reduce energy consumption together. The chart shows how the marginal abatement costs of a whole house retrofit scheme for a detached dwelling are lower than three potential elements (triple glazing, head pump and cavity wall installation) when applying them in combination.

As discussed in section 2 slide 21 of the summary report, low carbon measures that are large in scale or diverse in scope can be particularly cost effective because they can simultaneously meet multiple needs

Chart 8: Presenting the relative MACs of various low carbon measures that can be combined through integrated delivery.

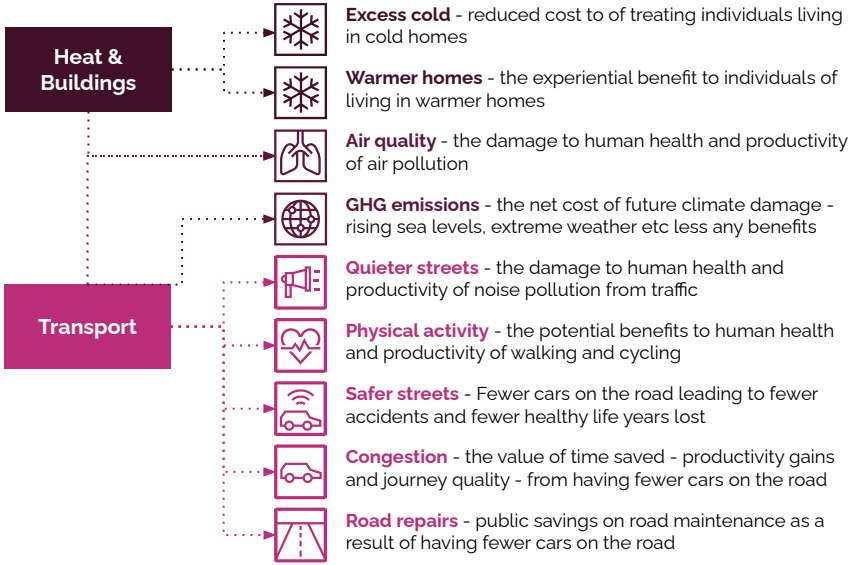


Where whole house retrofits are delivered through an area-based programme, several houses can be tackled at the same time. Economies of scale mean that installers can bulk-buy products and employ retrofit engineers on long-term rates, lowering the unit costs of installation and administration.

Decarbonisation will also create significant wider social costs and benefits which vary depending on the Measure...

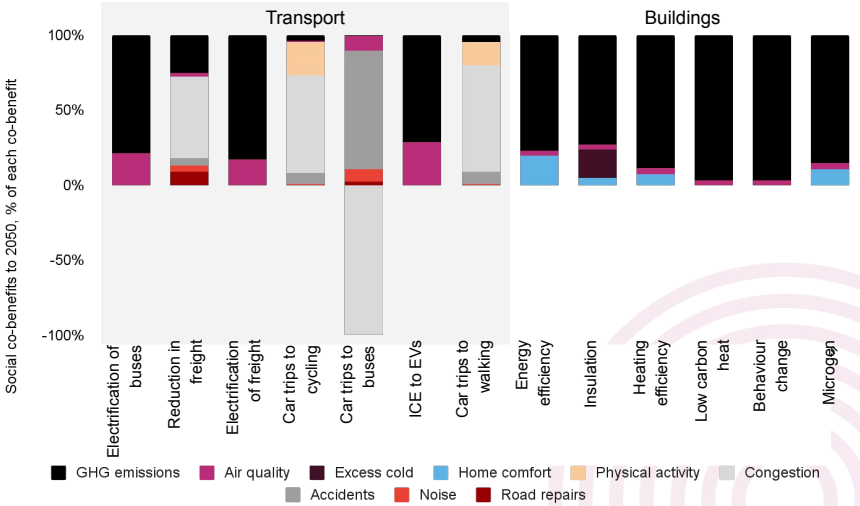
3

We estimate that the adoption of low carbon measures in towns and cities will generate significant wider social benefits over the next 30 years. The scale and nature of these wider social benefits varies between low carbon measures. We use an impact pathway approach (see next slide), and follow HM Treasury guidance on valuation to estimate the wider social costs and benefits of each LCM, as follows:



Each measure drives different social benefits to different degrees, but on aggregate, the largest social benefit for buildings is the reduction in carbon emissions while for transport, there are significant benefits from reductions in congestion and increases in physical activity.

Chart 9: Social benefits by type, % of each low carbon measure category*



* Full deployment of all measures across UK towns and cities outside of London

...and these also vary by place

3

The geographic, economic and social characteristics of a place affect the likely social benefits of decarbonisation:

- **Physical activity:** The health of the population differs by place. Places with less healthy populations can gain larger benefits from active travel
- **Air quality:** The negative health impact of air pollution caused by car exhausts or a gas boilers is higher in more densely populated places
- **Warmer homes:** There is also a utility benefit to having a warm home so places with colder homes can gain more
- **Excess cold:** The cost to the NHS of excess-cold-related illness varies by place, due to variations in temperature, housing and fuel poverty.
- **GHG emissions*:** A tonne of carbon emitted anywhere will have the same effect on climate change, but places with higher per capita emissions reductions will contribute more towards the reduction in climate risk
- **Reduced congestion:** The level of traffic varies by place-based on regional road networks and congestion levels. Places with higher levels of congestion can gain more by reducing it.
- **Quieter streets:** Places with higher traffic levels will experience higher levels of noise pollution, so will gain more from a shift towards non-motorised transport.
- **Safer streets:** Places with higher traffic levels will experience higher levels of road accidents - all things equal - so stand to gain more from reduced car usage
- **Road repairs:** Places with more active travel will require fewer road repairs

As a result, two city regions employing the same measure would generate different benefits. Glasgow has lower than average life-expectancy, so would gain more from the physical activity health benefits of active travel, as shown in the chart below.

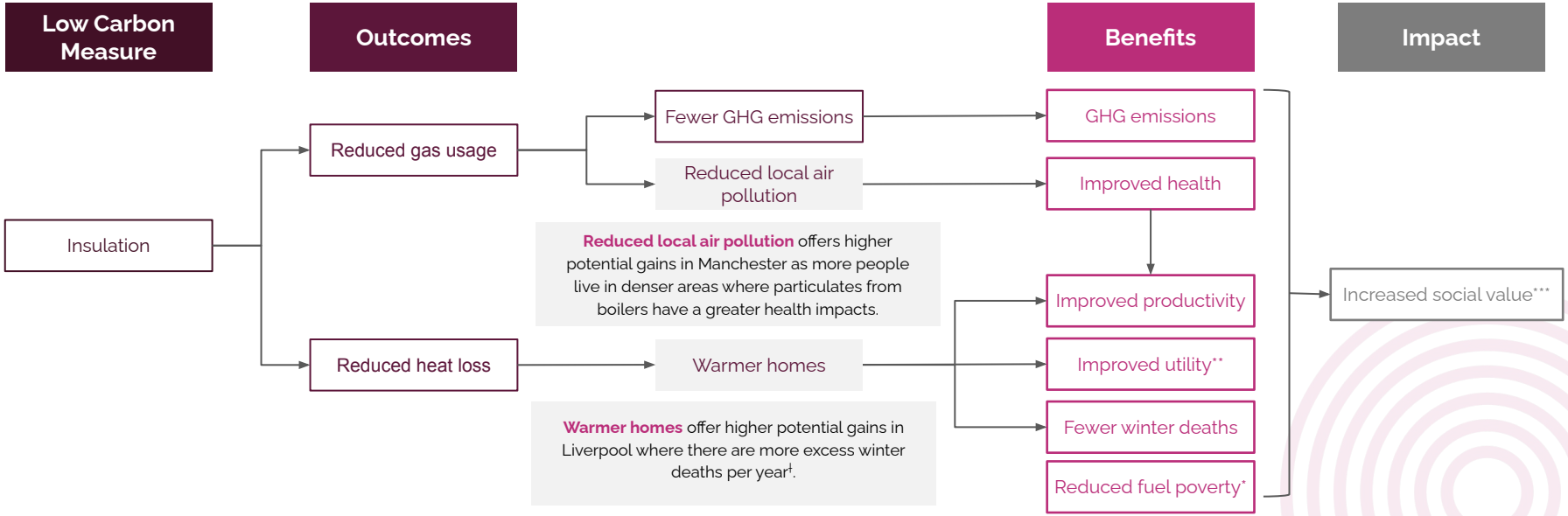
Chart 10: Social benefits generated per person if walking and cycling schemes were deployed to their full potential in each city-region

Impact pathways show how local factors drive social benefits: Insulation benefits are driven by housing stock and fuel poverty...

3

The benefits of insulation depend on housing stock, poverty and other factors. Implementing this low carbon measure can have different impacts depending on the city-region (see annotations).

Figure 2: Impact pathway of the installation of insulation.



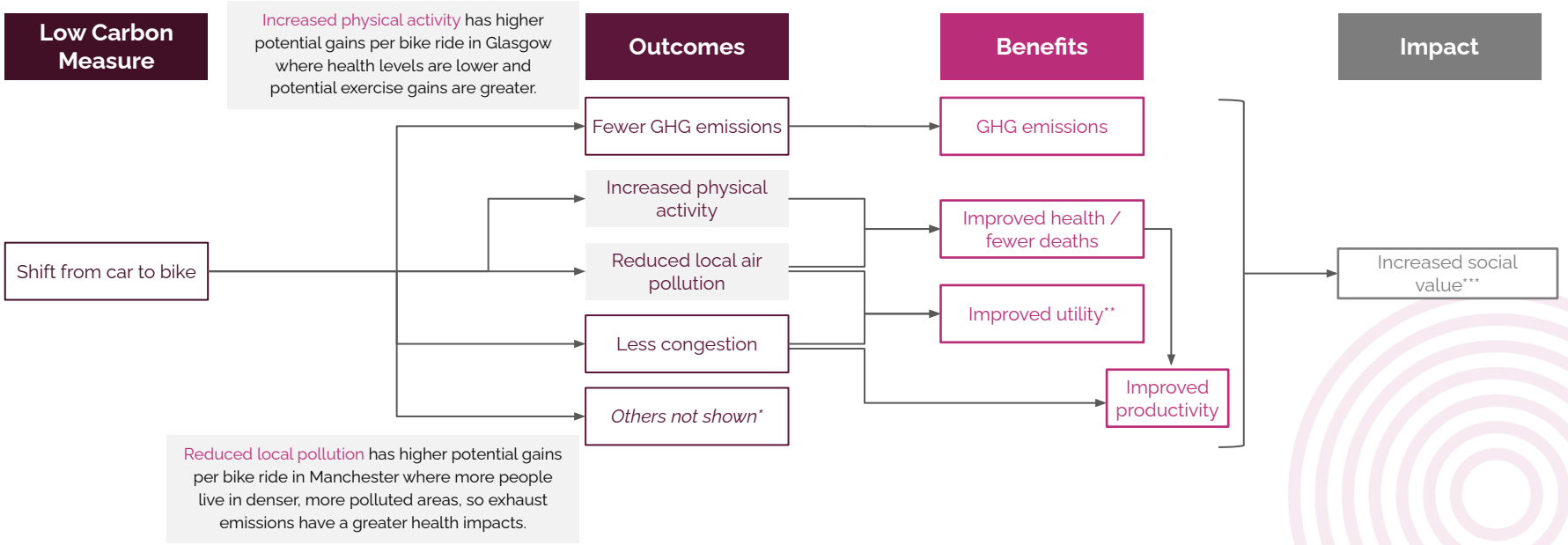
*The vast majority of the benefits of warmer homes will be gained by poorer households living in fuel poverty. However, we have not carried out a distributional analysis of this so cannot present figures for reduction in fuel poverty per se.
**Utility = satisfaction received from consuming a good or service, in this case living in a warm home
‡ Average 624 excess winter deaths per 1m people, vs 405 in Cambridgeshire & Peterborough
*** Social Value is a measure of total social welfare. As a net value it is the sum of total benefits and total costs to society of a proposal. See p.6 of The Green Book for further details.

...and active transport benefits depend on the demographics and transport system of each city-region

3

The benefits of moving from a car to a bike depend on demographics and the transport system. Implementing this low carbon measure can have different impacts depending on the city-region (see annotations).

Figure 3: Impact pathway of the shift in journeys from car to bike.



* Incl. noise pollution, motor vehicle accidents, road repairs. Not all linkages are shown for brevity.
** Utility = satisfaction received from consuming a good or service, in this case cleaner air and faster journeys.
*** Social Value is a measure of total social welfare. As a net value it is the sum of total benefits and total costs to society of a proposal. See p.6 of The Green Book for further details.

The total social benefits generated depend on how many measures can be and are deployed in each place

3

There are large differences in the social benefits generated by different Measures while abating carbon. Chart 11A shows that when deployed to their full potential in Greater Manchester (GMCA), Low carbon measures could generate £100bn of social benefits between now and 2050 with most of these coming from transport measures (see next slide).

However, 'full deployment ' is a hypothetical scenario in which measures are not limited by cost but only by their technical potential. For example, 1st floor flats cannot install ground source heat pumps and cycling is limited to a maximum of 3km extra per person per day*. Despite being technically feasible, many of these measures depend on high levels of behaviour change or expenditure, both of which policy appraisal would deem unlikely.

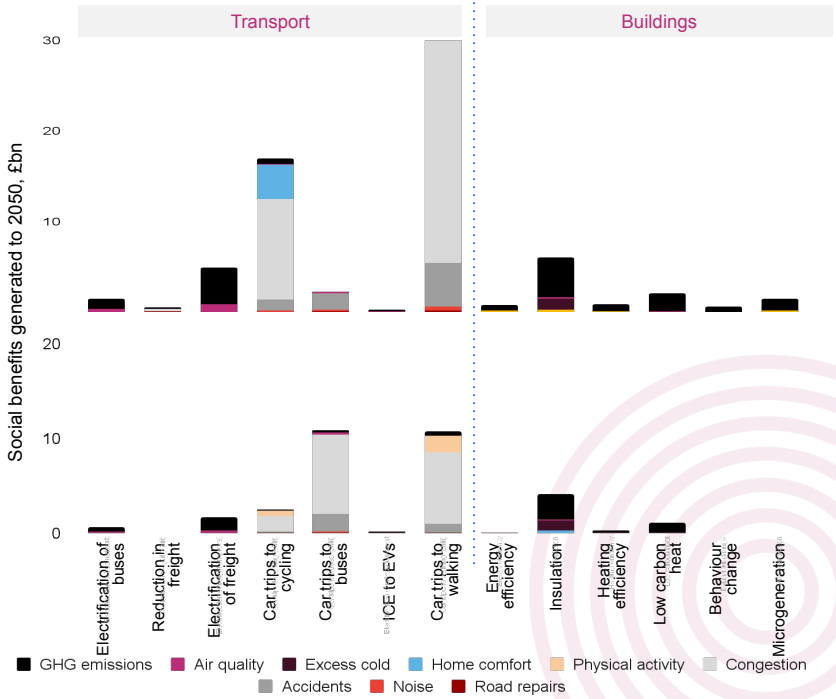
On the other hand, chart 11B shows the place-agnostic scenario for GMCA - i.e. the pathway for the city that is aligned to the Government's NZS. realisation of this scenario would generate £32bn in social benefits.

The NZS is not lacking in ambition (see slide 38). For example, in GMCA, the average working-age person would walk an extra 400m and cycle an extra 400m a day by 2050, versus 2.3km and 2.8km respectively in the full-deployment scenario.

*In addition, under both scenarios the overall level of mobility only increases with population. Bus ridership is lower in full deployment because there are only so many trips that can shift from cars, and most shift to active travel, whereas the place-agnostic scenario is based on the Net Zero Strategy which includes ambitious levels of bus usage outside of London, as set out in the National Bus Strategy

Chart 11: Social benefits by type for each Low Carbon Measure:

A. Full deployment scenario, GMCA: £100bn total benefits



Greener measures do not always generate more social benefits

3

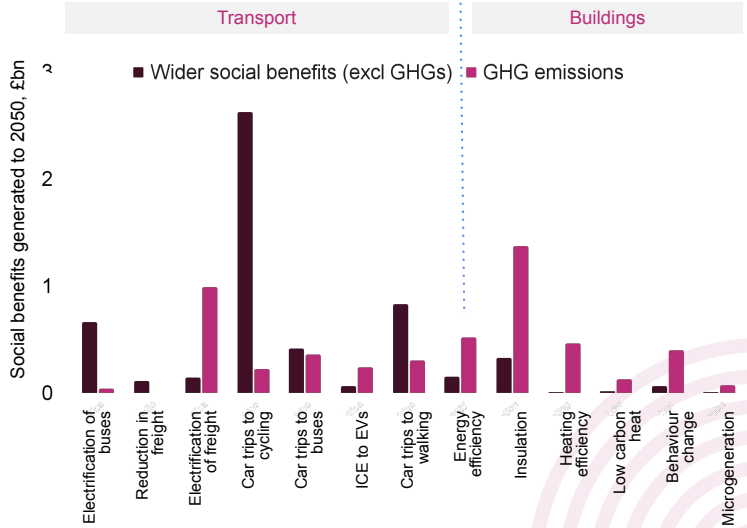
Different low carbon measures generate different wider social benefits (see previous page), and the relative contribution of each social benefit varies by city and scenario.

The social benefit that is common across all low carbon measures - decarbonisation - is also among the largest benefit in all scenarios. However, there is no clear link between a measure's decarbonisation potential and its overall social benefits.

The chart opposite compares GHG emissions benefits with the sum of all other benefits for all categories of low carbon measure in Swansea.

Many buildings measures contribute disproportionately towards GHG abatement, with lower wider social benefits, which are limited to those associated with warming homes. Conversely, while transport measures have significant GHG abatement potential, the wider social benefits far outweigh these. This is due in large part to the high social costs associated with congestion and poor levels of physical activity across UK towns and cities.

Chart 12: Total social benefits vs GHG emission reduction benefits; Swansea, full-deployment of all measures*



* Full-deployment of all measures is not a realistic scenario, but it is used to demonstrate differences between measures that ignore choices about deployment

Deep Dive: Sensitivity analysis of transport mode shift options

Social benefits will predominantly be driven by behaviour change including the shift from cars to walking, cycling and buses...

3

Chart 13 shows the total social benefits that could be generated by 2050 in Liverpool. The two columns on the left show the transport sector under the place-agnostic scenario and under a 'no mode shift' scenario which achieves the same amount of emission reduction through a high degree of electrification: no journey modes are changed. The heat & buildings sector is shown for comparison.

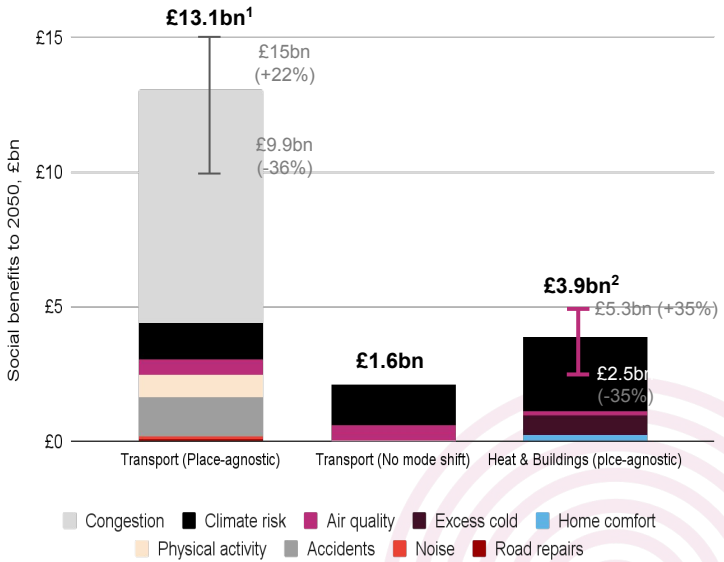
Mode shift interventions are particularly impactful because they create multiple simultaneous benefits: reduced emissions, congestion, air & noise pollution, accidents, and physical activity. As a result, under the place-agnostic scenario, 70% of all social benefits are derived from mode-shift low carbon measures; removing these reduces the potential social benefits in Liverpool by £11.5bn.

Reduced congestion is the largest benefit in most scenarios, with benefits of £182bn across UK towns and cities under the place-agnostic scenario. This is due to improved journey times (productivity) and journey quality[1]. These benefits are subject to uncertain projections about future traffic levels, as demonstrated by the error bars[1].

The importance of uptake: In this study, there is no analysis of how likely it is that LCMs will actually be implemented by the public - this is taken as a given. The chart shows the large gains available from reduced car usage - a policy area where uptake has been difficult to achieve in many cities.

Extra power capacity needed: under the place-agnostic scenario, around half of all vehicles will be low carbon (predominantly electric) by 2035, and ~100% by 2050. This will require a lot of electricity. If widespread uptake of active travel is not successful, the 'no mode shift' scenario, implies even more electricity demand. Analysis shows that the place-agnostic scenario is likely to require 2500MW of extra annual capacity across UK towns and cities by 2035, with the 'no mode shift' scenario adding a further 1500MW - in total, greater than the than the capacity of Hinkley Point or Sizewell C (3260MW)[3]

Chart 13: Social benefits by type for each sector, Liverpool



* Valuation uses TAG unit A5-4. Error bars show that congestion benefits are subject to highly uncertain DfT forecasts about how much time is likely to be spent in 'congestion band 5' - i.e. no traffic flow - on different road types and areas up to 2050. See technical annex for full methodology
** The future marginal abatement cost of carbon is also highly uncertain. BEIS provide high and low estimates, shown by the error bars. These adjust the cost by +/-50% which has a significant impact on total benefits
***The cost of a new nuclear plant the size of Sizewell C is ~£18-25bn, however it would not be appropriate to add this cost to the analysis since the cost of electricity, including policy costs is already accounted for

As a result the total social cost-effectiveness of different measures varies by city-region...

Total cost-effectiveness is defined as the sum of all costs and benefits (NPSV) excluding GHG emissions, divided by carbon abated*

This section has used three 'drivers' to demonstrate how each of these components - costs, benefits, emissions - vary by place and by measure:

The deployment potential of different Measures varies by city-region 1

The cost of decarbonisation varies by Measure 2

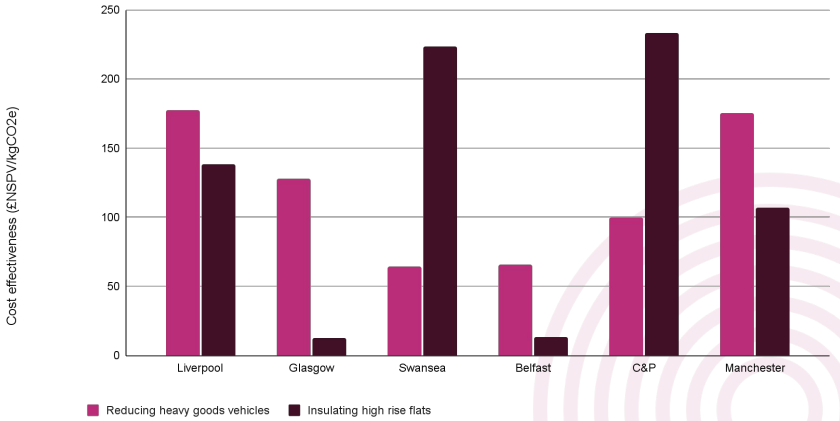
Social benefits of decarbonisation vary by Measure and by city-region 3

As a result total cost-effectiveness varies by place and there are large potential gains for each city-region of choosing the most cost-effective decarbonisation portfolio

The following section explores different portfolios of LCMs, starting with a 'place-agnostic' approach, which uses similar assumptions as the Government's Net Zero Strategy, for the Building and Transport sectors.

For example, the benefits of insulation depends on the housing stock and income of a place and the benefits of moving from a car to a bike depends on demographics and the density of a place. Given this, the cost-effectiveness, or the social value created while abating one tonne of CO2e, of a measure is dependent on place, as demonstrated by two measures in the chart below:

Chart 14: Cost-effectiveness of two LCMs, deployed to their full potential in different cities



*See slide 13: GHG emissions is calculated using the cost of carbon. This is a key social benefit but is removed when calculating cost-effectiveness to avoid it being on both sides of the equation

The costs and benefits of decarbonisation occur over different time horizons

However, it is worth noting that the various costs and benefits of decarbonisation accrue at different times. On aggregate, significant early costs are followed by slow cumulative energy savings and social benefits.

Some of the social benefits are particularly slow to accumulate. For example, the health benefits of increased physical activity take around 5 years of increased active travel to reach their full value.

This means that the payback period under the place-agnostic scenario is ~15 years, with positive net social values beginning to accrue from 2029.

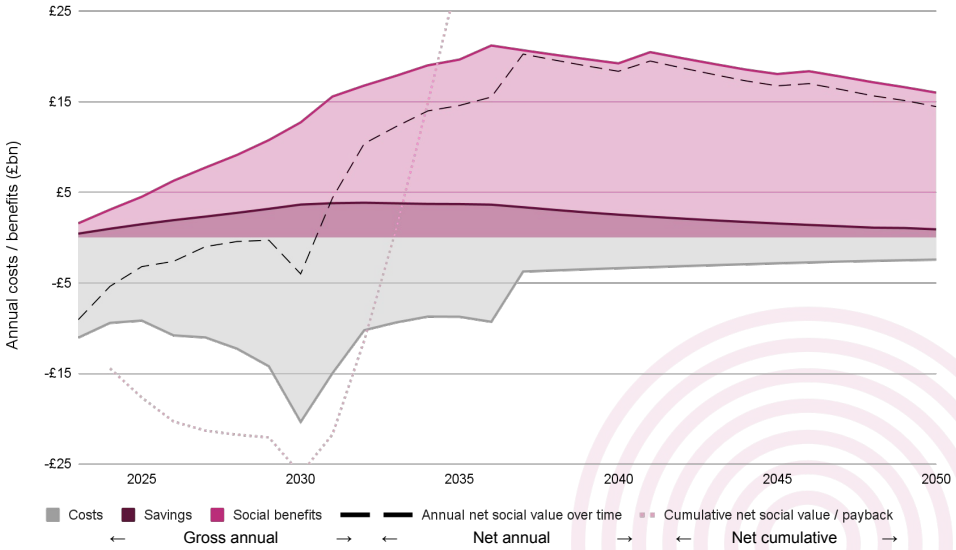
Timing assumptions in this analysis

In our analysis, all costs and benefits are measured between 2022 and 2050. However, we assume that all low carbon measures are implemented by 2035, in order to reach the Sixth Carbon Budget emissions reductions target, which means that a higher burden is placed on taxpayers, homeowners, business and passengers today, with benefits accruing disproportionately to later cohorts. Note that:

1. Most capital costs happen by 2035 though replacement costs continue to 2050
2. In the place-specific scenario (not shown on this chart) emission reductions are achieved with lower levels of some of the less cost-effective LCMs (such as some types of insulation and heat pumps - total deployment of heat pumps in the place-specific scenario is around 60% of that in the PA scenario). If better / cheaper technology is not available in 2035 - which is possible - these LCMs would then need to be deployed, which would make the 7th and 8th carbon budget periods much less cost-effective as there is no 'low hanging fruit' left

Chart 15: Accumulation of costs, savings and benefits over time under the place-agnostic scenario, non-London Urban UK

Gross, net, annual and cumulative



2.3

Scenarios: Examples Of More Cost-Effective Portfolios Of Low Carbon Measures

This analysis is designed to demonstrate the benefits of place based actions

REMINDER: Scenarios - the benefits of deploying the right low carbon measures in the right place

We modeled a spectrum of scenarios with increasing cost-effectiveness. While the place-agnostic scenario assumes all places are uniform in need, the place-specific scenario achieves the same reduction in carbon emissions but assumes that each city deploys the most **socially cost-effective** measure first.

The table shows the difference in deployment between the place-agnostic and place-specific scenarios.

Table 6: Deployment vs the baseline of Place-agnostic and Place-specific scenarios

Sector	Category of Low Carbon Measure	Unit	Place-agnostic	Place-specific
Transport	Car trips to cycling	Trips shifted	2%	26%
	Car trips to buses	Trips shifted	17%	0%
	Car trips to walking	Trips shifted	10%	19%
	Electrification of private transport	Trips improved	14%	88%
	Electrification of bus network	Trips improved	46%	0%
	Electrification of freight	Trips improved	37%	0%
Domestic buildings	Energy efficiency	Measures per home**	0.00	0.68
	Insulation	Measures per home	1.15	0.91
	Heating efficiency	Measures per home	0.00	0.08
	Low carbon heat	Measures per home	0.26	0.00
	Behaviour change	Measures per home	0.26	0.08
	Integrated domestic Measures	Measures per home	0.03	0.21
Public and commercial buildings	Energy efficiency	Floor space (%)	5.7%	40.2%
	Heating efficiency	Floor space (%)	86.4%	73.8%
	Low carbon heat	Floor space (%)	22.5%	4.2%
	Insulation	Floor space (%)	1.4%	50.9%
	Microgeneration	Floor space (%)	0.0%	23.8%
	Integrated commercial Measures	Floor space (%)	0.0%	42.3%

* As shown in the chart, under the place-specific scenario, certain measures have deployment of close to zero - for example heat pumps (low carbon heat). In fact, these measures are deployed at scale but are incorporated into 'Integrated domestic Measures' - e.g. whole house retrofit.
** It is not actually possible to have less than 1 measure installed but 'Measures per home' averages all homes so, for example a score of 0.1 might mean that 10% of the country have 1 measure installed, or 5% of the country have 2 measures installed

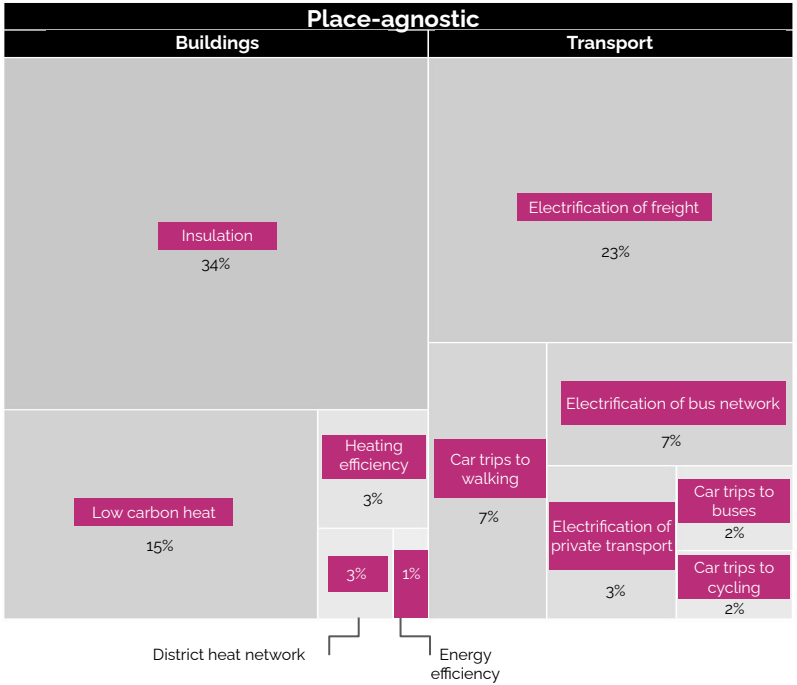
Deployment levels drive investment, energy savings and wider social benefits

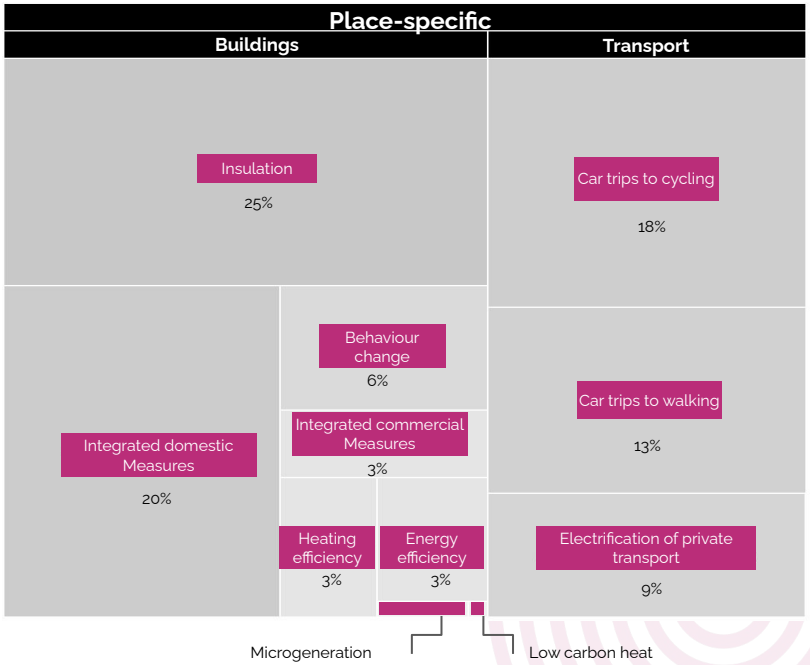
Table 7: The relationship between the deployment of different categories of measures, and the resulting costs and benefits for each scenario

Scenario -->			Place-agnostic				Place-specific			
Sector	Category of Low Carbon Measure	Deployment Unit	Deployment	Investment (£ billions)	Energy and opex savings (£ billions)	Wider social benefits (£ billions)	Deployment	Investment (£ billions)	Energy and opex savings (£ billions)	Wider social benefits (£ billions)
Transport	Car trips to cycling (shift)	Trips shifted	2%	£325	£2,557	£38,881	26%	£2,285	£27,221	£413,982
	Car trips to buses (shift)	Trips shifted	17%	£96,731	£4,808	£106,547	0%	£0	£0	£1
	Car trips to walking (shift)	Trips shifted	10%	£0	£10,603	£146,367	19%	£0	£20,374	£281,261
	Electrification of private transport (improve)	Trips improved	14%	£12,027	£7,085	£7,560	88%	£10,542	£19,650	£17,844
	Electrification of bus network (improve)	Trips improved	46%	-£1,673	£5,639	£11,745	0%	£1	£1	£1
	Electrification of freight (improve)	Trips improved	37%	£22,250	£6,528	£37,472	0%	£1	£0	£1
Domestic buildings	Energy efficiency	Measures per home**	0	£0	£0	£1	0.68	£347	£4,306	£3,104
	Insulation	Measures per home	1.15	£49,884	£24,100	£68,594	0.91	£16,072	£13,117	£41,918
	Heating efficiency	Measures per home	0	£0	£0	£0	0.08	£127	£406	£542
	Low carbon heat	Measures per home	0.26	£10,150	-£7,313	£13,026	0	£0	£0	£0
	Behaviour change	Measures per home	0.26	£0	£0	£0	0.08	£0	£5,050	£8,262
	Integrated domestic Measures	Measures per home	0.03	£890	-£816	£2,481	0.21	£16,873	£2,668	£34,697
Public and commercial buildings	Energy efficiency	Floor space (%)	5.70%	£46	£1,217	£957	40.20%	£300	£3,209	£2,335
	Heating efficiency	Floor space (%)	86.40%	£1,399	£2,818	£4,011	73.80%	£1,391	£2,758	£3,959
	Low carbon heat	Floor space (%)	22.50%	£2,949	-£293	£6,241	4.20%	£176	£22	£84
	Insulation	Floor space (%)	1.40%	£478	£444	£347	50.90%	£2,447	£3,063	£12,178
	Microgeneration	Floor space (%)	0.00%	£0	£0	£0	23.80%	£1,957	£609	£451
	Integrated commercial Measures	Floor space (%)	0.00%	£0	£0	£0	42.30%	£5,458	£5,597	£4,706

There are different ways to reach reduce the same amount of carbon emissions by 2035...

Chart 1: The two tree graphs show the contribution of each category of low carbon measure to abatement in the **place-agnostic** and and **place-specific** scenarios, demonstrating that the same abatement can be achieved with quite different measures.





...and there are large potential gains for each city of choosing the most cost-effective portfolio...

There are large potential gains from integrated place-based action. The benefits of integration and optimising the delivery of decarbonisation based on the place can a considerable impact on the social value gained from delivering Net Zero. When aggregated to represent towns and cities across the UK this benefit is almost six times a place-agnostic approach.

The importance of place-specific delivery is well understood and there are at least seven existing place-based spending programmes. Rather than duplicating previous efforts, the government can seek to build on these schemes and develop a broader strategy around how these fit together.

The implication of this analysis is that delivery of decarbonisation in the most socially beneficial way requires that each place adopt the unique combination of low carbon measures which are most beneficial for it.

Table 8: Comparison of cost-effectiveness of different scenarios for each city

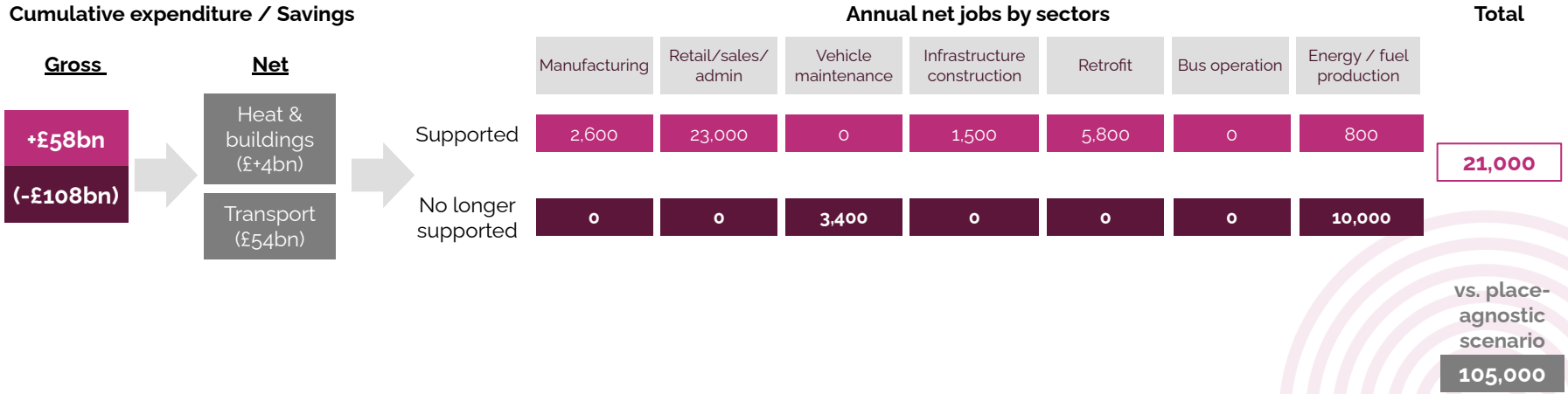
City-regions	Average unit benefit of decarbonisation (NPSV/kgCO2e)			Total benefit of place-specific scenario (£NPSV)*
	Place-agnostic	Place-specific	Difference	
Liverpool	£6.80	£22.70	£15.90	**33 bn**
Glasgow	£6.44	£20.49	£14.06	**38 bn**
Manchester	£9.35	£24.19	£14.84	**59 bn**
Belfast	£3.02	£14.28	£11.26	**12 bn**
Swansea	£3.18	£13.88	£10.70	**12 bn**
C&P	£2.82	£14.77	£11.95	**15 bn**
Urban UK	£4.71	£18.59	£13.87	**825 bn**

**Including GHG emissions

...however, lower investment means lower levels of local growth and job creation

This analysis finds that investment in the place-specific scenario would support an average of 21,000 net jobs per annum in UK towns and cities between 2022 and 2050. This is significantly less than the 105,000 extra annual jobs supported in the place-agnostic scenario due to significantly more efficient - and thus reduced - investment.

Figure 4: GVA and job impacts - Place-specific scenario



*We use input-output tables to estimate direct and indirect jobs based on local deployment of LCMs. Most home retrofits are likely to be carried out by local tradespeople - but not others - increased EVs will not lead to local manufacturing jobs except in places like Oxford and Sunderland where EV factories are located. Uncertain assumptions include the breakdown of costs across industries, the extent to which how much of each technology will be produced in the UK in future years, and the limitation of I-O models to incorporate changes to prices or economic structures over time. See technical annex for more information on methodology.

2.4

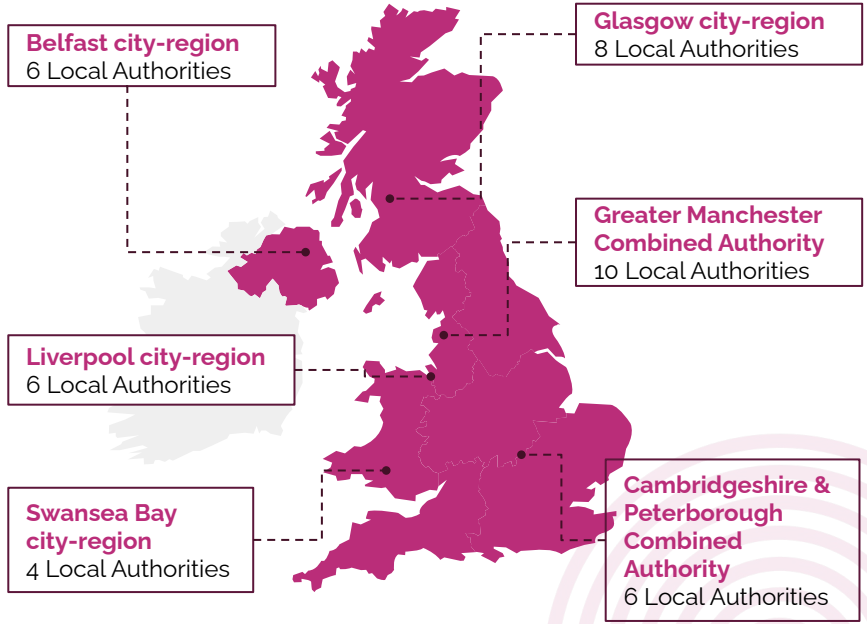
Cities: Choosing the Most Cost-Effective Portfolio of Low Carbon Measures in Six City-Regions

This section shows the benefits of place-based decarbonisation in six city regions

Each city will have its own optimal portfolio the following section shows the benefits of place-based decarbonisation in the six city regions that we modelled.

This section describes the impact of place-specific decarbonisation. With on-going decarbonisation of grid electricity, and taking into account existing policy commitments, population and economic growth within the city region, we project the level of annual emissions output in 2035 for each city. This section presents the results from this baseline vs the emissions abated by the scenarios set out in our approach.

This section then compares the social costs and benefits associated with place-agnostic delivery .



Liverpool city-region

6 LAs: Halton, Knowsley, Liverpool, Sefton, St. Helens, Wirral

Population	GVA per capita	Average EPC of commercial buildings	Average EPC of domestic buildings	Density (people per sq. km)
1,564,015	0.021	63	59 (D)	2,137

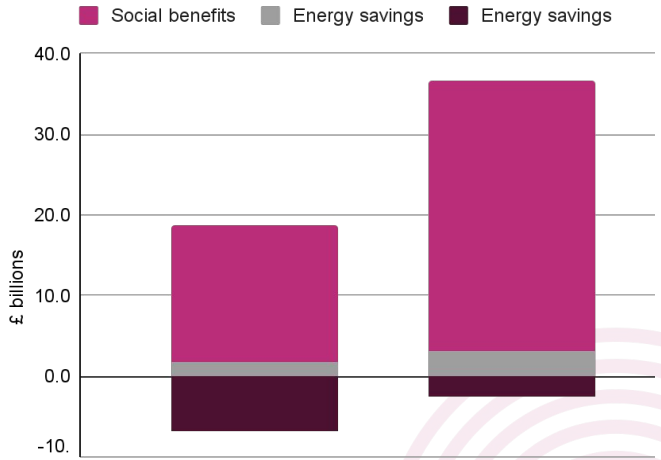
Emissions 2021	**3.65**
Projected baseline 2035 emissions per capita (tCO2e/capita)	**2.93**
Projected emissions 2035 per capita of all scenarios (tCO2e/capita)	**2.12**
The scenarios reduce the baseline by:	**28%**

Categories ranked by their cost-effectiveness

1 Car trips to cycling
2 Car trips to walking
3 Reduction in freight
4 Reduction in freight
5 Behaviour change
6 Energy efficiency
7 Heating efficiency
8 Electrification of freight
9 Electrification of bus network
10 Insulation
11 Low carbon heat
12 Microgeneration
13 Car trips to buses

Existing related projects/ demonstrators: Multi-vector Energy Exchange

Chart 2: Balance of major costs and benefits; place-agnostic vs place-specific scenario



	Place-agnostic	Place-specific
Investment	-6.8	-2.5
Energy savings	1.8	3.1
Social benefits	17.0	33.6
NPSV	**12.0**	**34.3**

Glasgow city-region

8 LAs: East Dunbartonshire, East Renfrewshire, Glasgow City, Inverclyde, North Lanarkshire, Renfrewshire, South Lanarkshire, and West Dunbartonshire

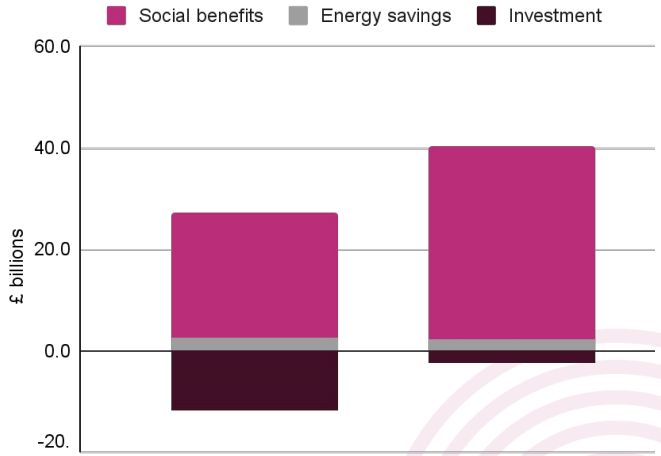
Population	GVA per capita	Average EPC of commercial buildings	Average EPC of domestic buildings	Density (people per sq. km)
1,847,200	0.026	N/A	68 (D)	552

Emissions 2021	**2.57**
Projected baseline emissions per capita (tCO2e/capita)	**2.11**
Projected emissions per capita of all scenarios (tCO2e/capita)	**1.26**
The scenarios reduce the baseline by:	**40%**

Categories ranked by their cost-effectiveness

1 Car trips to cycling
2 Car trips to walking
3 Electrification of private transport
4 Reduction in freight
5 Behaviour change
6 Energy efficiency
7 Heating efficiency
8 Electrification of freight
9 Electrification of bus network
10 Insulation
11 Low carbon heat
12 Microgeneration
13 Car trips to buses

Chart 3: Balance of major costs and benefits; place-agnostic vs place-specific scenario



	Place-agnostic	Place-specific
Investment	-11.7	-2.4
Energy savings	2.7	2.4
Social benefits	24.5	38
NPSV	**15.5**	**38**

Greater Manchester Combined Authority

10 LAs: Bolton, Bury, Manchester, Oldham, Rochdale, Salford, Stockport, Tameside, Trafford, and Wigan

Population	GVA per capita	Average EPC of commercial buildings	Average EPC of domestic buildings	Density (people per sq. km)
2,848,286	0.026	61	58 (D)	2,234

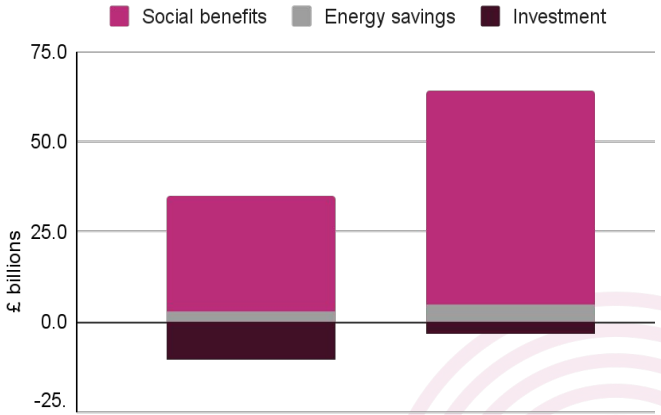
Emissions 2021	**3.66**
Projected baseline emissions per capita (tCO2e/capita)	**2.89**
Projected emissions per capita of all scenarios (tCO2e/capita)	**2.11**
The scenarios reduce the baseline by:	**27%**

Categories ranked by their cost-effectiveness

1 Car trips to cycling
2 Car trips to walking
3 Electrification of private transport
4 Reduction in freight
5 Behaviour change
6 Energy efficiency
7 Heating efficiency
8 Insulation
9 Electrification of freight
10 Electrification of bus network
11 Low carbon heat
12 Microgeneration
13 Car trips to buses

Existing related projects/ demonstrators: GM Local Energy Market

Chart 4: Balance of major costs and benefits; place-agnostic vs place-specific scenario



	Place-agnostic	Place-specific
Investment	-10.2	-3.2
Energy savings	2.9	5.0
Social benefits	32.2	59.2
NPSV	**24.9**	**61.0**

Belfast city-region

6 LAs: Antrim and Newtownabbey, Ards and North Down, Belfast, Lisburn and Castlereagh, Mid and East Antrim, Newry, Mourne and Down

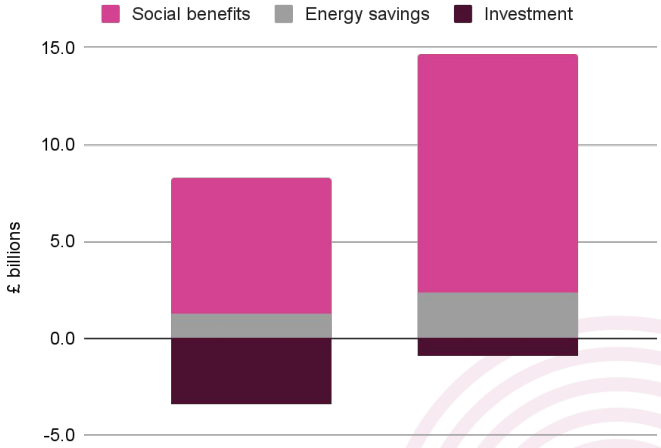
Population	GVA per capita	Average EPC of commercial buildings	Average EPC of domestic buildings	Density (people per sq. km)
1,115,936	0.025	N/A	N/A	247

Emissions 2021	4.96
Projected baseline emissions per capita (tCO2e/capita)	4.01
Projected emissions per capita of all scenarios (tCO2e/capita)	3.33
The scenarios reduce the baseline by:	17%

Categories ranked by their cost-effectiveness

1 Car trips to cycling
2 Car trips to walking
3 Reduction in freight
4 Behaviour change
5 Energy efficiency
6 Heating efficiency
7 Insulation
8 Microgeneration
9 Low carbon heat
10 Electrification of freight
11 Electrification of bus network
12 Electrification of private transport
13 Car trips to buses

Chart 5: Balance of major costs and benefits; place-agnostic vs place-specific scenario



	Place-agnostic	Place-specific
Investment	-3.4	-0.9
Energy savings	1.2	2.3
Social benefits	7.1	12.4
NPSV	**5.0**	**13.8**

Swansea Bay city-region

5 LAs: Pembrokeshire, Carmarthenshire, Swansea, Neath, and Port Talbot

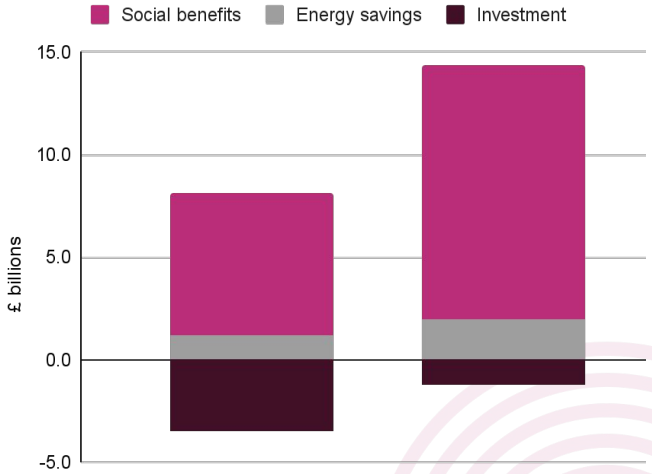
Population	GVA per capita	Average EPC of commercial buildings	Average EPC of domestic buildings	Density (people per sq. km)
707,773	0.020	63	53 (E)	147

Emissions 2021	**4.44**
Projected baseline emissions per capita (tCO2e/capita)	**3.47**
Projected emissions per capita of all scenarios (tCO2e/capita)	**2.42**
The scenarios reduce the baseline by:	**30%**

Categories ranked by their cost-effectiveness

1 Car trips to cycling
2 Car trips to walking
3 Reduction in freight
4 Behaviour change
5 Energy efficiency
6 Heating efficiency
7 Electrification of freight
8 Insulation
9 Electrification of bus network
10 Low carbon heat
11 Microgeneration
12 Electrification of private transport
13 Car trips to buses

Chart 6: Balance of major costs and benefits; place-agnostic vs place-specific scenario



	Place-agnostic	Place-specific
Investment	-3.4	-1.2
Energy savings	1.2	2.0
Social benefits	6.9	12.4
NPSV	**4.7**	**13.1**

Cambridge & Peterborough Combined Authority

6 LAs: Peterborough, Cambridge, East Cambridgeshire, Fenland, Huntingdonshire, and South Cambridgeshire

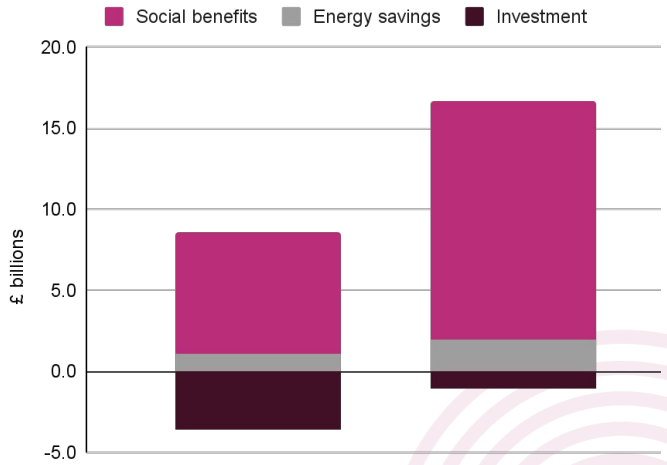
Population	GVA per capita	Average EPC of commercial buildings	Average EPC of domestic buildings	Density (people per sq. km)
859,830	0.031	60	58 (D)	254

Emissions 2021	**5.10**
Projected baseline emissions per capita (tCO2e/capita)	**4.03**
Projected emissions per capita of all scenarios (tCO2e/capita)	**3.04**
The scenarios reduce the baseline by:	**25%**

Categories ranked by their cost-effectiveness

1 Car trips to cycling
2 Car trips to walking
3 Reduction in freight
4 Behaviour change
5 Energy efficiency
6 Heating efficiency
7 Electrification of bus network
8 Insulation
9 Electrification of freight
10 Low carbon heat
11 Microgeneration
12 Electrification of private transport
13 Car trips to buses

Chart 7: Balance of major costs and benefits; place-agnostic vs place-specific scenario



	Place-agnostic	Place-specific
Investment	-3.6	-1.1
Energy savings	1.1	2.0
Social benefits	7.5	14.7
NPSV	**5.0**	**15.6**

2.5

Case Studies:
Scale and Scope Measures

This section provides further information about the cost effectiveness of scale and scope low carbon measures

These measures are more effective than individual measures and are generally larger in scale - making them more attractive to government or private investment

What this section covers:

In this section we provide more detailed information about low carbon measures that are large scale and / or diverse in scope (see slide 13) and what makes them more cost effective. In particular, we discuss:

- How low carbon measures can vary in their scale or scope
- How being large scale or diverse in scope makes low carbon measures more cost effective
- Case studies which illustrate how much more cost effective low carbon measures are when they are large scale or diverse in scope; these case studies provide part of our evidence base of why low carbon measures are more cost effective when they are larger scale or more diverse in scope. In particular, they compare the cost effectiveness of these low carbon measures with alternatives which are not large scale or diverse in scope
- Detailed case study on the place-specific factors that determine the cost effectiveness of district heat networks and how the Net Zero Strategy is addressing blockers to their adoption

This evidence is informed by:

- Interviews with stakeholders including Innovate UK and Energy Systems Catapult to draw out key themes about what types of low carbon measures are considered to be beneficial because they are large scale or diverse in scope
- Desk research into the costs and benefits of low carbon measures that are large scale or diverse in scope to demonstrate their cost effectiveness, including literature review of academic papers and reports on existing schemes
- Analysis from Resourceful Futures on the factors affecting the cost effectiveness of district heat networks

Case study: Whole house retrofit

Whole house retrofit has a diverse scope as it combines lots of different energy efficiency low carbon measures, for example insulation, draught proofing and boiler upgrades. As a result, the low carbon measure benefits from economies of scope: delivering the low carbon measures at once leads to lower costs of installation and administration.

Figure 5 summarises the differences in cost for delivering a whole house retrofit as staggered interventions compared to an integrated approach.

Whole house retrofit can also be delivered through an area-based or neighbourhood programme which tackles a number of houses in one area at the same time, rather than individually. For example, social housing providers could retrofit all dwellings within a development at once. This also makes the low carbon measure large-scale and benefits from to economies of scale due to lower costs of installation and administration per unit.

Figure 5: Cost effectiveness of whole house retrofit compared to the isolated installation of Low Carbon Measures

Whole house retrofit[8]

£23,500 Average cost per dwelling (£)

2,515 Per unit emissions reduction (kgCO2e p.a.)

Isolated installation of Low Carbon Measures[9]

£35,700 Average cost per dwelling (£)

2,515 Per unit emissions reduction (kgCO2e p.a.)

:
[8]Department of Business, Energy & Industrial Strategy (2017), What does it cost to retrofit homes?
[9]Cosy Homes Oxfordshire (2021), Pilot phase learnings and impact report 2019-2021

Case study: Electric vehicle sharing scheme

Electric vehicle sharing scheme is an scheme where multiple households have access to a pool of electric vehicles, for example through a car club. It is it is large-scale and benefits from economies of scale: fewer cars are needed to deliver the same number of ICE vehicle to electric vehicle changes as the cars are more highly utilised, and buying a fleet in bulk can lead to lower per unit costs.[10,15]

This leads to cost savings as the total cost / km of each car is reduced. Evidence suggests that a private vehicle has 10% utilisation, compared to shared electric vehicle that can achieve 30% utilisation.[14]

Figure 6 summarises the differences in cost and emissions reduction per km. Note that costs only consider upfront capital costs and do not include the cost of running the ICE or electric vehicle.

Figure 6: Cost effectiveness of electric vehicle sharing compared to private electric vehicle ownership

Electric vehicle sharing scheme[11,12,13,14]

-£0.06 Capital cost / km (£ / km)

0.11 Emissions reduction / km (kgCO2e p.a.), petrol

0.17 Emissions reduction / km (kgCO2e p.a.), diesel

Private electric vehicle ownership[11,12,13]

£0.03 Average cost per dwelling (£)

0.11 Emissions reduction / km (kgCO2e p.a.), petrol

0.17 Emissions reduction / km (kgCO2e p.a.), diesel

Sources:

[10] Climate-KIC (2018), InclusiveEV: Executive Summary
[11] Department of Business, Energy & Industrial Strategy (2021), Greenhouse gas reporting: Conversion factors 2021
[12] NimbleFins (2021), Average Cost of Cars UK 2021
[13] NimbleFins (2021), Average Cost of an Electric Car UK 2021
[14] Transport & Environment (2017), Does sharing cars really reduce car use?
[15] PetrolPrices (2019), It's quicker to cycle than drive in UK cities, says report

District Heat Networks

As the Government has recognised, district heat networks are a cost effective low carbon measure for decarbonising heat generation. District heat networks are highly cost effective because they benefit from economies of scale.

Opportunities for district heat networks are place-specific, so a whole system approach is needed. District heat networks can use different heat sources as inputs, including waste heat, which affects their cost effectiveness. The opportunities for different heat sources will be place-specific, and so the cost effectiveness of a heat network will vary by place. In addition, the cost effectiveness of a district heat network will be affected by its size and the location that it is in. This means that a whole systems approach is needed to identify the best opportunities for district heat networks heat sources and the most cost effective locations for a district heat network to be developed.

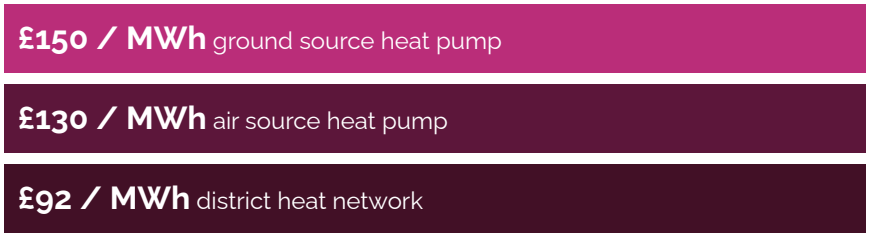
Opportunities for district heat networks are place-specific and novel, so an iterative approach to portfolio design is needed. The place-specific nature of district heat networks mean that the cost effectiveness of each one will be particular to that place. In addition, district heat networks are a novel technology so existing data on their costs and benefits is limited. This means that it may not be possible to fully understand the costs and benefits of a district heat network until it has been designed. As such, there is a need to take an iterative approach to portfolio design, so that low carbon measures can be revised once the costs and benefits of different district heat network opportunities are better understood.

This section provides evidence to demonstrate the cost effectiveness of district heat networks and how their cost effectiveness can vary depending on the specifics of their design. In addition, we summarise key policies set out in the Net Zero Strategy to stimulate the adoption of district heat networks.

District heat networks are large scale Low Carbon Measures that can decarbonise heat generation in a more cost effective way than heat pumps, however their costs are highly place-specific

District heat networks are large scale low carbon measures that can decarbonise heat generation more cost effectively than heat pumps. A district heat network is a distribution system of insulated pipes that takes heat from a central source and delivers it to a number of domestic and/or non-domestic buildings. It is large scale because it meets decarbonising needs for multiple buildings at once. This low carbon measure is an alternative to installing heat pumps in every building. District heat networks are often more cost effective than individual heat pumps because they benefit from economies of scale. For example, research suggests the following indicative levelised costs of heat for heat pumps compared to district heat networks:

Figure 7: Cost effectiveness of district heat networks vs ground source and air source heat pumps [16,17]



[16] Wang, Z. (2018), Heat pumps with district heating for the UK's domestic heating: individual versus district level. 16th International Symposium on District Heating and Cooling, DHC2018
[17] Gudmundsson, O., Thorsen, J. E. and Zhang, L. (2013), Cost analysis of district heating compared to its competing technologies

The cost effectiveness of district heat networks can be highly place-specific and is often not known until they have been fully designed. The cost effectiveness of district heat networks is determined by:

- The size and location of the district heat network
- The heat source for the district heat network
- The temperature of the distribution network

Each of these factors will vary significantly between different places. The immaturity of the heat network market in the UK means that the cost of different heat network variations is not well established. This means that the cost effectiveness of the network cannot be fully known until the network has been designed.

The following pages considers each of the factors that determine the cost of the district heat network in turn.

This analysis of district heat networks has been compiled based on advice and insight from Resourceful Futures.

The size and location of the district heat network can affect its cost-effectiveness[18]

District heat networks benefit from economies of scale, which increase with the location and size of the network. As the scale of the district heat network increases the initial capital cost per dwelling declines. This is because the fixed costs of installing the network can be spread between a greater number of dwellings. As a result the levelised cost of heat also decreases with scale. In general heat networks are more cost-effective in urban rather than rural areas, due to the higher density of heat loads.

The adjacent table reflects how these costs can change as the size of the network increases.

Table 9: Initial capital cost and levelised cost of heat for different size heat networks[18]

Size of heat network	Initial capital cost per dwelling (£)	Levelised cost of heat (£ / MWh)
Small heat network (<100 residential properties)	14,200	120
Medium heat networks (between 100 and 500 residential properties)	10,700	116
Large heat networks (over 500 residential properties)	10,000	115
Single developments (up to 3,000 homes)	9,800	114
Medium multi-development scales (up to 20,000 homes)	9,700	114

[18] Wang, Z. (2018), Heat pumps with district heating for the UK's domestic heating: individual versus district level. 16th International Symposium on District Heating and Cooling, DHC2018

The location of the distribution network can affect its cost effectiveness

Heat networks in areas of higher housing density have a lower investment cost per unit of heat. Research has shown that higher building to area ratios are associated with lower investment costs per unit of heat.This is because dwellings are closer together, meaning fewer pipes need to be laid in order to connect the same number of dwellings to the network. For example, the adjacent table demonstrates that investment costs per house are lower in inner city areas compared to outer city areas, where areas are likely to be more densely built in inner city areas.[19]

Building a district heat network on greenfield sites is likely to have a lower investment cost than on prebuilt areas. Research by the Swedish District Heating Association demonstrates how the cost of the distribution network per house can vary between already established building areas and greenfield areas. In particular, greenfield areas are about 20-30% less expensive than pre-built areas. The adjacent table reflects these differences in cost for inner and outer city areas.[20,21]

Table 10: Distribution network investment costs per dwelling for inner or outer city areas and greenfield or pre-built sites

Type of area	Investment cost, greenfield area (£ / house)	Investment cost, prebuilt area (£ / house)
Inner city	1,190	1,660
Outer city	1,360	1,740

[19] Gudmundsson, O., Thorsen, J. E. and Zhang, L. (2013), Cost analysis of district heating compared to its competing technologies. Energy and Sustainability, Vol 176.
[20] Nordenswan, T. (2007), Report: Kulvertkostnadskatalog, Svensk Fjarrvarme, cited in Gudmundsson, O., Thorsen, J. E. and Zhang, L. (2013), Cost analysis of district heating compared to its competing technologies. Energy and Sustainability, Vol 176.
[21] Persson, U. and Werner, S. (2011), Heat Distribution and the Future Competitiveness of District Heating. Applied Energy, p568-576, cited in Gudmundsson, O., Thorsen, J. E. and Zhang, L. (2013), Cost analysis of district heating compared to its competing technologies. Energy and Sustainability, Vol 176.

The cost of heat source for the district network can affect its cost effectiveness

District heat networks can connect to various heat sources. The heat source might be a facility that provides a dedicated supply to the heat network, such as a combined heat and power plant; or heat recovered from industry and urban infrastructure, canals and rivers, or municipal energy from waste plants. In particular, possible technologies that can provide the input to a heat network include power stations, energy from waste (EfW) facilities, industrial processes, biomass and biogas fuelled boilers and Combined Heat and Power (CHP) plants, gas-fired CHP units, fuel cells, heat pumps, geothermal sources, electric boilers and solar thermal arrays.

The adjacent table demonstrates how the levelised cost of heat can vary depending on the heat source used. These figures provide indicative costs for district heat schemes using different heat sources, while holding distribution network and substation costs constant. The total cost will also need to consider the cost of infrastructure needed to capture this waste heat. For example, the cost of pumping water from a mineshaft.

It is important to note that in practice, a district heat network is likely to rely on multiple heat sources in order to improve resilience.[22]

If the heat source is waste heat, then the incremental emissions of the district heat network will be minimal. When the heat would otherwise be wasted, then this input to the heat network creates no additional carbon emissions. However, if the temperature of the waste heat is too low (generally considered below 60˚C) then heat pumps will be needed to raise heat inputs to full temperature either in a centralised energy centre or with individual heat networks in buildings. In this case, the emissions and cost of electricity as well as the cost of the heat pump would need to be considered.

Table 11: Cost of heat for district heat network from various heat sources

Heat source	Cost of heat £ / MWh
Gas boiler	76
Biomass boiler	94
Geothermal plant	129
CHP surplus / waste heat	57

[22] Gudmundsson, O., Thorsen, J. E. and Zhang, L. (2013), Cost analysis of district heating compared to its competing technologies. Energy and Sustainability, Vol 176.

The temperature of the district heat network will affect its cost effectiveness

Heat networks can operate at a range of temperatures which affect its costs. Older networks tend to operate at a higher temperature. Newer networks tend to be designed to run at lower temperatures. The choice of temperature is important as it has a direct relationship with the design of the system and achievable system efficiency. However, there are a number of factors that need to be balanced against each other when choosing the optimal system temperature for a particular network, described further below.

Higher temperature networks tend to be more expensive than lower temperature networks. High temperature networks use steel pipes, which tend to be more expensive than the plastic pipes which can be used for lower temperature networks. However, plastic pipes are usually larger than steel pipes and so may require more space in the road to be laid and have higher civil works costs.

Higher temperature networks tend to experience greater heat loss which reduces their efficiency. High temperature heat circulation is associated with greater heat loss by the distribution network. This reduces the efficiency of the heat network system. In contrast, in an ultra-low temperature network the water flows around the system at a temperature which is often the same or close to the temperature of the ground in which the network runs, minimising heat loss.

Higher temperature networks are more suitable for poorly insulated buildings and so reduce the need for retrofit works. Less well insulated buildings will need higher temperature heating to achieve comfortable temperatures. Therefore, higher temperature networks are better suited to poorly insulated buildings. Lower temperature networks may only be acceptable if significant retrofit works are done to the properties, which can add to the cost of the district heat network.

These factors mean that the cost of a network can vary significantly and the optimal system temperature will be highly network-specific. The temperature of the heat network will affect its costs. The optimal temperature will depend on heat losses, energy efficiency of buildings and the cost of the network. Therefore, it is necessary to undertake techno-economic modelling for each scheme to determine optimal network design to suit local circumstances to ensure a Net Zero design that provides affordable heat to the end users.

The Net Zero Strategy set ambition to increase heat network deployment and announced Government support measures

The Net Zero Strategy has set ambitions for heat networks in the UK. Currently heat networks supply 3% of heat demand in the UK. The ambition of the Net Zero Strategy is to increase this to 20% of UK heat demand by 2050. The Net Zero Strategy announced heat network zoning, investment and the need for a market framework to achieve this aim.[23]

Heat network zones will identify areas where heat networks are the default solution for decarbonising heating. The Net Zero Strategy set out an aim to deliver new heat network zones in England by 2025. The Government is currently consulting on proposals for central and local government to work together with industry and local stakeholders to identify and designate appropriate zones.

The Green Heat Network Fund will help to grow the market for low carbon heat networks. The Net Zero Strategy announced £270 million to support the development of more low carbon heat networks.

A new market framework is being created and is expected to be published in 2022. A market framework is needed to increase investment and put consumer protections in place for heat network customers that are currently lacking. The Net Zero Strategy announced that new legislation would regulate the sector for consumers, give heat networks the statutory powers they need to build, and regulate the carbon emissions of projects from the early 2030s.

High electricity prices present a barrier to heat network deployment. Lower temperature heat networks tend to use heat pumps within their design and so require electricity as an input cost. The UK Environmental Audit Committee wrote to the UK Government in December 2020 highlighting the negative impact of high electricity prices in the UK, which are roughly four times the price of gas, on the uptake of heat pumps.[24] Any policies to reduce the price of electricity will also help to promote the adoption of district heat networks.

[23] Department for Business, Energy and Industrial Strategy (2021), Net Zero Strategy
[24] Environmental Audit Committee (2020), Correspondence: Environmental Audit Committee Chair writes to energy minister Kwasi Kwarteng MP about heat pumps

3

Blockers to adoption of Low Carbon Measures

This section sets out the blockers to adoption of Low Carbon Measures, their causes and how government intervention aims to resolve them

What this section covers:

In this section we provide more evidence on the blockers to the adoption of low carbon measures. In particular, we discuss:

- Our framework for categorising the blockers to adoption of low carbon measures
- The market failures and unintended consequences of government policies that are the root causes of many blockers to adoption
- Current government intervention, including those set out in the Net Zero Strategy, aimed at addressing these blockers
- Case studies of how these blockers are affecting different low carbon measures

This evidence is informed by:

- Climate Action Readiness Assessment workshops with representatives from the six city regions: Belfast, Glasgow, Liverpool, Manchester and Cambridgeshire & Peterborough
- Interviews with UK100, EIT Climate-KIC, Department for Levelling Up, Housing and Communities, Department for Business, Energy and Industrial Strategy and Innovate UK
- Desk research into policy evaluations and assessments of the challenges facing Local Authorities
- Desk research of existing analysis of blockers preventing adoption of low carbon measures by individuals and organisations
- Interviews with Energy Systems Catapult (ESC) about their analysis of Local Area Energy Plans

3.1

What is blocking the adoption of Low Carbon Measures?

Individuals, households and organisations need to change their behaviours and practices to increase adoption of Low Carbon Measures

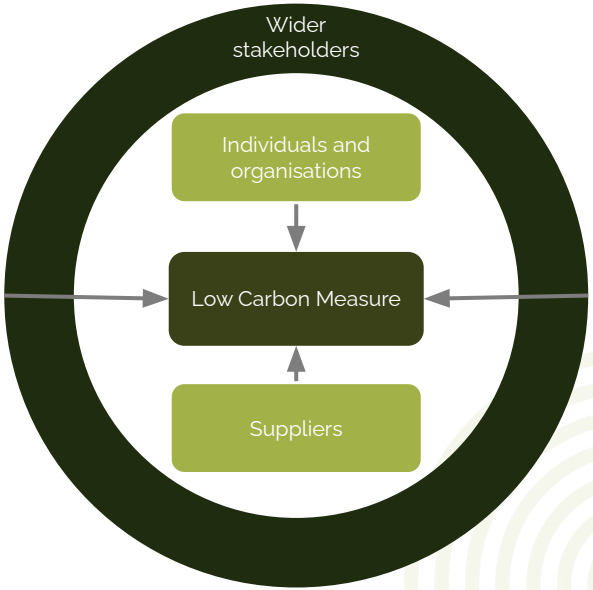
A large number of ways to decarbonise buildings and transport already exist. Examples of low carbon measures include: taking public transport rather than driving an Internal Combustion Engine (ICE) vehicle, electrifying the bus fleet, installing a district heat network or retrofitting social housing.

Under our baseline scenario, we do not expect adequate adoption of low carbon measures to reduce carbon emissions to meet the Sixth Carbon Budget. Moreover, both our place-agnostic and place-specific scenarios - which anticipate that the Net Zero Strategy will deliver a reduction in carbon emissions in line with the Budget - still depend on significant adoption of low carbon measures. Further detail on this scenario analysis is available in Annex: Economic modelling.

For this adoption of low carbon measures to happen, households and organisations need to change their behaviours and practices which would require collaboration between:

- Individuals and organisations who need to buy or adopt the low carbon measure. Note this is not necessarily the end user, for example, Local Authorities would have to buy retrofit products for social housing but it is the tenants who benefit from improved the energy efficiency)
- Suppliers, who must be available to deliver the products needed for adoption of low carbon measures
- Wider stakeholders, who can affect decision-making and opportunities in the market. These can include policy makers and local communities (Figure 1)

Figure 1: Market for Low Carbon Measures



We have identified a set of “blockers” which are preventing the adoption of low carbon measures

We have identified a set of “blockers” that are preventing adoption of low carbon measures from happening.

For example, individuals and organisations may not know that they need to make changes to their behaviour. ESC found that 51% of people did not recognise that their gas boiler contributes to climate change and this is a “blocker” preventing the adoption of low carbon heating, such as heat pumps[25]. Another “blocker” to adoption of heat pumps is that suppliers may not have the right skills to install them and so individuals and organisations may not be able to find a supplier to install them.

We need to understand the blockers to adoption to be able to diagnose the problem with the existing arrangements. We have developed a categorisation of these blockers to articulate the distinct blockers that individuals and organisations may face.

[25] Energy Systems Catapult (2021), Enabling Smart Local Energy Systems: Finance and Investment

We have categorised the types of blockers to adoption of Low Carbon Measures

Our categorisation groups identified blockers for different low carbon measures into key categories under the "COM-B" framework. These are:

Individuals and organisations do not have the capability to make the required changes

To do things differently, an individual or organisation needs to understand what they need to do, how to do it, and they need the capacity (e.g. the time) to do it.

Individuals and organisations do not have the opportunity to make the required changes

In particular:

- **The supply chain is not offering good opportunities**: To do things differently, an individual or organisation both needs opportunities to do it, and they need those opportunities to be good quality (e.g. safe and convenient)
- **Third parties are preventing change**: Sometimes individuals and organisations will not be able to take advantage of opportunities to do things differently because third parties will have prevented the opportunity from being available
- **Individuals or organisations cannot afford to make the required changes**: To have the opportunity to do things differently, an individual or organisation needs to be able to finance the required changes

Individuals and organisations are not motivated to make the required changes

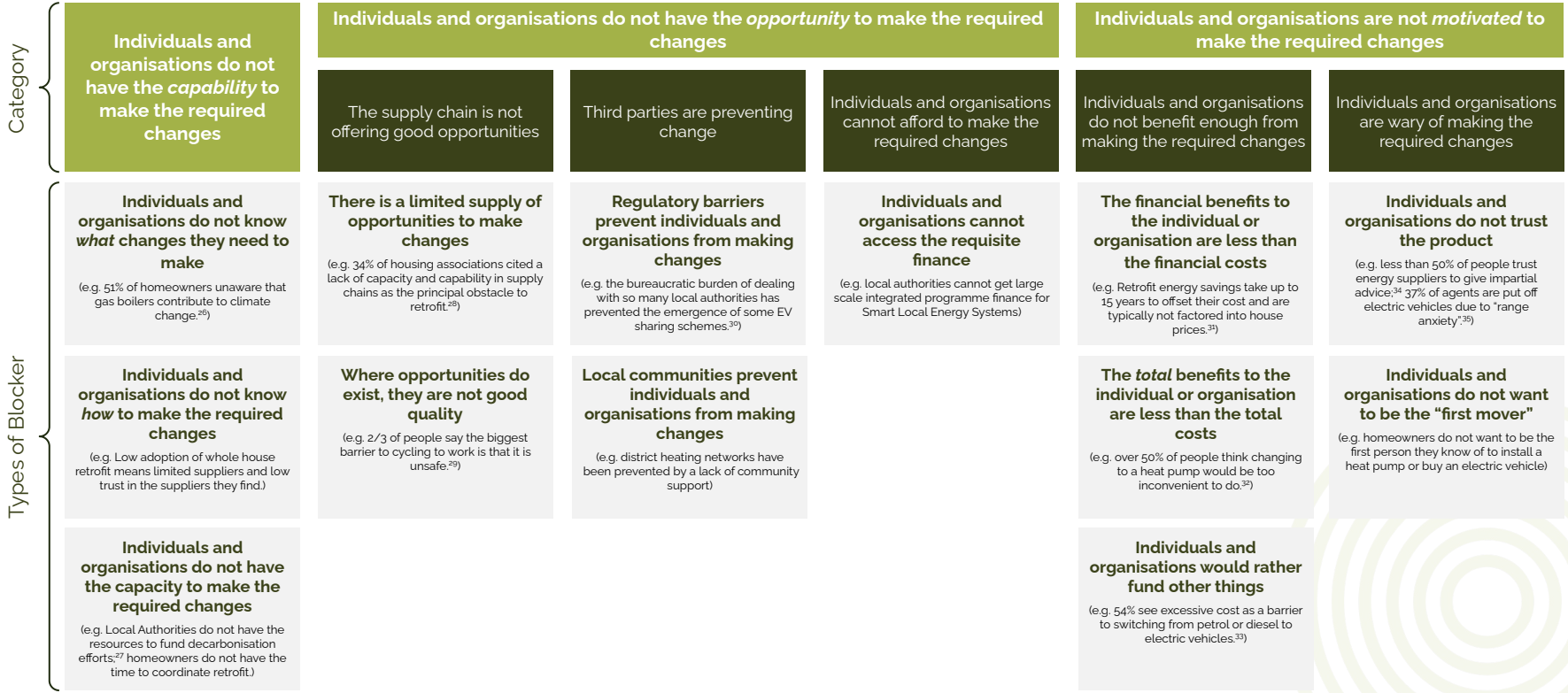
In particular:

- **Individuals and organisations do not benefit enough from making the required changes**: For an individual or organisation to be motivated to do things differently, it needs to be beneficial for them
- **Individuals and organisations are wary of making the required changes**: For an individual or organisation to be motivated to do things differently, they need to have faith in it and to feel like they are not doing it alone

Each category is composed of several sub-categories. Figure 2, on the following page summarises these subcategories and provides examples of what they might look like.

Figure 2: Framework for categorising "blockers"

Through a combination of interviews, desk research and workshops with individuals from Local Authorities and Combined Authorities, we have identified the main blockers to adoption of low carbon measures and developed a thematic categorisation.



References: Framework for categorising “blockers”

[26] Energy Systems Catapult (2020), Understanding Net Zero: A Consumer Perspective

[27] London Councils (2020), Boroughs seek £115m retrofitting boost to secure London’s environmental and economic future

[28] National Housing Federation (2020), New NHF research highlights barriers to retrofitting homes

[29] Department for Transport (2020), Walking and Cycling Statistics, England: 2019

[30] Evening Standard (2020), Electric car-sharing scheme scrapped in London after poor uptake

[31] Pursuit (2018), Does it pay to improve your home’s energy efficiency?

[32] Energy Systems Catapult (2020), Understanding Net Zero: A Consumer Perspective

[33] Energy Systems Catapult (2020), Understanding Net Zero: A Consumer Perspective

[34] Energy Systems Catapult (2021), Energy Outcomes Evaluation: Interim Update

[35] Renewable Energy Magazine (2020), UK consumers not seriously considering buying an EV due to confusion around technology

3.2

What is causing blockers to adoption?

The “blockers” to adoption of Low Carbon Measures are caused by a series of market failures and the unintended consequences of government policies

There are market failures and unintended policy consequences that are “blocking” adoption of low carbon measures. We have used root cause analysis to identify market failures and unintended policy consequences that create blockers to adoption of low carbon measures. These root causes can also interact and compound the effects of blockers.

This means that Government intervention is justified to implement policies and investment projects to relieve the blockers to adoption. The following pages detail how these blockers are caused.

Figure 3: Root causes of the blockers to adoption

Market failures	Externalities	The private cost of low carbon measures is high relative to their private benefit to individuals and organisations, e.g. heat pumps cost seven times more than traditional gas boilers.
	Imperfect information	Individuals and organisations do not know about the assets they own or the low carbon measures available to them.
	Coordination failure	Large scale low carbon measures, e.g. district heating, require coordination of demand to be cost effective, when this is not achieved they are not affordable.
Unintended policy consequences		Policies (both related and unrelated to net zero) have created adverse circumstances that prevent adoption of low carbon measures, e.g. restrictions on conservation areas. The overall approach to government policy making can also have unintended consequences. In particular, the stop/start nature of Government policy making has created uncertainty about the long-term policy environment for low carbon measures, e.g. Green Homes Grant.

We have used root cause analysis to identify the market failures and the unintended policy consequences that create blockers to adoption of Low Carbon Measures

Why don't individuals and organisations know what changes they need to make?

Individuals and organisations not knowing what changes they need to make is one of the ways that individuals and organisations lack the capability to make the required changes. The complex and often technical nature of low carbon measures mean it is often hard for individuals and organisations to easily understand what they need to do differently. Additionally, low carbon measures are often new or evolving technologies, making it harder for individuals and organisations to understand which low carbon measures are available.

This is a type of market failure known as "**imperfect information**" - individuals and organisations lack information that they need in order to make the required changes; this is in contrast to less technical products, where the individual or organisation is normally significantly better informed about what the choices open to them.

Why don't individuals and organisations know how to make the required changes?

Individuals and organisations not knowing how to make the required changes is another one of the ways that they lack the capability to make the required changes. Similarly to how individuals and organisations do not know what changes they need to make, the complex, technical and novel nature of low carbon measures means that individuals and organisations may face "**imperfect information**" about how to make those changes.

This blocker is also compounded by low demand and other blockers,

- Firstly, individuals and organisations could find out how to make changes if able to get recommendations from their peers. However, low demand for low carbon measures means that individuals and organisations may not know anyone who has adopted a low carbon measure, and therefore will not receive recommendations about how to make the change. As such, this creates a feedback loop whereby current low demand, leads to future low demand
- Individuals and organisations could find out how to make changes through recommendations from suppliers. However, suppliers will not recommend low carbon measures that they are not able to deliver. As such, the lack of opportunities for individuals and organisations reinforces their lack of knowledge about how to make the required changes

We have used root cause analysis to identify the market failures and the unintended policy consequences that create blockers to adoption of Low Carbon Measures

Why don't individuals and organisations have the capacity to make the required changes?

Individuals and organisations not having the time or resources to make changes is the third way in which individuals and organisations lack the capability to make the required changes.

In the case of private individuals, the capacity constraint is often in terms an inability to accommodate the process of making the change, for example finding the time to understand or organise the change. This is often caused by individuals and organisations not having the motivation to find ways to accommodate making the change, because the opportunities to make the change do not benefit them enough. As such, this is a secondary blocker caused by the total benefits to the individual or organisation being less than the total costs.

Where the organisation is a Local Authority or company, the capacity constraint is often in terms of lacking the skilled resources who are capable of understanding and delivering the required changes.

Local Authorities are often not able to develop this capacity because they face constrained budgets and must prioritise delivering their statutory duties over decarbonisation. This is the result of austerity and the setting of statutory duties for Local Authorities, which mean that Local Authorities do not have budget they are willing to use to prioritise decarbonisation. This is an "**unintended policy consequence**" - other Government policies have resulted in negative impacts that were not anticipated or considered.

Companies often do not develop this capacity because the benefits to the company do not outweigh the costs of doing so. As such, they do not account for the social benefits it would bring, i.e. the social benefits of decarbonisation. This type of market failure is known as "externalities" where the individual or organisation does not account for the social costs of benefits of their decision-making.

However, low carbon measures that are large in scale or diverse in scope require the coordination of either other individuals and organisations or different suppliers. Often this means that the individual or organisation needs even greater capacity in order to make the change. This type of market failure is known as "**coordination failure**" - individuals and organisations cannot align their decision-making to achieve a more desirable outcome. As such, coordination failure can compound the individual or organisation's lack of capacity.

We have used root cause analysis to identify the market failures and the unintended policy consequences that create blockers to adoption of Low Carbon Measures

Why is there a limited supply of opportunities to make changes?

The limited supply of opportunities is one way in which the supply chain does not offer good opportunities for individuals and organisations, meaning they lack the opportunity to make the required changes.

There are multiple market failures that prevent the supply chain from supplying opportunities for individuals and organisations to adopt low carbon measures.

Firstly, suppliers may not develop the capability to supply opportunities because they believe that Government policy could change in future to provide better opportunities for them to upskill. This belief is caused by persistent changes to Government policy surrounding decarbonisation, which means that suppliers expect it to change again in future - here the the "**unintended consequence**" of the approach to government policy making is policy uncertainty.

Secondly, suppliers may face **imperfect information** around low carbon measures, and so rely on recommendations about technologies from the manufacturers themselves. Suppliers tend to have better relationships with incumbent manufacturers, who will only recommend technologies that they produce.

Finally, low carbon measures that are large in scale or diverse in scope require the coordination of different suppliers to be delivered. If suppliers are unable to coordinate, then they may not be able to provide a viable offering for the opportunity. As such, **coordination failure** can compound this blocker.

This blocker is also compounded by a lack of demand. If suppliers face low demand for low carbon measures, then they are not motivated to undertake training to learn about them. As such, low demand creates a feedback loop that prevents suppliers from developing their capability to deliver low carbon measures. Similarly, the incumbent manufacturers have limited incentive to reorient themselves towards producing the technology for low carbon measures because demand for those technologies is low.

We have used root cause analysis to identify the market failures and the unintended policy consequences that create blockers to adoption of Low Carbon Measures

Why are the opportunities that do exist low quality?

The poor quality of the opportunities that are available is another way in which the supply chain does not offer good opportunities for individuals and organisations, meaning they lack the opportunity to make the required changes.

There are multiple market failures that prevent the supply chain from developing good opportunities for individuals and organisations.

Firstly, low carbon measures may not have been improved because they struggle to attract investment to develop the technology. In particular, clean tech firms often struggle to attract the necessary finance, because investors see them as riskier than other investments. This view is borne from the complexity and technical nature of low carbon measures, which means that investors often have **imperfect information** about the investment opportunity.

Secondly, even where the private sector is able to develop good opportunities for individuals and organisations it may not do so due to the lack of return it is likely to earn on it. This is because individuals and organisations are not willing to pay enough for companies to earn an adequate return. Individuals and organisations are not willing to pay because they do not value the social benefits associated with low carbon measures. As such, this blocker is created by the market failure known as **externalities**.

Why do regulatory barriers prevent individuals and organisations from making changes?

Regulatory barriers that prevent individuals and organisations from making changes are one way that third parties can prevent them from having the opportunity to make the required changes.

These regulatory barriers exist when other policies unintentionally prevent individuals and organisations from making changes. For example protection for conservation areas prevents homeowners from making changes to properties in that area. This is caused by **unintended policy consequences**.

We have used root cause analysis to identify the market failures and the unintended policy consequences that create blockers to adoption of Low Carbon Measures

For some low carbon measures, this blocker is compounded by the need to coordinate. When a low carbon measure is large scale or diverse in scope, it means coordinating across multiple different sectors or jurisdictions. As the number of possibilities for unintended policy consequences increases, the challenge of coordinating increases. This market failure is known as **coordination failure**.

Why do local communities prevent individuals and organisations from making changes?

Local communities preventing individuals and organisations from making changes is another way in which third parties can prevent them from having the opportunity to make the required changes.

This blocker occurs when local communities are negatively affected by the individual or organisation making changes and use their influence to stop the change from going ahead. This is caused by the individual or organisation failing to account for the social costs of their changes, and so not compensating local communities for this impact. As such, the market failure that causes this blocker is known as "**negative externalities**" - the individual or organisation does not account for the negative impacts their decision-making has on third parties.

This blocker is compounded by the fact that the need for planning permission means that local communities have the ability to prevent the individual or organisation from making changes. As such, **unintended policy consequences** of planning regulations reinforce the impact of this blocker.

Why can't individuals and organisations access the requisite finance?

A lack of access to finance means that individuals and organisations cannot afford to make changes, and so do not have the opportunity to make the required changes.

The complex and technical nature of low carbon measures means that financial institutions have not developed suitable financing mechanisms to help individuals and organisations afford to make the required changes. As such, this blocker is created by the market failure of **imperfect information**.

We have used root cause analysis to identify the market failures and the unintended policy consequences that create blockers to adoption of Low Carbon Measures

The impact of **imperfect information** is particularly significant for low carbon measures that are diverse in scope or large in scale as they are even more complex. Financing these low carbon measures requires financial institutions to understand the interactions between low carbon measures as well as the low carbon measures themselves.

If financial institutions do not provide programmatic finance for these low carbon measures then individuals and organisations or suppliers will have to coordinate multiple sources of finance. This challenge can result in the market failure known as **coordination failure** where an inability to coordinate results in worse outcomes.

The need for appropriate financing mechanisms is particularly acute for Local Authorities making long-term investments. This is because they face the pressure of balancing their budgets on an annual basis, and so need finance that can facilitate this. This particular financing need is caused by persistent years of budget cuts due to austerity, as such it is the result of **unintended policy consequences**.

Why are the financial benefits to the individual or organisation less than the financial costs?

Financial benefits to the individual or organisation being less than the financial costs is one way in which individuals and organisations do not benefit enough from making the change and so lack the motivation to make the required changes.

For some low carbon measures, individuals or organisations may not be able to fully recoup the benefits of their investment if the final beneficiaries of the Low Carbon Measure are not willing to pay for it or if they cannot pass the cost on to the ultimate beneficiaries.

The ultimate beneficiaries may not be willing to fund the low carbon measure because they do not value the social benefits associated with the low carbon measure. As such, the market failure of **externalities** means that the individual or organisation is unable to recoup the financial costs associated with the low carbon measure.

Alternatively, Government policies may prevent the individual or organisation from recouping the financial cost of low carbon measures from the ultimate beneficiaries. For example the cap on rents for social housing means social landlords cannot recoup the costs from their tenants. As such, this is an **unintended policy consequence**.

We have used root cause analysis to identify the market failures and the unintended policy consequences that create blockers to adoption of Low Carbon Measures

For low carbon measures that are large scale or diverse in scope, the financial benefits may only exceed the financial costs when the demand- or supply-side are coordinated to deliver potential synergies. The market failure that can prevent this from being achieved is known as coordination failure. As the scale of demand- or supply-side coordination required increases, the risk of **coordination failure** becomes greater.

This blocker is also compounded when the supply chain has not developed good opportunities for individuals and organisations. As a result, either the cost of the low carbon measure is too high or it is not efficient enough to generate adequate financial benefits for the individual or organisation. As such, this can also be a secondary blocker created by the lack of good opportunities.

Why are the total benefits to the individual or organisation less than the total costs?

Total benefits to the individual or organisation being less than the total costs is one way in which individuals and organisations do not benefit enough from making the change and so lack the motivation to make the required changes.

This blocker is caused by the combination of the financial benefits to the individual or organisation being less than the financial costs and the lack of good quality opportunities for individuals and organisations.

If the financial benefits to the individual or organisation are less than the financial benefits, then the non-financial benefits must significantly outweigh the non-financial costs in order to make the low carbon measures an attractive proposition for individuals and organisations.

However, often the lack of good quality opportunities for individuals and organisations means that there can be significant non-financial costs associated with low carbon measures or very limited non-financial benefits.

As such, financial benefits to the individual or organisation being less than the financial costs and the lack of good quality opportunities can combine to create a secondary blocker, where the total benefits to the individual or organisation are less than the total costs.

We have used root cause analysis to identify the market failures and the unintended policy consequences that create blockers to adoption of Low Carbon Measures

Why would individuals and organisations rather fund other things?

Individuals and organisations preferring to fund other things is another way in which they may not benefit enough from making the change and so lack the motivation to make the required changes.

The preference to fund other things is caused by both market failures and the unintended consequences of government policymaking.

Firstly, individuals and organisations do not prioritise funding low carbon measures because they do not value the social benefits associated with them. That is, they do not consider "**externalities**" associated with their decision making.

Secondly, individuals and organisations may defer funding low carbon measures because they believe there will be a better opportunity to purchase them in future. This perspective may be caused by policy uncertainty around low carbon measures. The continued lack of long-term policy certainty means that individuals and organisations may expect the policy environment to change in future, which may offer them an opportunity to purchase low carbon measures for better value. As such, this **policy uncertainty** creates the blocker to adoption.

Why don't individuals and organisations want to be the "first mover"?

Individuals and organisations not wanting to be the "first mover" is another way in which individuals and organisations may be wary about making changes, and so do not have the motivation to make the required changes.

This blocker is the result of low demand for low carbon measures.

In general, individuals and organisations do not want to be the first to make a change - this is a behavioural bias. Low demand in the wider market means that if individuals or organisations make the change, they are likely to have to be one of the first to do so. This is a particular challenge because low carbon measures are often new or emerging technologies, so individuals and organisations may not know others who have already adopted the latest low carbon measures. Therefore, the lack of demand creates a feedback loop, which leads to a secondary blocker to adoption.

We have used root cause analysis to identify the market failures and the unintended policy consequences that create blockers to adoption of Low Carbon Measures

Why don't individuals and organisations trust the product?

Individuals and organisations not trusting the product is one way in which they may be wary about making changes, and so do not have the motivation to make the required changes.

This is caused by the combination of individuals and organisations not knowing how to make changes and the low quality of existing opportunities.

Because individuals and organisations do not know how to make changes, they often rely on their peers for recommendations. The novel and evolving nature of many low carbon measures means that individuals and organisations may be particularly reliant on recommendations from their peers because there is less information available to understand the low carbon measures. However, the low quality of existing opportunities means that their peers may have had bad experiences with a low carbon measure. For example, suppliers may have done a poor installation or individuals and organisations may not enjoy using the low carbon measure.

As a result, individuals and organisations are less likely to trust the product, creating a secondary blocker to adoption.

3.3

How do blockers to adoption affect different Low Carbon Measures and what policies are already in place?

Low Carbon Measures do not all face the same blockers to adoption (1/2)

In our research our case studies show that not all low carbon measures face the same blockers to adoption

Different low carbon measures face different blockers to adoption. In order to promote adoption of each low carbon measure, we need to diagnose what is currently preventing adoption from happening, i.e. the "blockers" to adoption.

We have developed case studies into six low carbon measures to demonstrate how different blockers prevent adoption of each Measure. The low carbon measures are as follows:

1. Domestic heat pumps
2. Domestic whole house retrofit
3. Commercial solar PV
4. Smart local energy systems
5. Cycling
6. Electric vehicle sharing schemes

These case studies are informed by a combination of desk research and interviews.

In each case study we look at what is preventing individuals and organisations from adopting low carbon measures. This could be individuals, homeowners, owners of commercial and public buildings, landlords, local authorities - or any other individual or organisation that needs to change their behaviour to adopt a low carbon measure.

Table 12 summarises the blockers that prevent the adoption of each of our case studies.

Low Carbon Measures do not all face the same blockers to adoption

Table 12: Low Carbon Measures face different types of blockers to adoption

Blockers		Low Carbon Measures					
Category	Types of blocker	Domestic heat pumps	Domestic whole house retrofit	Commercial solar PV	Smart local energy system	Cycling	Electric vehicle sharing
Individuals and organisations do not have the capability to make the required changes	Individuals and organisations do not know what changes they need to make	●	●	●	●	○	○
	Individuals and organisations do not know how to make the required changes	●	●	●	●	○	○
	Individuals and organisations do not have the capacity to make the required changes	●	●	●	●	○	○
The supply chain is not offering good opportunities	There is a limited supply of opportunities to make changes	●	●	●	●	○	●
	Where supply of opportunities does exist, they are low quality	●	●	●	●	●	●
Third parties are preventing change	Regulatory barriers prevent individuals and organisations from making changes	○	●	●	●	○	○
	Local communities prevent individuals and organisations from making changes	○	○	●	●	○	○
Individuals and organisations cannot afford to make the required changes	Individuals and organisations cannot access the requisite finance	○	●	●	●	○	○
Individuals and organisations do not benefit enough from making the required changes	The financial benefits to the individual or organisation are less than the financial costs	●	●	●	●	○	○
	The total benefits to the individual or organisation are less than the total costs	●	●	●	●	●	●
	Individuals and organisations would rather fund other things	●	●	●	●	○	●
Individuals and organisations are wary of making the required changes	Individuals and organisations do not want to be the “first mover”	●	●	●	●	○	○
	Individuals and organisations do not trust the product	●	●	●	●	○	○

Previous Government policy making has attempted to implement policies and investment projects to reduce the blockers to adoption

Previous Government policy-making has attempted to implement policies and investment projects to relieve the blockers to adoption, however, often it has not addressed all of the blockers and so has not been fully effective. For example:

Low Carbon Measure	Policy or investment project	What does the policy do?	What is the blocker it is looking to address?	Which blockers still remain?
District heat networks	Heat Networks Investment Project	The project provides grants and loans for heat networks across England and Wales during the commercialisation and construction stages of a project.	Local authorities cannot always access the requisite finance for heat networks. This means that they do not always have the *opportunity* to implement them leading to a lack of adoption.	Some stakeholders interviewed by Policy Studies Institute and Risk Solutions observed that the success of this scheme could be compromised by blockers such as shortages of skills in the supply chain, so they may still not fully have the *opportunity* to make the change[36].
Electric vehicles	Plug-in Grant	The grant provides a discount on the price of a brand new low-emission vehicle	Low emission vehicles are often more expensive for consumers than other vehicles. This means that individuals may lack the *motivation* as the financial benefits to the individual are less than the financial costs.	A review of the scheme noted that a lack of knowledge about Electric Vehicles was one of the main blockers to adoption facing individuals, meaning they did not have the *capability* to make the change[37]
Domestic retrofit	Green Homes Grant	The policy provided a Grant for up to two-thirds of the cost of chosen improvements, with maximum government contribution of £5,000	The financial benefits to the individual or organisation of energy efficient home improvements are often less than the financial costs. This means that homeowners do not benefit enough from making the required changes and so do not have the *motivation* to retrofit their property.	Homeowners complained that it was difficult to find an installer and short timescales made it hard for energy efficiency installers to meet demand. This means that there was limited supply of *opportunities* to make changes.[38,39]
Private rented housing retrofit	Non Domestic Private Rented Sector Energy Efficiency Regulations	The regulations require properties to have a minimum energy performance rating of E on an Energy Performance Certificate (EPC) in order to be privately rented.	Landlords are often not *motivated* to increase the energy efficiency of their rental properties as it is the tenant that sees the benefits of lower energy costs, meaning that the financial benefit to the landlord is less than the financial cost.	A review of the scheme by BEIS found that the cost of energy efficiency improvements and lack of access to finance was preventing some landlords from complying from the Regulations. This means that lack of *motivation* and *opportunity* may still remain.[40]

[36] HM Government (2020). Evaluation of the Heat Networks Investment Project (HNIP) pilot scheme

[37] HM Government (2013). Assessing the role of the plug-in car grant and plugged-in places scheme in electric vehicle take-up

[38] National Audit Office (2021). Green Homes Grant Voucher Scheme

[39] House of Commons Committee of Public Accounts (2021). Green Homes Grant Voucher Scheme

[40] BEIS (2021). Non-Domestic Private Rented Sector Minimum Energy Efficiency Standards Research

The Net Zero Strategies aim to address some of the blockers to adoption of Low Carbon Measures

For example, the table below shows that some of the policies in the Net Zero Strategy are aiming to address some of the blockers to installing **Domestic Heat Pumps**.

What is the Policy in the Net Zero Strategy?[1]	How how does it aim to address the blockers to adoption?	What is the blocker it is looking to address? *(refs from blockers case studies)*	What is the type of blocker it is looking to address?
Enhance the Simple Energy Advice online platform and moving to GOV.UK	Creates a government-led home energy advice journey which supports individuals and organisations who do not know that they should install heat pumps.	Individuals and organisations currently do not know that they need to install heat pumps: a study from 2019 showed that only 45% of homeowners agree that moving to a renewable heating system would significantly reduce their personal impact on climate change.	Individuals and organisations do not know *what* changes they need to make
	Tailored local advice will support individuals and organisations who already know about heat pumps to find a trusted supplier to install a heat pump.	Even if individuals and organisations do know about heat pumps, they often cannot find a trusted supplier who could install a heat pump. Individuals and organisations often rely on supplier recommendations from peers, therefore if total demand for heat pumps is low then individuals and organisations will not have peers who are able to recommend a trusted supplier.	Individuals and organisations do not know *how* to make the required changes
£32m Public Sector Low Carbon Skills Fund	Aims to improve public sector organisations access to the expert skills needed to identify, develop and deliver decarbonisation projects e.g. installing heat pumps	For Local Authorities, constrained budgets and statutory duties mean that they do not have the resources to develop the capabilities needed to identify opportunities for innovation.[41] This includes, for example, procuring heat pumps.	Individuals and organisations do not have the capacity to make the required changes
Boiler upgrade scheme grants up to £5k for low carbon heating systems / £950m Home Upgrade Grant	Aims reduce the cost of low carbon heating systems e.g. heat pumps	Heat pumps are expensive relative to alternatives and to their benefits to the individual or organisation. This is due to the high cost of electricity relative to gas and the lack of good opportunities for individuals and organisations, for example the technology is not efficient enough to make the financial benefits cover the financial cost.[42]	The financial benefits to the individual or organisation are less than the financial costs
£60 million to be invested in heat pump innovation	Aims to make heat pumps more beautiful and easier to install	Individuals and organisations may be put off from purchasing heat pumps due to the noise, disruption during installation and the fact that they take up space outside properties.[43]	The *total* benefits to the individual or organisation are less than the total costs
Reform of skills system and lifetime Skills guarantee	Aims to incentivise and equip training providers, employers and learners to deliver in line with needs of employers and the green economy	There are few suppliers with the capability to install heat pumps. This means that even if individuals and organisations know about and want a heat pump, they may find that there is a limited supply of opportunities to have them installed.[44]	There is a limited supply of opportunities to make changes

[41] Urban Foresight (2021), Getting to net zero: bridging the innovation gap between places and companies

[42] Department for Business, Energy & Industrial Strategy (2020), Heat pump manufacturing supply chain research project

[43] Building (2021), Major challenges in persuading homeowners to install heat pumps, government admits

[44] Nesta (2021), Heating engineers could hold the key to unlocking the low carbon revolution

The Net Zero Strategies aim to address some of the blockers to adoption of Low Carbon Measures

For example, the table below shows that some of the policies in the Net Zero Strategy are aiming to address some of the blockers to installing **active travel (cycling/walking)**.

What is the Policy in the Net Zero Strategy?[1]	How how does it aim to address the blockers to adoption?	What is the blocker it is looking to address? *(refs from blockers case studies)*	What is the type of blocker it is looking to address?
Invest £2 billion in cycling and walking, building first hundreds, then thousands of miles of segregated cycle lane and more low-traffic neighbourhoods The Scottish Government will support transformational active travel projects with over £500 million of investment over 5 years and has committed to ensuring that at least £320 million or 10% of all the transport capital budget is spent on supporting walking, cycling and wheeling by 2024-25	Increasing the number of segregated cycle lanes and low traffic neighbourhoods means that cyclists are less likely to have to travel alongside large motor vehicles, increasing the safety of journeys and therefore increasing the number of good opportunities for cycling.	The danger associated with cycling is the most commonly cited reason for a lack of cycling adoption; in other words, there are a lack of good opportunities for cyclists. For example, 66% of adults in England agreed that it was too dangerous to cycle on the roads, and women are more likely than men to agree (71% vs 61%).[45]	Where opportunities do exist, they are not good quality
We will enable behaviour change through targeted personal incentives, such as GP prescribing of active travel, existing tax reliefs, and rewards programmes	Increasing the personal incentives to the individual reduces the total costs and therefore the total costs are less likely to outweigh the total benefits to the individual.	Although there are significant financial benefits to cycling for relatively low financial cost, there are major non-financial costs that can put individuals off cycling and can be difficult to address directly, meaning the "total costs" can be higher than the total benefits. For example: • Cycling often takes longer than other modes of transport, and individuals must weigh up the time savings associated with driving or public transport in comparison to cycling. • Cycling is often considered inconvenient due to the lack of storage, exposure to adverse weather conditions and need to change clothes or wash at the end of a journey	Total costs to individuals and organisations are greater than the total benefits

[45] HM Department for Transport (2020), Walking and Cycling Statistics, England: 2019

The Net Zero Strategies aim to address some of the blockers to adoption of Low Carbon Measures

For example, the table below shows that some of the policies in the Net Zero Strategy are aiming to address some of the blockers to installing **whole house retrofit**.

What is the Policy in the Net Zero Strategy?[21]	How how does it aim to address the blockers to adoption?	What is the blocker it is looking to address? *(refs from blockers case studies)*	What is the type of blocker it is looking to address?
Enhance the Simple Energy Advice online platform and moving to GOV.UK	The aim is to deliver a government-led home energy advice journey which supports individuals and organisations who do not know that they should install whole house retrofit	**Individuals and organisations do not how to retrofit their property:** retrofit is highly complex and specific to different properties. This makes it difficult for individuals and organisations to find out what is the best retrofit solution for them. The technical nature of retrofit and heterogeneity of UK housing stock means that individuals and organisations often rely on suppliers to assess the right solution for their property.[46] If the supply chain does not have the capability or motivation to make such recommendations, then individuals and organisations will not be able to find out how to retrofit their property.	Individuals and organisations do not know *what* changes they need to make
£800 million investment into the Social Housing Decarbonisation Fund over financial years 2022/23 to 2024/25	The investment makes funding available to enable local authorities to retrofit social housing and aims to upgrade the EPC rating of a significant amount of social housing stock	Local Authorities often lack the funding for home retrofit beyond managing their existing housing portfolios.[47] This is particularly a blocker because the benefits of retrofit, i.e. the reduction in energy bills, accrue to the tenant rather than the Local Authority who pays for the retrofit.	The financial benefits to the individual or organisation are less than the financial costs
The Government will look to incentivise certification to the relevant British Standards Institution standards in place for energy efficiency retrofit and work with industry to support training and new routes of entry in key skills shortage areas.	Incentivised certifications and new routes of entry into relevant roles is likely to increase adoption and therefore increase the skills available to deliver whole house retrofit	Sparse and inconsistent educational provision for new entrants as thermal efficiency retrofitting does not generally feature in formal skills training (as evidenced in Chapter 2.3 of the Heat & Buildings Strategy)	There is a limited supply of opportunities to make changes

[46] Buro Happold (2012), Domestic UK retrofit challenge: Barriers, incentives and current performance leading into the Green Deal

[47] Urban Foresight (2021), Getting to net zero: bridging the innovation gap between places and companies

3.4

Case studies:
Blockers to adoption

Introduction

We have developed case studies to diagnose what is blocking the adoption of different low carbon measures

Different low carbon measures face different blockers adoption. This means that they are missing different Enabling Conditions.

In order to solve the problem for each low carbon measure, we need to diagnose what is currently preventing adoption from happening in order to correctly rectify the blockers.

We have developed case studies into six low carbon measures to demonstrate how different blockers prevent adoption of each Measure. The low carbon measures are as follows:

1. Domestic heat pumps
2. Domestic whole house retrofit
3. Commercial solar PV
4. Smart local energy systems
5. Cycling
6. Electric vehicle sharing schemes

These case studies are informed by a combination of desk research and interviews.

In each case study we look at what is preventing individuals and organisations from adopting low carbon measures. This could be individuals, homeowners, owners of commercial and public buildings, landlords, local authorities - or any other person or organisation that needs to change their behaviour to adopt a low carbon measure.

We would like to thank colleagues from UK100, EIT Climate-KIC, Ministry of Housing, Communities and Local Government, Department for Business, Energy and Industrial Strategy and Innovate UK for contributing valuable insight that has informed and developed these case studies.

Case study: Domestic heat pumps (1/4)

What is blocking the adoption of domestic heat pumps?

Context

The Government has set a target to install 600,000 heat pumps a year by 2028.[1] This will involve a large number of homeowners, landlords and Local Authorities making changes. Homeowners will need to purchase heat pumps for their properties, landlords for leased properties and Local Authorities for social housing. These groups of individuals and organisations will face different blockers, discuss in more detail below.

Individuals and organisations do not know that they should install heat pumps

- **45% of homeowners** agree that moving to a renewable heating system would significantly reduce their personal emissions
- This knowledge gap arises from limited information about the need to decarbonise heating and the technology that could do this,
- Efforts to improve information accessibility have not fully addressed the problem - e.g. **EPC recommendations tend not to recommend heat pumps often because the surveyors assigning the rating are not familiar with the technology**.[48]

Individuals and organisations do not know how to get a heat pump installed

- **There is a lack of awareness** about heat pumps paired with a lack of trusted suppliers for installation.[49]
- People often rely on supplier recommendations from peers, therefore if total demand for heat pumps is low then they will not have peers who are able to recommend a trusted supplier.
- There is also reliance on product recommendations from suppliers, who may not recommend them - **43% of installers surveyed by the Sustainable Energy Association had no experience with heat pumps.[50]**
- The lack of information means that individuals or organisations need time and resources to learn and procure the installation.
- Local Authorities with constrained budgets and statutory duties do not have the resources to develop the capabilities needed to identify opportunities for innovation.[51] This includes procuring heat pumps.

[48] Yorkshire Energy Systems (2019), EPCs: A major obstacle to heat pumps and decarbonisation

[49] Heat Pump Association (2019), Delivering net zero: A roadmap for the role of heat pumps

[50] Sustainable Energy Association (2019), Installer Survey Results 2019

[51] Urban Foresight (2021), Getting to net zero: bridging the innovation gap between places and companies

Case study: Domestic heat pumps (2/4)

What is blocking the adoption of domestic heat pumps?

Individuals and organisations cannot find suppliers who can install a heat pump

- There are few suppliers with the capability to install heat pumps. This means that even if individuals and organisations know about and want a heat pump, they may find that there is a limited supply of opportunities to have them installed.[52]

There are multiple reasons that the supply chain has not developed its capability to deliver heat pumps:

1. Demand for heat pumps is low therefore suppliers have no incentive to take time off work to undertake paid training
2. Suppliers often rely on recommendations and training from manufacturers to inform their decision making.[53] Given that the gas boiler industry is significantly more developed than the heat pump industry, the incumbent manufacturers have more scope to communicate with and influence suppliers and they will prioritise their incumbent technologies. **For example, gas boiler manufacturers regularly provide free, high quality training for suppliers to ensure that there are adequate capable suppliers who can install their technology**

The opportunities for heat pump installations are low quality

Even in cases where individuals and organisations have the capability to make changes and the opportunity for changes exists, often the opportunities for installing heat pumps are low quality. **For example, heat pumps are noisy and are not well designed for the UK housing stock where properties tend to be poorly insulated**.[54] The reason for the poor quality of opportunities is two-fold:

- Firstly, the historic lack of demand for heat pumps has limited investment in improving efficiency and suitability for the UK.[54]
- Secondly, the risk associated with clean tech propositions means that startups struggle to attract finance to develop better opportunities.[55] Investors may see heat pumps as too risky to invest in as they often do not understand the clean technology or associated business models.
- Furthermore, heat pumps are often sold in isolation even though they are typically more effective when installed as part of a retrofit to optimise the size of the heat pump required.[56]

[52] Nesta (2021), Heating engineers could hold the key to unlocking the low carbon revolution

[53] Wade et al (2016), Understanding the missing middlemen of domestic heating: Installers as a community of professional practice in the United Kingdom, Energy Research & Social Science, 19

[54] Department for Business, Energy & Industrial Strategy (2020), Heat pump manufacturing supply chain research project

[55] PwC (2020), The State of Climate Tech 2020: The next frontier for venture capital

[56] PHAM News (2020), Insulation helps get the best out of heat pumps

Case study: Domestic heat pumps (3/4)

What is blocking the adoption of domestic heat pumps?

The financial benefits to the individual or organisation are less that the financial cost

- Lack of motivation to install heat pumps in building and homes
- Heat pumps are expensive relative to alternatives and to their benefits to the individual or organisation
- This is due to the high cost of electricity relative to gas and the lack of good opportunities for individuals and organisations, for example the technology is not efficient enough to make the financial benefits cover the financial cost.[57]

However, even where heat pumps can create adequate energy savings to cover the financial cost of installation, the financial benefits of energy savings may not accrue to the individual or organisations. For example:

- For homeowners, the long payback period of heat pumps means that it takes a long time for the financial benefits to cover the financial costs of installation. If the owner occupier sells the property before this payback period is reached, they cannot guarantee that the property value will reflect the impact of energy efficiency improvements such as heat pumps
- Some evidence does suggest that energy efficiency improvements do increase house prices.[58] However, this increase cannot be guaranteed, for example the value put on a heat pump system could vary due to personal preference and the weather at the time of sale[59]
- For private landlords, the financial benefits of installing a heat pump would accrue to the tenant in the form of lower energy bills. However, the landlord is not able to recoup the cost through charging higher rent if private tenants are not willing to pay more for more energy efficient properties[59]
- For social landlords, i.e. Local Authority or housing association, the financial benefits of installing a heat pump would accrue to tenants through lower energy bills. However, in this case the social landlord has no means to recoup the cost through charging more for rent due to the caps on social housing rent[60]
- Additionally, all landlords will have to forgo rental income during the installation of the heat pump if they have to either compensate tenants during the installation or undertake the installation while the property is not occupied. This additional financial cost further reduces the net benefit to the landlord

[57] Department for Business, Energy & Industrial Strategy (2020), Heat pump manufacturing supply chain research project

[58] Department of Energy & Climate Change (2013), Energy saving measures boost house prices

[59] The Renewable Energy Hub UK (2020),

[60] Are heat pumps worth the investment UKGBC (2020), The Retrofit Playbook: Driving retrofit of existing homes - a resource for local authorities

Case study: Domestic heat pumps (4/4)

What is blocking the adoption of domestic heat pumps?

The total costs to individual or organisation also exceed the total benefits

The non-financial costs and benefits may also mean that individuals and organisations do not want to install heat pumps, because the total costs exceed the total benefits. In the case of heat pumps, individuals and organisations may be put off by the noise, disruption during installation and the fact that they take up space outside properties.[61]

Individuals and organisations would rather fund other things

In the absence of a compelling offer, homeowners may prioritise other expenditure. If an owner occupier is taking out a loan for refurbishment, they may use additional finance to for alternative improvements.

Furthermore, individuals and organisations may expect Government support for low carbon measures in domestic properties to change in future, particularly as the Heat & Buildings Strategy is expected to be published this year. Government support has stopped and started and been short-term, so individuals and organisations may choose to defer. installing a heat pump in the hope that there could be future grants that reduce their need to fund the installation

Individuals and organisations do not want to be the "first mover"

These blockers compound to mean that adoption of heat pumps is low across city-regions, which create further reasons that individuals and organisations do not want to make the change. For example, agents do not want to be the first mover in their neighbourhood and so will wait for others to install heat pumps before they are interested in doing so.

Individuals and organisations do not trust the product

- Homeowners tend to rely on recommendations from their peers or from the installer about whether and how to replace their boiler. Given that overall demand is low and installers often do not have the capability, they are therefore unlikely to receive these recommendations
- Potential buyers are more likely to be influenced by bad experiences that they hear about through the news or from peers
- Bad news stories about poor heat pump installations can make individuals and organisations distrust the product,[62] and bad experiences are likely caused by the lack of capability in the supply chain, which makes a faulty installation more likely.

[61] Building (2021), Major challenges in persuading homeowners to install heat pumps, government admits

[62] The Times (2021), Heat pump howler cost us thousands on our bills

Case study: Whole house retrofit (1/3)

What is blocking the adoption of domestic whole house retrofit?

Context

The Government's Ten Point Plan highlights the critical role of decarbonising homes and the Climate Change Committee's Sixth Carbon Budget calls for a national programme to improve building efficiency in the UK.[63,64]

Whilst there is no fixed definition of "whole house retrofit" it refers to a comprehensive approach to making homes more energy efficient. It typically focuses on the fabric of the building first and addresses ventilation in a complementary way. It increasingly targets a net zero design by considering elements such as smart controls, renewable heating, cooling, generation and storage. As is the case for heat pumps, individual or organisation can be private homeowners or Local Authorities for domestic buildings.

The blockers to adoption of whole house retrofit are similar to those for heat pumps: homeowners do not know that they need retrofit and do not know how to find out about opportunities or suppliers; the supply chain is not set up to deliver retrofit, in particular good retrofit opportunities; and homeowners do not want to fund retrofit based on the balance of financial and non-financial costs and benefits.[65]

However, there are additional blockers that are specific to retrofit:

Homeowners do not how to retrofit their property

Retrofit is highly complex and specific to different properties. This makes it difficult for homeowners to find out what is the best retrofit solution for them.

The technical nature of retrofit and heterogeneity of UK housing stock means that homeowners often rely on suppliers to assess the right solution for their property.[66] If the supply chain does not have the capability or motivation to make such recommendations, then homeowners will not be able to find out how to retrofit their property.

[63] HM Government (2020), The Ten Point Plan for a Green Industrial Revolution: Building back better, supporting green jobs, and accelerating our path to net zero

[64] Climate Change Committee (2020), Sixth Carbon Budget

[65] UKGBC (2020), The Retrofit Playbook: Driving retrofit of existing homes - a resource for local authorities

[66] Buro Happold (2012), Domestic UK retrofit challenge: Barriers, incentives and current performance leading into the Green Deal

Case study: Whole house retrofit (2/3)

What is blocking the adoption of domestic whole house retrofit?

Homeowners do not have the capacity to accommodate retrofit or procure a comprehensive retrofit solution

Whole house retrofit is associated with significant disruption to the property. This means that homeowners may have to move out of their property for at least some period of the retrofit or experience significant inconvenience. Some homeowners will not have the capacity to find alternative accommodation or accommodate the inconvenience, for example living without a kitchen or heating during some of the installation.

Furthermore, retrofit is a combination of lots of different energy efficiency low carbon measures. This means that, in the absence of suppliers offering a single combined solution, homeowners will have to coordinate lots of suppliers in order to deliver a full retrofit. This coordination and project management can be difficult and requires significant skills and time on the behalf of individual or organisation.

For Local Authorities, the need to retrofit heterogeneous social housing stock increases the need for skilled resource to assess and manage different requirements. However, as noted before, this resource is often not available.

The supply chain has not coordinated to develop good opportunities

The supply chain could resolve this issue by coordinating the provide a value offering to homeowners. Coordination can be difficult, but the main reason this offering has not been developed is likely due to low demand from homeowners.

Regulatory barriers prevent homeowners from making changes

For some homeowners, regulations prevent them from retrofitting their property. In particular, there are significant restrictions on what modifications can be made to protected or listed buildings, which mean that homeowners may not be allowed to make the changes they want to.[67]

Homeowners cannot access the requisite finance

There is a lack of finance mechanisms that could help homeowners pay for their retrofit and can accommodate different financial and tenure circumstances.[68] This is likely due to the lack of demand for such products in the market.

For Local Authorities, current procurement processes can prevent them from procuring innovative business models that would help them finance retrofit.[69] For example, models where suppliers earn a return from the energy savings without charging for installation.

[67] Buro Happold (2012), Domestic UK retrofit challenge: Barriers, incentives and current performance leading into the Green Deal

[68] UKGBC (2020), The Retrofit Playbook: Driving retrofit of existing homes - a resource for local authorities

[69] Urban Foresight (2021), Getting to net zero: bridging the innovation gap between places and companies

Case study: Whole house retrofit (3/3)

What is blocking the adoption of domestic whole house retrofit?

Financial benefits to the homeowner are less than the financial costs

The disruption associated with retrofit means that occupants of the property are likely to have to move out for at least some of the duration of works. This adds to the financial costs to the individual or organisation, where:

- Owner occupiers would need to pay for an alternative place to stay during the works
- Private or social landlords would either need to wait for tenants lease to end or accommodate tenants elsewhere during the works. If landlords wait until the lease ends and tenants move out, then this amounts to forgone rental income. Alternatively, the landlord would have to compensate tenants for replacement accommodation while the retrofit is underway

Case study: Commercial solar PV (1/5)

What is blocking the adoption of commercial solar PV?

The Climate Change Committee states that renewables - including solar and wind - needs to represent 80% of the grid balance by 2050, delivered through solar capacity of 85 TwH capacity.[70]

As of 2019, the UK had only 10 TwH of solar generation. Commercial solar has an opportunity to provide a high profile, visible and uncontroversial source of renewable energy.

Furthermore, the reintroduction of Contracts for Difference (CfD) auctions (a form of Government pricing support) for solar PV in 2021 acknowledges both the residual economic challenges with solar and its importance in the energy mix.

For the purpose of this study we have focused on non-utility scale solar (defined as) on commercial land and buildings.

Organisations do not know they should install solar

Whilst there is a growing awareness around the importance of climate action, most companies are yet to commit to net zero pledges and others are in the process of developing their associated action plans. This means that the key role that solar can play in decarbonising operations and the wider financial and reputational benefits they offer are not yet fully appreciated.

This applies to an even greater extent to the more integrated energy systems and business models that can enhance the benefits of solar installations.

Organisations do not know how to get solar installed

For most organisations who have had little or no experience of energy generation, they do not know where to start with the process of understanding the solar opportunity, technical considerations, and supplier choices.

There are industry bodies such as the Microgeneration Certification Scheme (MCS) which provide accredited supplier lists but there is little coordinated promotion of these sources. The current low levels of installation also result in a lack of available recommendations within business networks.

[70] Climate Change Committee (2020), The Sixth Carbon Budget The UK's path to Net Zero

Case study: Commercial solar PV (2/5)

What is blocking the adoption of commercial solar PV?

These factors are again more acute in the context of solar sitting within more integrated systems.

Organisations do not have the capacity to identify the need for solar or procure its installation

In the absence of high-level board commitments and strategic alignments to net zero, low carbon measures such as solar PV remain a low organisational priority without committed resource for project development and finance. This is exacerbated where there is a lack of the technical knowledge and skills and further where circumstances and systems are more complicated.[71] For example, procurement departments require resource and face a steep learning curve to navigate face choices around different business and funding models and their associated legal agreements.

In local authorities this challenge is compounded by the lack of revenue funding for the development of capital projects, cross departmental responsibilities, and where procurement processes are more protracted.[71]

Organisations cannot find suppliers to install solar

The launch of the Feed in Tariff led to a significant growth in the number of operators in the sector but its early withdrawal and drop in demand resulted in significant numbers of business closures and reductions in capacity.

Increasing demand is already putting pressure on global supply chains, making it harder to find suppliers. Rapid increases in demand may not be able to be met as it takes time for the supply chain to upskill.

The opportunities for solar installation are low quality

The proliferation of installers under the Feed in Tariff inevitably led to instances of poor quality work and concerns around reputation in the sector. Organisations such as MCS are providing confidence where there is awareness, however this barrier may remain to a certain extent.

Many of the challenges around quality relate to the nature of the opportunity in particular circumstances, for example the construction of the existing buildings, size of potential array, aspect, location and shading.[71] All of these affect the viability of a potential scheme.

[71] Solar Power Portal (2021), The 10 most common mistakes in solar farm development by local authorities, part two

Case study: Commercial solar PV (3/5)

What is blocking the adoption of commercial solar PV?

Regulatory and policy barriers prevent organisations from making changes

The installation of solar panels on commercial buildings is typically considered permitted development for planning permission. However, this is not the case for listed buildings and conservation areas. Therefore, these buildings will face regulatory barriers to installation.[72]

Furthermore, solar farms face far greater challenges in achieving planning permission particularly when overlooked by housing, on green belt and where there are ecological concerns. Even where development may be able to go ahead, this regulatory uncertainty can place additional risk on project development costs.

[72] Solar Power Portal (2021), The 10 most common mistakes in solar farm development by local authorities, part two

[73] Solar Power Portal (2021), The 10 most common mistakes in solar farm development by local authorities, part one

Local communities and other stakeholders prevent organisations from making changes

In the context of planning permission for solar farms and decisions for buildings in conservation zones, the community can play a significant part in either supporting or objecting to solar installations.[73]

One of the key barriers to solar installations is the cost and process for obtaining grid connections. Where an upgrade of the local grid is required, in the absence of strategic local plans, grid connection charges for individual projects can be prohibitive. The negotiation process can be complex and uncertain as local requirements change over time.

Furthermore, many businesses do not own the property they operate from which can lead to complications in agreements with multi-layered negotiations. Differences in occupancy and ownership time horizons for tenants and property owners can complicate investment and contract decisions, and may prevent opportunities from going ahead.[72]

Organisations cannot access the requisite finance

Finance for solar installations is available from multiple sources including traditional corporate finance products and specialist emerging models. The choice and ultimate availability of finance is limited by each organisation's individual circumstances including existing balance sheet strength, profitability, cashflow, and investment decision making processes.

Case study: Commercial solar PV (4/5)

What is blocking the adoption of commercial solar PV?

Access to lower cost and longer term finance is typically restricted to larger scale projects, and without coordinated aggregation of projects is beyond the reach of most organisations. The emergence of models such as Community Municipal Investments allow local authorities to access low cost and longer term debt finance but these are not available to most other organisations.

The financial benefits to the organisation are less than the financial costs

Installing solar PV generates financial benefits by reducing the users' energy demand from the grid, and therefore energy bills. Without mature and attractive export business models there is often a need for high levels of own use of energy generated to make the energy savings cover the cost of installation.

These export business models may not have been created due to the current energy market regulations which set a nationwide price for electricity. The absence of flexible pricing means there is no incentive to develop distributed energy generation solutions where they are most needed.

If a business does not have sufficient requirement for the solar power generated, the pay back periods often exceed investment decision making parameters.[74]

Furthermore, the current business rates regime allows for charges to be made for solar panels and can negatively impact the operational cost of a scheme as well as lead to uncertainty around local application of the rules.[74]

Finally, the impact of solar installations on property values remains uncertain and so the organisation cannot guarantee that they will be able to recoup the costs when the building is sold.

There are means for organisations to improve the financial returns, for example achieving reduced supply and installation costs through economies of scale or using storage systems to both increase the amount of own use and provide access to the grid flexibility market. However, these opportunities are generally limited to large property portfolio owners or operators.

As such, the financial benefits of installing solar PV may not exceed the financial benefits.

[74] Reindl & Palm (2021), Installing PV: Barriers and enablers experienced by non-residential property owners. Renewable and Sustainable Energy Reviews, Vol. 141

Case study: Commercial solar PV (5/5)

What is blocking the adoption of commercial solar PV?

The total benefits to the organisation are less than the total costs

There is a growing emphasis on the brand reputation and staff recruitment, motivation, and retention associated with climate change and sustainability commitments. This pressure from customers, suppliers and staff could increase the total benefits to a organisation of installing solar PV, however remains insufficient in many cases.

Organisations would rather fund other things

In the absence of board level commitment to net zero and sufficient commercial pressure, solar installation sits outside of core organisational strategic objectives, and therefore operational priorities. As such, companies would rather fund other activities.

Furthermore, the removal of the Feed in Tariff had a significant impact on solar installations as organisations were uncertain about the opportunity for future subsidies. As such, companies are likely to delay investment decisions in the expectation of future policy changes that may provide a better opportunity.

Organisations do not want to be the “first mover”

There remains an insufficient level of solar installations to provide confidence and influence for many organisations in terms of overcoming the complexity and managing the risks and rewards associated with solar installations. Low demand means that often an organisation would be the first in their area or business park and so they lack the positive examples that can drive change.

Organisations do not trust the product

Through organisations like MCS, the industry is overcoming concerns over quality but some will remain. Also many organisations will question whether now is the right right time to invest as the efficiency of solar panels continues to improve and prices are reducing.

Increasing awareness of the benefits of more integrated systems may also lead to questions over solar installations as a standalone solution.

Case study: Smart Local Energy Systems (1/6)

What is blocking the adoption of Smart Local Energy Systems?

Smart Local Energy Systems (SLES) will play an essential role in the balancing of supply and demand as we switch to more distributed and intermittent sources of energy.[75]

SLES come in many forms including combining individual low carbon measures such as large scale solar and battery storage, through to designs for local and regional scale energy systems that combine power and heat across sectors such as buildings, transport, and waste.[76]

The customer for a SLES will therefore vary from project to project. For the purposes of this case study, we focus on local and regional scale approaches and consider blockers to Local and Combined Authorities (local government) playing an active role in their development.

Local governments do not know *what* is involved in developing SLES, or what their role should be

There are growing calls for Local and Combined Authorities to play an active role in the development of SLES but a low level of awareness amongst politicians and officers about what they involve and their importance within the transition to net zero.[77]

A lack of a national strategy on SLES means there is no central commitment, roadmap, or resources to inform local governments about what they should do. This includes the absence of a clear framework for the role of local government within national, regional, and local governance structures alongside other stakeholders.[78]

Whilst there is an emerging understanding within the sector of what a SLES should incorporate from a technical perspective, this information has not been widely disseminated in a way that acknowledges different applications depending on local circumstances.

Local governments do not know *how* to develop SLES

The design and demonstrator projects within the PFER programme are yet to reach a point where they can provide sufficient confidence in either the technology or commercial models to support the development and procurement of SLES at scale.[79] As such, local governments who want to pursue a SLES struggle to inform themselves about best practices.

There is a clear enabling role for Local Area Energy Plans (LAEP) as a way of coordinating both data and stakeholders to understand the future requirements of SLES and lay the foundations for the design process.[78]

[75] UK:100 (2020), Accelerating the Rate of Investment in Local Energy Projects
[76] Energy Systems Catapult (2021), Enabling Smart Local Energy Systems: Finance and Investment
[77] Climate Change Committee (2020), Local Authorities and the Sixth Carbon Budget
[78] Regen (2020), Local leadership to transform our energy system
[79] Innovate UK (2019), Prospering from the Energy Revolution

Case study: Smart Local Energy Systems (2/6)

What is blocking the adoption of Smart Local Energy Systems?

However, understanding of the LAEP approach is only starting to emerge amongst local government. Similarly, the associated resources to support local government participation are still in the process of being released, meaning local government do not have access to information about how best to follow the LAEP approach.

Local governments are already grappling with how to develop net zero roadmaps in the absence of clear national strategies. In the context of the design and development of SLES, uncertainty around national support for different technologies compounds the challenge of how to establish programmes that accommodate different scenarios, and enable immediate, "low regret" project development.[80]

As such, even if local governments want to develop SLES they do not know the best way to go about doing so.

Local governments do not have the capacity to develop SLES

There has been widespread commitment by local government to tackling climate change and ambitious local and regional targets for achieving net zero. This is being matched by operationalising those commitments across existing functions. However, often they do not have the capacity to develop SLES.

The technical nature of SLES means that local governments need significant levels of resource to develop them. In particular, they are beyond the existing commercial and technical knowledge and skills within local government teams and require capacity building across all departments if they are to be tackled in an holistic way, across different sectors. For example, identifying opportunities for individual projects to be combined as part of wider SLES programme development would require building the capacity to work across traditionally siloed departments.[81]

Local governments have not been able to develop this capacity for several reasons.

Firstly, local governments have not been able to develop this capacity because of a lack of a clearly articulated business case for early-stage investment in capacity for local government involvement in LAEPs. Such a business case would need to demonstrate the tangible income, and social value generating opportunities that they can unlock, which has yet to be confirmed.[81]

[80] Regen (2020), Local leadership to transform our energy system
[81] UK:100 (2020), Accelerating the Rate of Investment in Local Energy Projects

Case study: Smart Local Energy Systems (3/6)

What is blocking the adoption of Smart Local Energy Systems?

Secondly, local governments lack the statutory responsibilities and powers to effectively lead the planning, design, and delivery of SLES. There is no requirement for them to participate in developing Local Area Energy Plans and therefore they have not been provided with the necessary funding, resources or reporting requirements.[82] Instead, local governments inevitable focus on existing or immediate opportunities for funding which tend to be on a limited and competitive project-by-project basis.[83]

This results in local government not having the capacity to develop a SLES, including having the skills necessary to design procurement processes that could facilitate the procurement of these services.

There is a limited supply of opportunities to develop SLES

As the SLES market is currently in the technical development stage, the business models and supply chains do not yet exist for end-to-end delivery of area scale SLES. There are mature products and services across many of the individual elements of SLES, however the scale and complexity of bringing these together in an integrated approach suggests the need for a coordinated business model.

A number of the large energy service providers offer the scale and broad range of expertise required to develop and manage local and regional SLES, however they themselves are in process of developing their own offerings along with the rest of the market.

Where opportunities to develop SLES do exist, they are not good quality

In the absence of mature models, opportunities for local government to engage in SLES projects are inevitably at the development stage. This means that they often require uncertain grant funding applications, match funding from local government with uncertain benefits and carry a greater degree of risk.[83]

As a result, they tend to be of lower quality and limited in scope in terms of the level of integration they involve, apart from those projects funded through the PFER programme.

[82] UK:100 (2020), Accelerating the Rate of Investment in Local Energy Projects
[83] UK:100 (2021), Power Shift: Research into Local Authority powers relating to climate action

Case study: Smart Local Energy Systems (4/6)

What is blocking the adoption of Smart Local Energy Systems?

There is a similar lack of expertise available within professional services firms. The immaturity of the market means that professional services firms do not have the capability to offer independent guidance local government participation in the development of SLES, that could support the development of better quality opportunities.[84]

Regulatory and policy barriers prevent local governments from developing SLES

Current regulations do not enable the integration of energy planning within wider spatial planning powers.[84] As a result, regulatory barriers make increasing the level of integration in a SLES more difficult.

Local communities and other stakeholders could limit the success of SLES

Behaviour change will likely play an essential role in the development of SLES as communities and organisations will be required to reduce energy demand, invest in the building stock, switch to alternative technologies, and adopt different service models.

However, there are low levels of awareness and engagement around the importance and benefits of SLES outside of the sector. This includes a lack of national messaging, local advocacy, and importantly direct opportunities to engage on project development. Local government are in the ideal position of trust to support a coordinated approach to community engagement but lack the mandate and capacity to do so.[85]

Without the awareness and engagement of local communities, they may prevent SLES from going ahead if they object to any disruption that could be involved.

Additionally, key stakeholders such as Distribution Network Operators, who play a central role in managing energy demand, lack the capacity to support the development of SLES.[86]

Local governments cannot access the requisite finance for the development of SLES

The early stage of the development of SLES means that finance models for their development and delivery do not yet exist. This is particularly acute in terms of early-stage development capital to provide resources that could support LAEPs and local government participation.[85]

[84] UK:100 (2021), Power Shift: Research into Local Authority powers relating to climate action
[85] UK:100 (2020), Accelerating the Rate of Investment in Local Energy Projects
[86] Regen (2020), Local leadership to transform our energy system

Case study: Smart Local Energy Systems (5/6)

What is blocking the adoption of Smart Local Energy Systems?

The scale of the finance requirement for the development and delivery of SLES indicates the need to unlock significant funding from large institutional investment and capital markets. These typically require a level of certainty around future income and expenditure that is not currently available for SLES.[87]

Early-stage seed and development capital from the private sector requires shareholdings and significant potential returns to justify the riskier nature of the investment. The uncertainty of future governance structures and a lack of experience within local governments around such arrangements, prevents these forms of investment.

Local governments are currently reliant on uncertain grant applications as part of competitive funding programmes to develop SLES. The UK Infrastructure Bank presents a potential source of both development capital and expertise recognising that SLES is a key infrastructure requirement in delivering net zero. The bank is not yet ready to make investments and its initial investment priorities are not yet clear.

The financial benefits to local governments have not yet been demonstrated to be greater than the financial costs

In the absence of clear case studies for larger scale SLES, the investment requirements and associated returns are currently unclear apart from for some individual, isolated projects.

The total benefits to local governments have not been demonstrated to be greater than the total costs

Similarly to the financial benefits, the wider positive social impact of SLES has yet to be sufficiently demonstrated to support broad political buy-in and unlock investment in resource from multiple potential departments and sources. For example, SLES can generate benefits such as job creation, local economy, social inclusion, and better health outcomes.

[87] UK:100 (2020), Accelerating the Rate of Investment in Local Energy Projects

Case study: Smart Local Energy Systems (6/6)

What is blocking the adoption of Smart Local Energy Systems?

Local governments would rather fund other things

In the absence of statutory responsibilities, and alternative sustainable business and finance models for SLES development, local governments prefer to focus on their core priorities such as social care and carbon reduction programmes within their direct control.

In addition, the uncertain role for local government and potential future fiscal measures and economies of scale mean that local governments struggle to understand the financial case for their involvement in SLES development.[88] As a result, they would rather fund other activities.

Local governments do not trust the SLES market

Due to the early-stage nature of SLES including many of the constituent parts, local government does not have sufficient knowledge or skills to make informed decisions around design and procurement. This presents significant risk to local government in considering SLES opportunities.

They are naturally wary to take on responsibility for SLES without clear frameworks and funding and are therefore unwilling and unable to allocate resources.

Local governments do not want to be "first movers"

Most Local and Combined Authorities simply do not have the knowledge, skills or resource to be a first mover in developing SLES, and even if they did, they would be reluctant given the significant uncertainty around the future development and financing of the market.

There are pioneering cities and regions, who have embarked on developing LAEPs and SLES and are in the process of identifying and overcoming challenges that will assist others.

[88] Energy Systems Catapult (2021), Enabling Smart Local Energy Systems: Finance and Investment

Case study: Cycling (1/2)

What is blocking the adoption of cycling?

Cycling is a key measure in decarbonising transport. In particular, the Government has set a target of doubling rates from 2013 levels by 2025 in the Ten Point Plan, with half of all journeys in towns and cities to be cycled or walked by 2030 as part of DfT's 'Decarbonising Transport' plan.[89,90] This will involve a lot of individuals purchasing bicycles and deciding to use them.

Cycling is a well-established mode of transport, meaning that individuals generally have the capability to change their behaviour and that the supply chain is well set up to provide and repair bicycles.

As such, the main blockers to adoption are the lack of *good* opportunities and the balance of costs and benefits for individuals.

There is a lack of good opportunities for cycling

The danger associated with cycling is the most commonly cited reason for a lack of cycling adoption; in other words, there are a lack of good opportunities for cyclists. For example, 66% of adults in England agreed that it was too dangerous to cycle on the roads, and women are more likely than men to agree (71% vs 61%).[91]

Cycling is deemed to be unsafe due to the proximity, speed and behaviour of other road users such as cars, buses and HGVs, as well as the volume of motor traffic.[92] The lack of segregated cycle lanes mean that cyclists often have no option but to travel alongside large motor vehicles, meaning that the opportunities to cycle are not good quality.

Segregated cycle lanes would improve the opportunities for individuals, however they are not being built. Local Authorities have not been able to build more cycle lanes due to a lack of funding and objections from car users. The opportunities for the private sector to step in are also likely to have been limited due to the need for planning permission from Local Authorities and their inability to earn an adequate return on the investment from users. Users do not value the public benefits of cycle lanes, therefore are not willing to pay enough to make the optimal level of cycle lanes viable.

[89] HM Government (2020), The Ten Point Plan for a Green Industrial Revolution: Building back better, supporting green jobs, and accelerating our path to net zero
[90] HM Department for Transport (2021), Decarbonising transport: a Betterm, Greener Britain
[91] HM Department for Transport (2020), Walking and Cycling Statistics, England: 2019
[92] Cycling UK (2021), Cycling UK's Cycling Statistics

Case study: Cycling (2/2)

What is blocking the adoption of cycling?

Total costs to the individual or organisation are greater than the total benefits

Although there are significant financial benefits to cycling for relatively low financial cost, there are major non-financial costs that can put individuals off cycling and can be difficult to address directly.

Firstly, cycling often takes longer than other modes of transport, and individuals must weigh up the time savings associated with driving or public transport in comparison to cycling.

Secondly, cycling is often considered inconvenient due to the lack of storage, exposure to adverse weather conditions and need to change clothes or wash at the end of a journey.

Case study: Electric vehicle sharing schemes (1/2)

What is blocking the adoption of electric vehicle sharing schemes?

The Government has brought forward the ban on the sale of new petrol and diesel cars and vans by ten years to 2030. This ban will enforce a significant shift from petrol and diesel cars towards electric vehicles. Car sharing is recognised as a more cost effective solution, where have access to a pool of cars that can be picked up and dropped off where suitable. This would be more cost effective as each vehicle would be used more often.

However, there are already blockers to adoption of electric vehicles and there are further blockers to adoption of a shared electric vehicle scheme.

There is a limited supply of opportunities to use electric vehicle sharing schemes

Individuals are aware of the impacts of transport: 77% of people associate emissions from transport with causing climate change.[93] As demand for electric vehicles has increased, the supply chain has developed to provide them. However, there has been limited development of opportunities to use electric vehicle sharing schemes.

Evidence from car sharing schemes that have attempted to operate in London suggest that the following causes are to blame:[94]

- Demand has proved to be lower than expected, meaning that it is not viable for car sharing schemes to operate. Car sharing schemes are only viable for the private sector if demand is high enough that cars are well utilised.
- Suppliers have to negotiate individually with every Local Authorities in order to be able to park their electric vehicles within that area. This bureaucratic burden means that it is often not worthwhile for suppliers to pursue operations.

Where electric vehicle sharing schemes do exist, they are low quality

If a Local Authority does not give permission for an electric vehicle sharing scheme to park in that area, then the quality of the opportunities for individuals living in the area falls significantly as the convenience of the scheme compared to private car ownership is reduced. For example, Bluecity found that its service was no longer viable as it was only able to secure deals with three London councils.[95]

[93] Cycling UK (2021), Cycling UK's Cycling Statistics
[94] Catapult Energy Systems (2020), Understanding Net Zero: A Consumer Perspective
[95] Fleetworld (2019), Lack of demand blames for London car sharing closure

Case study: Electric vehicle sharing schemes (2/2)

What is blocking the adoption of electric vehicle sharing schemes?

Total costs outweigh the total benefits for the individual

Low demand even where schemes do exist suggests that individuals do not want to use electric vehicles or car sharing schemes. For example, individuals cite the lack of ease (43%) and inconvenience as barriers to switching from a petrol or diesel car to an electric vehicle.[96] These barriers increase the non-financial costs associated with using an electric vehicle, making the offer of an electric vehicle less compelling.

Furthermore, inconvenience is often cited as a disadvantage of car sharing schemes as vehicles cannot be guaranteed to be available where and when individuals want to use them.[97] This non-financial cost, whether perceived or actual, means that individuals would prefer to have their own car.

Individuals would rather fund other things

Finally, cars are seen as more than a mode of transport. Individuals buy cars as a luxury good and an indicator of status which means that even if there is a compelling offer for an electric vehicle sharing scheme, customer preferences may continue to lead to low motivation for adoption.

[96] Evening Standard (2020), Electric car-sharing scheme scrapped in London after poor uptake
[97] Krzton (2018), Car sharing - everything you should know

4

Climate Action Readiness Assessment (CARA) Workshops

This section summarises and provides the findings from Climate Action Readiness Assessment workshops held with participants from each of our representative city-regions

What this section covers:

In this section we explain the methodology and findings from Climate Action Readiness Assessment (CARA) workshops held with all six city-regions invited and attendance by representatives from Belfast, Cambridgeshire & Peterborough, Glasgow, Liverpool, and Greater Manchester.

The workshops were used to:

- Enhance our understanding of the blockers to adoption of low carbon measures
- Identify the problems in the current policy and delivery landscape
- Test the development of a Net Zero Delivery Framework to resolve these problems

Table 13: Sectors and sub-sectors for CARA workshops

Housing	Commercial and public buildings	Transport
• Social housing • Private rental housing • Owner occupied housing	• Commercial offices • Retail • Leisure, hospitality, culture and arts • Public sector	• Active travel • Cars, vans and lorries • Public transport

Please note that these workshops were held before the Net Zero Strategy was published. As such, participants' views on national government action may have changed since these workshops too place.

Findings from CARA Workshops have contributed to our analysis of the blockers to the adoption of Low Carbon Measures and the challenges facing the current delivery framework

CARA workshops have informed our categorisation of blockers to adoption of low carbon measures. Insights from participants in the CARA workshop have helped to validate our categorisation of the blockers to the adoption to different low carbon measures. In particular, participants provided insights into the similarities and differences between the problems facing different places and sectors in delivering decarbonisation. For more information on the blockers to the adoption of low carbon measures see Annex: Blockers.

CARA workshops have also helped us to identify the challenges facing the current delivery framework. Key findings from CARA workshops are one source of evidence we have reviewed in identifying the challenges facing the current delivery framework. The right hand side summarises the key findings from CARA that have contributed to our analysis of the challenges facing the current delivery framework.

We also used the workshops to test proposals for a new Net Zero Delivery Framework. In particular, we discussed what was preventing current organisations from delivering more interventions and the capabilities that an organisation would need to take on this role.

Key challenges posed by the current delivery framework identified in CARA Workshops

Local government does not have the specialist expertise it needs to design and deliver interventions, e.g. planners and civil engineers

Local government often does not have capacity to deliver on all of their priorities, e.g. both net zero and delivery of statutory duties.

Local government and Energy Hubs have struggled to recruit specialist expertise because of short term funding

Local authorities do not have access to finance to make larger, long-term programmes viable because Government grant schemes are often small-scale and project-specific

Some blockers are left unresolved because the siloed process for policy development prevents coordination between national and local interventions and between different local interventions

4.1

Methodology

Workshop methodology and participants

The workshops, based on the approach devised by PCAN researchers at the University of Leeds, used interactive techniques to assess how 'ready' participants and representatives think their city-regions are to adopt low carbon measures across housing, commercial and public buildings and transport.

For each sector, we convened workshops with representatives from the city-regions with relevant expertise and insights from the public, private and third sectors in each city-region (see table for the city-region representation in each workshop).

We held two 90 minute workshops for each sector to assess readiness for action, propose changes that could improve readiness and test how a Net Zero Delivery Framework could deliver these changes. We held a third workshop with representatives to test further development of the Net Zero Delivery Framework and confirm findings from previous workshops.

Table 14: City-region representation in CARA Workshops

	Housing	Commercial and public buildings	Transport
Workshop 1	21 September 2021	22 September 2021	24 September 2021
Participants	• Belfast • Glasgow • Liverpool • Manchester	• Glasgow • Liverpool • Manchester	• C'shire and Peterborough (via online survey) • Glasgow • Liverpool
Workshop 2	28 September 2021	29 September 2021	1 October 2021
Participants	• Belfast • C'shire and Peterborough • Liverpool • Manchester	• Liverpool • Manchester	• Glasgow • Liverpool

Workshop 1: Score allocation

In Workshop 1, participants were asked to assess how ready they think their city-region is to adopt low carbon measures to reduce energy use / carbon emissions in terms of five key categories:

- **Technical readiness**: Are the technologies needed to reduce energy use / carbon emissions available and ready to deploy now?
- **Policy readiness**: Have we got the policies/plans needed to support delivery in place now, whether locally, regionally and nationally?
- **Financial readiness**: Are the funds available, are there investable options with business models ready to be deployed?
- **Community readiness**: Do we have support and buy-in from the public and/or from the business community, or from some sectors of the public/business?
- **Delivery readiness**: Do we have the skills, the supply chains and the organisations ready to deliver?

Participants scored their readiness for each sub-sector by category using a 5-point scale:

- **Completely ready** (5 points)
- **Largely ready** (4 points)
- **Partially ready** (3 points)
- **Largely unready** (2 points)
- **Completely unready** (1 points)

Participants were also asked to give readiness scores for different levels of ambition in relation to place-based integration:

- **High**: Place-based actions fully integrated to deliver net zero
- **Medium**: Piecemeal exploitation of local potential for net zero
- **Low**: No place-based action

Throughout the workshop, participants were asked to provide a brief justification for the scores they allocated and these notes are appended to the scores below.

Workshop 2: Resolving local blockers

Having reviewed and built a consensus on the scores allocated in the first workshop, the second workshop was focussed on answering questions designed to help identify how a Net Zero Delivery Framework could be deployed so as to overcome the local blockers.

Questions discussed included:

If you were recruiting for an 'agency' with responsibility to resolve local blockers, what would be the 'essential qualities' in a person specification?

Why is no organisation delivering this role at the moment?

What is the appropriate geography for this to happen?

Do you have examples from your city-region where any such activity is happening?

4.2

Summary of results

City-regions are facing similar blockers to decarbonisation, but these blockers vary by sector and by sub-sector

In Workshop 1, participants identified local blockers to decarbonisation in each city-region and scored their readiness. These findings were endorsed by participants (with some minor comments) at the second set of workshops. Key findings across all sectors include:

There are noticeable similarities in local blockers across all city-regions. City-regions face similar blockers, but these are often caused by local issues associated with infrastructure, supply chains and communities. This suggests that different city-regions are likely to need similar blockers, but they may need to be tailored to local circumstances and need local involvement to be successful.

Technical readiness is not a significant blocker to decarbonisation in any sector or city-region. Instead, participants tended to highlight the lack of acceptance of the technology as a more important blocker to readiness, i.e. communities prevent opportunities for district heat networks from being developed.

Policy, community, financial and delivery readiness does vary by sector and by sub-sector. This is due to the differences in the behaviour changes needed for decarbonisation as well as differences in infrastructure and ownership structures.

The following pages discuss key findings of readiness for the housing, commercial and public buildings and transport sectors in turn.

Delivery, policy and financial readiness are particularly low in the housing sector

The lack of policy certainty is preventing readiness in all city-regions. Participants reflected that the lack of policy certainty meant that social housing owners could not incorporate retrofit low carbon measures into their property management.

Participants cited the limited powers for local government as a barrier to policy readiness. Participants felt that local government did not have the necessary powers to make significant decarbonisation happen, particularly in the owner occupied sector, and so was reliant on more to happen at the national level.

Participants from both Belfast and Glasgow felt they had better community readiness compared to their counterparts in Liverpool and Manchester. This may reflect different housing types between city-regions or that the devolved administrations consider that they have a different suite of community engagement options available to them.

Financial readiness for the owner occupied sector varies due to differences in income. For example, representatives from Glasgow noted that they have lots of owner occupiers who are on the edge of fuel poverty and so cannot afford to pay for retrofit.

Financial readiness is particularly low for social housing and the private rented sub-sector. In both rental sectors, financial readiness was seen to be low because while landlords or social housing providers have to pay for retrofit, it is the tenants who accrue the benefits. This was considered a particular difficulty in the social housing sector where rents are capped and local authority budgets are limited, but participants noted that the Social Housing Decarbonisation Fund was helping to relieve this blocker. Participants in Manchester noted that only buildings below EPC C were eligible for this fund which meant they were unable to access it for a lot of their properties.

Delivery readiness was consistently the least ready category for all city-regions. In particular, participants noted a need for policy certainty to help build capacity in the supply chain and for standards in skills so that suppliers can be certified.

The social housing sector often cited as the least ready in terms of delivery, in part because this is frequently done in house. Social housing providers often maintain their own properties and so would be responsible for the retrofit, but a lack of in house capacity was highlighted as preventing them from being able to do so.

The commercial and public buildings sector has better delivery readiness than housing, but still faces low policy and financial readiness

Policy readiness is often seen to be very low because local governments prefer to set less stringent standards to attract business to the area. Participants reflected that although ambition for decarbonising commercial and public buildings was high, standards were often not set to a stringent enough standard to achieve this. This is because lower carbon buildings often have higher costs, which could lead potential businesses to decide to locate elsewhere.

Community readiness was considered to be higher for the leisure and arts sub-sectors compared to commercial and retail. Participants mentioned that most commercial and retail space is privately rented, so there are more stakeholders who need to agree to the disruption associated with retrofit. Office workers are often also seen as being resistant to changes if they do not see the value in it, as while their company may see a reduction in energy bills, they have to accept lower heating levels. In contrast, the public is generally seen to be more accepting of the need to retrofit arts and public buildings.

Financial readiness was seen to be as low as policy readiness, in particular because of the prevalence of private renting in this sector. It is the building owners who have to pay for retrofit or low carbon buildings, which can incur a significant cost, however the tenants are the beneficiaries. Owners have limited incentive to retrofit their buildings because tenants do not make decisions based on the energy efficiency of a building and will not accept paying higher rent as a result.

Low capacity in the supply chain was cited as preventing delivery readiness. All participants cited limited availability of the skills necessary to retrofit buildings. However, colleges are not incentivised to provide these opportunities and suppliers have no incentive to sacrifice their time and pay to upskill. Long term policy certainty would help to address this. They also cited the importance of increasing net zero skills throughout the supply chain, for example so that consultants would recommend low carbon solutions even where they come at a premium.

Delivery readiness was seen as being higher in the commercial and public buildings sector compared to housing. The scale of public or private property owners in the commercial and public buildings sector compared to individual owner occupiers in the housing sector means that they may have existing access to suppliers who could deliver retrofit.

Financial readiness is the most significant challenge facing transport and community readiness is often lower than in other sectors

Technical readiness was generally considered lowest for the transport sector. In particular, there are few alternative options to electric vehicles and grid capacity is not adequate to electrify transport at a large scale.

Participants noted that the need to coordinate across local and national government has led to low policy readiness. Participants noted that the number of policies being implemented and that the ban on petrol and diesel vehicles had had significant impact. However, the devolution of powers to different parts of government made it hard to coordinate. For example, some local interventions may need national government involvement to succeed.

Reducing road capacity was noted as a politically sensitive issue in all city-regions, which has reduced community readiness. There is significant community resistance to any intervention that reduces road capacity by putting in cycle lanes. Car drivers have often been reluctant to change their behaviour to use other modes of transport.

Participants felt that finance was the least ready of the five categories. It was noted that the difficulty of identifying revenue streams is preventing financial readiness. For example, adoption of electric vehicles is dependent on the availability of on street charging, but it is not currently clear who would be responsible for the ongoing costs and what revenue they would receive from this service.

The lack of skills in local authorities to develop interventions that stimulate behavioural change was seen as a cause of low delivery readiness. Local government often lacks the planners and civil engineers that are needed to design and deliver the enabling infrastructure for behavioural changes towards active travel or electric vehicles. As a result, the absence of plans is holding back delivery of interventions.

While there is some need for upskilling in the private sector, this is less of a concern for delivery readiness. Participants noted that there was some need for upskilling in maintenance and servicing of electric vehicles, however this was less significant than the need for upskilling in local authorities.

Workshop participants also provided useful feedback on our proposals for a Net Zero Delivery Framework that could help to improve readiness in each city-region

Participants were supportive of a local agency to help resolve the blockers to adoption of low carbon measures. All participants endorsed the suggestion for a local agency with responsibility for removing local blockers to adoption and promoting low carbon measures, particularly those that are large scale or diverse in scope.

They felt that such an agency would require a diverse range of skills in order to deliver this role. Capabilities included geographic information system mapping, energy and transport planning, systems thinking, data analysis, consumer engagement, policication engagement and marketing. Participants noted that the agency would need to be innovative, commercially aware and with strong political leadership.

Participants felt that the siloed approach to policy development had prevented local government from fulfilling this role so far. The lack of coordination between national and local government and within local government has meant that interventions that have been delivered may have conflicting objectives or not address all the blockers.

Policy uncertainty was cited as a key issue for existing organisations trying to accelerate decarbonisation. Participants noted that policy uncertainty meant that the private sector struggled to plan ahead and was reluctant to invest in long term commercial viable solutions that current organisations may develop.

The approach to funding was considered a barrier to local governments recruiting the expertise they need. Local government and the Energy Hubs are often only funded for particular projects and programmes, or for a short period of time. As a result, they have struggled to recruit individuals with the experience and skills needed to design and deliver interventions.

No single geography emerged as a clear favourite with participants. In general, participants favoured having strong strategic regional agencies (potentially at a city-region level) with clear relationships with local delivery agencies (potentially at the local authority level).

Participants noted that the decision about the right geographic level would need to consider maximising the use of in demand skills. There are not many people with the necessary skills and they are often in high demand. Therefore, the geography should bring these people together to maximise the deployment of their skills.

4.3

Readiness assessment results

Technical readiness for housing in Belfast scored highly, but policy, financial and delivery readiness present challenges

Table 15: Readiness scores for housing in Belfast

	Social housing			Private rented			Owner occupied			Average		
Readiness category	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition
Technical	5.0	5.0	4.0	5.0	5.0	4.0	5.0	5.0	4.0	5.0	5.0	4.0
Policy	2.0	2.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0
Community	4.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.3	2.3	2.0
Financial	3.0	2.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.3	2.0	1.0
Delivery	2.0	2.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.3	1.0
Average	3.2	2.8	1.8	2.8	2.4	1.8	2.8	2.4	1.8	2.9	2.5	1.8

Participants from Belfast noted a need for policy certainty and reforms to improve readiness in the housing sector

Technical: The technology to decarbonise housing is ready. Participants from Belfast felt that the technology to decarbonise all types of housing was available for almost all levels of ambition. As such, technical readiness scores highly for all but the highest levels of ambition across all sub-sectors. Instead they felt that the challenge was around getting the community to accept the technology.

Policy: Energy policy is highly devolved in Northern Ireland, they have the potential to pursue a different approach, however important reforms are not happening. The lack of policy certainty was cited as a barrier preventing action. For example, participants felt that if housing providers knew what changes they needed to make over a 15 year horizon then they would factor this into their property management. They also noted a need for reform in electricity regulation to bring down the price relative to gas. They suggested a role for dynamic electricity pricing to incentivise distributed generation or for wholesale electricity to be used to power district heat networks where the impact of a brief interruption to supply would be less significant, similar to how large business energy customers buy wholesale gas. The failure to make these reforms led to consistently low policy readiness scores.

Community: People are reluctant to change behaviour or expect their energy providers to roll out technology. Although there is some acceptance for change, many homeowners are seen to have concerns about the reliability of available technologies and do not want to damage their valuable assets. This results in a lower community readiness for the owner occupied and private rented sectors. There is particular difficulty in estates with many different owners who could object to external wall insulation as cold bridges between properties reduces its effectiveness.

Financial: Participants felt that financial readiness is limited by the difficulty of funding retrofit through rental income and the failure to consider EPCs in property prices. In the rental sector owners are often unable to pay for upfront costs: participants felt social housing rent caps make funding retrofit challenging and in the private sector the difficulty of accessing loans makes financing hard. In the owner occupied sector, the challenge is that EPCs are not utilised, so the benefits to the owner may be reduced, e.g. if retrofit does not increase house prices.

Delivery: Policy certainty and skills certification were cited as necessary for delivery. Limited capacity across all sub-sectors leads to low readiness. Participants noted social housing providers often had capable retrofit contractors, meaning their readiness is slightly higher.

Readiness to decarbonise housing in Glasgow scored slightly higher than in Belfast, but challenges remain around policy, financial and delivery readiness

Table 16: Readiness scores for housing in Glasgow

	Social housing			Private rented			Owner occupied			Average		
Readiness category	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition
Technical	5.0	5.0	4.0	5.0	5.0	4.0	5.0	5.0	4.0	5.0	5.0	4.0
Policy	3.0	2.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.3	2.0	1.0
Community	4.0	3.0	2.0	3.5	3.0	2.0	3.5	3.0	2.0	3.7	3.0	2.0
Financial	3.0	2.5	2.0	2.0	2.0	1.0	2.0	2.0	1.0	2.3	2.2	1.3
Delivery	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0
Average	3.4	2.7	2.0	2.9	2.6	1.8	2.9	2.6	1.8	3.1	2.6	1.9

Participants from Glasgow noted that readiness varied across the city-region because of the impacts of COP26 and the differences between rural and urban areas

Technical: The technology to decarbonise housing is almost there. Participants in Glasgow felt that the technology to decarbonise all types of housing was ready for low and medium levels of ambition, but more would be needed to achieve more ambitious decarbonisation.

Policy: Glasgow faces similar policy issues as other city-regions, highlighting a particular need for more national action. Participants noted a similar need for policy certainty and reform as elsewhere and so reported similar policy readiness scores. In particular they highlighted the importance of more national policy making to accelerate readiness.

Community: Community readiness may be higher in rural areas of Glasgow compared to other city-regions. There are lots of rural areas in Glasgow with social housing which is not connected to the gas grid. Many of these communities are used to distributed heat generation and so more accepting of air source heat pumps. As a result community readiness was seen as higher than other city-regions, particularly for social housing.

Financial: COP26 has meant Glasgow City Council may have higher financial readiness but this is not replicated in other areas or sub-sectors. Participants noted that Glasgow City Council has been able to attract international investment as a result of COP26, which is helping to pay for retrofit of social housing. However, this finance has not been available in other areas such as South Lanarkshire or to other sub-sectors. In particular, participants noted that Glasgow has lots of owner occupiers who are on the edge of fuel poverty, meaning that they would struggle to pay for retrofit.

Delivery: Glasgow faces similar challenges to other city-regions in terms of the readiness of the supply chain to deliver. The stop / start policy cycle was cited as a particular reason for the low readiness in the supply chain. Participants also noted that in Glasgow social housing retrofit is often done in house rather than contracted out. As a result their capabilities for retrofit tended to lower, resulting in lower delivery readiness for social housing compared to Glasgow.

Similar to the housing sector in other city-regions, Liverpool scored most highly on readiness to decarbonise social housing

Table 17: Readiness scores for housing in Liverpool

	Social housing			Private rented			Owner occupied			Average		
Readiness category	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition
Technical	5.0	5.0	4.0	5.0	5.0	4.0	5.0	5.0	4.0	5.0	5.0	4.0
Policy	3.0	2.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.3	2.0	1.0
Community	4.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.3	2.3	2.0
Financial	3.0	2.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.3	2.0	1.0
Delivery	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0
Average	3.4	2.6	1.8	2.8	2.4	1.8	2.8	2.4	1.8	3.0	2.5	1.8

Participants from Liverpool expressed similar justifications for readiness scores as other city-regions

Technical: Similar to other city-regions, participants from Liverpool felt that the technology was mostly ready to decarbonise housing. Participants in Liverpool felt that the technology to decarbonise all types of housing was ready for most levels of ambition.

Policy: Local government has limited powers to make a real difference, leading to low policy readiness. Participants felt that local government often had limited powers to make changes happen, for example they could introduce policies to guide behaviour change but not implement regulations to enforce change. They also noted that local government intervenes less in the private sector, resulting in lower readiness for private rented and owner occupied housing.

Community: Barriers to community readiness vary by sub-sector but in general awareness of the need for change is growing. Similarly to elsewhere, participants noted the challenge of encouraging private landlords to invest in retrofit when the benefits accrue mostly to the tenant. Particularly at the lower end of the sector where landlords do not want to give up any rental income. In the owner occupied sector, there is a need to address inertia, particularly when homeowners may be too busy to make changes.

Financial: Financial readiness tends to be higher in the social housing sub-sector because of government funding programmes. Participants felt that more resources and capacity were being directed towards this agenda, for example the Green Homes Grant Local Authority Delivery Scheme and Social Housing Decarbonisation Fund. However, challenges remain as many funding or finance sources provided by government have restrictions based on EPCs, disqualifying many properties, and the small size of funding makes large scale programmes harder to finance. Incorporating the private rental sector in the Green Homes Grant Local Authority Delivery Scheme was seen as positive for supporting this sector, but private landlords were proving reluctant to make a private contribution.

Delivery: Delivery challenges were noted across the sector. Participants raised similar concerns about delivery readiness as participants from other city-regions. In particular, the lack of delivery capability for many housing associations

Housing in Manchester scored similarly to in other city-regions

Table 18: Readiness scores for housing in Manchester

	Social housing			Private rented			Owner occupied			Average		
Readiness category	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition
Technical	5.0	5.0	4.0	5.0	5.0	4.0	5.0	5.0	4.0	5.0	5.0	4.0
Policy	3.0	2.0	1.0	2.0	2.0	1.0	3.0	2.0	1.0	2.7	2.0	1.0
Community	4.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.3	2.3	2.0
Financial	3.0	2.0	1.0	2.0	2.0	1.0	3.0	2.0	1.0	2.7	2.0	1.0
Delivery	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0	2.0	1.0	1.0
Average	3.4	2.6	1.8	2.8	2.4	1.8	3.2	2.4	1.8	3.1	2.5	1.8

Housing in Manchester scored similarly to in other city-regions

Technical: Participants from Manchester felt that the technology was mostly ready although less so for EPC C and D properties and smaller properties. Similar to other city-regions, participants felt that technology readiness is high and they are broadly well known even if not accepted. However, they noted that existing technologies may be less suited for improving EPC C and D properties, of which Manchester has lots.

Policy: There is a need for more national policy making and for it to be done in a coordinated way. Participants recognised the need for national policies that were outside the scope of local government powers and for interventions to be designed in a coordinated way, which is not currently the case. They felt that delivering Net Zero by 2038 would require regulatory change, but this is not within their powers and so there is a limit to what they can do. However, it was noted that policy readiness is greater for social housing due to the funding being provided.

Community: Community readiness is growing but technologies are often seen as a backwards step. Community readiness was seen as less of a challenge than other factors, however there is still resistance to many technologies. In particular, residents apparently see air source heat pumps and storage heaters as a backwards step in technology.

This challenge is exacerbated by the technical nature of many low carbon measures, which makes them hard to explain.

Financial: Financial readiness is higher for social housing, but willingness to pay is a challenge in the private sector. Participants said that the Social Housing Decarbonisation Fund has given housing associations access to funding or finance and as a result many are developing bids, but that this was not suitable for a lot of Manchester's buildings that are rated EPC C and D. They noted a greater challenge to financial readiness in the private rented sector. In particular, because homeowners may receive different quotes from different suppliers, making it hard to assess the financial requirements of retrofit. Private landlords are able to access a contribution towards retrofit through the Green Homes Grant Local Authority Delivery Scheme, but participants felt they had been reluctant to make the necessary private contribution.

Delivery: There is a need for long term policy certainty to build capacity in the supply chain. Participants felt that there is interest in retrofit, however people often do not know who to go to and the suppliers that are doing retrofit are very busy. It was suggested that the social housing sector may be more able to support the development of the supply chain through setting standards for their suppliers.

Technical and delivery readiness for commercial and public buildings in Glasgow scored highly, but policy and financial readiness present significant challenges

Table 19: Readiness scores for commercial and public buildings in Glasgow

	Commercial offices			Retail			Leisure, hospitality, culture and arts			Public sector			Average		
Readiness category	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition
Technical	5.0	4.0	4.0	5.0	4.0	4.0	5.0	4.0	4.0	5.0	4.0	4.0	5.0	4.0	4.0
Policy	2.0	1.5	1.0	2.0	1.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.0	1.6	1.0
Community	3.5	2.5	2.0	3.0	2.0	2.0	4.0	3.0	2.0	4.0	3.0	2.0	3.6	2.6	2.0
Financial	2.0	1.5	1.0	2.0	1.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.0	1.6	1.0
Delivery	4.0	4.0	3.0	4.0	4.0	3.0	4.0	4.0	3.0	4.0	4.0	3.0	4.0	4.0	3.0
Average	3.3	2.7	2.2	3.2	2.4	2.2	3.4	3.0	2.2	3.4	3.0	2.2	3.3	2.8	2.2

Participants from Glasgow highlighted the need for more stringent buildings regulations and the challenge posed by the extent of renting within the commercial and buildings sector

Technical: While technology is broadly available it is often not fit to decarbonise many of Glasgow's commercial and public buildings. Participants felt that some of the currently available technologies were not suitable for older buildings, which is a particular challenge for Glasgow given its significant stock of heritage Victorian buildings. As such, readiness is slightly lower than in the housing sector.

Policy: Policy readiness was seen to be the biggest challenge for the commercial and buildings sector due to competing incentives for local government. Participants noted that even if local authorities want to encourage lower carbon buildings, they had limited incentive to set standards that were more demanding than other places for fear of pushing up prices and driving investment away. Additionally, a lack of resources or toolkit meant that existing standards were hard to enforce. They felt that there was a need for a national policy framework to support and enforce higher buildings standards. Policy readiness is also challenged by competing priorities and a preference for what they are familiar with. In particular, they are often focused on solutions to address vacancies and dereliction in response to COVID-19 and declining high streets, rather than innovative solutions for Net Zero.

Community: The community is often concerned about damaging buildings even if the need for change is recognised. Participants noted that the there is growing recognition in some areas of the need for a step change in how buildings are treated, however the public is often concerned that retrofit could change or damage their buildings.

Financial: Financial readiness is particularly low because most commercial and public buildings are rented. Participants noted that building owners are often unwilling or unable to pay for retrofit as although they are responsible for the cost of retrofit, the benefits accrue to the tenant and tenants are not willing to pay more for energy efficient buildings. This is an even greater problem for commercial and public buildings compared to housing because of the prevalence of renting and the need to coordinate many different length leases within a building.

Delivery: There is a shortfall of skills in the supply chain, which is less significant than in housing. Participants said that a lack of skills was impeding delivery readiness. Glasgow does not have devolved responsibility for the adult education budget, unlike many Combined Authorities, they do still have influence over educational institutions and so could encourage upskilling. The lack of demand for retrofit meant that suppliers had no incentive to take time out and pay for this training.

Commercial offices in Liverpool scored slightly lower than in Glasgow

Table 20: Readiness scores for commercial and public buildings in Liverpool

	Commercial offices			Retail			Leisure, hospitality, culture and arts			Public sector			Average		
Readiness category	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition
Technical	5.0	4.0	4.0	5.0	4.0	4.0	5.0	4.0	4.0	5.0	4.0	4.0	5.0	4.0	4.0
Policy	2.0	1.0	1.0	2.0	1.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.0	1.5	1.0
Community	3.0	2.0	2.0	3.0	2.0	2.0	4.0	3.0	2.0	4.0	3.0	2.0	3.5	2.5	2.0
Financial	2.0	1.0	1.0	2.0	1.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.0	1.5	1.0
Delivery	4.0	4.0	3.0	4.0	4.0	3.0	4.0	4.0	3.0	4.0	4.0	3.0	4.0	4.0	3.0
Average	3.2	2.4	2.2	3.2	2.4	2.2	3.4	3.0	2.2	3.4	3.0	2.2	3.3	2.7	2.2

Participants from Liverpool noted similar concerns about the need for national standards and the difficulty of improving financial readiness given the extent of private renting

Technical: Technology is mostly available, but there are often challenges for commercial and public buildings. Participants from Liverpool felt that often the technology is ready but the transition poses a significant challenge. For example, the need to upgrade the grid and make changes in dense urban environments poses technical difficulties.

Policy: National commitments are in place but have not been followed up with policies. Participants felt there was a significant gap between the ambition and change being achieved for all sub-sectors. For example, the Building Regulations were seen as outdated and inadequate. While local authorities may consider setting standards above the minimum, the pressure from developers is likely to weaken this. If developers can prove the financial burden makes investments economically unviable, they can find exemptions, and local authorities do not want to dissuade developers from local development. Therefore the regulations need to be set at a national level.

Community: Community readiness is higher in cultural and public sub-sector than commercial and retail. Participants noted community was more accepting of changes to cultural and public buildings. They could understand the need to change and see the pathway to do so.

In contrast, it is generally seen as too difficult to decarbonise commercial and retail buildings due to the challenges in the rental market. This is a challenge for large developments where a retrofit programme would need agreement from all tenants and owners to go ahead.

Financial: Financial readiness is particularly low because many commercial and public buildings are privately rented. For privately rented buildings, the landlord often has limited means to recoup the cost of retrofitting, as the benefits accrue to the tenants. Participants said that tenants do not make location decisions based on energy efficiency, so will not pay higher rent for it. They noted that the Public Sector Decarbonisation Fund could help to fund retrofit, however often local authorities lacked the resources to put together bids.

Delivery: There are significant reskilling opportunities from allied industries, so delivery readiness is not a challenge. Low demand for retrofit and policy uncertainty meant there was limited incentive for the supply chain to upskill, and institutions to provide training. However, there are thousands of skilled people in heavy industries whose future is insecure, e.g. industrial processes and car manufacturers. There could be significant opportunities to reskill workers to deliver and maintain low carbon measures if strategy, funding and policies can be committed.

Readiness to decarbonise commercial and public buildings in Manchester scored the same as readiness in Liverpool

Table 21: Readiness scores for commercial and public buildings in Manchester

	Commercial offices			Retail			Leisure, hospitality, culture and arts			Public sector			Average		
Readiness category	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition
Technical	5.0	4.0	4.0	5.0	4.0	4.0	5.0	4.0	4.0	5.0	4.0	4.0	5.0	4.0	4.0
Policy	2.0	1.0	1.0	2.0	1.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.0	1.5	1.0
Community	3.0	2.0	2.0	3.0	2.0	2.0	4.0	3.0	2.0	4.0	3.0	2.0	3.5	2.5	2.0
Financial	2.0	1.0	1.0	2.0	1.0	1.0	2.0	2.0	1.0	2.0	2.0	1.0	2.0	1.5	1.0
Delivery	4.0	4.0	3.0	4.0	4.0	3.0	4.0	4.0	3.0	4.0	4.0	3.0	4.0	4.0	3.0
Average	3.2	2.4	2.2	3.2	2.4	2.2	3.4	3.0	2.2	3.4	3.0	2.2	3.3	2.7	2.2

Participants from Manchester highlighted similar challenge preventing readiness to decarbonise commercial and public buildings

Technical: Technology is available, but it is not enough to reach Net Zero. Participants felt that technical readiness was high, but innovation would be needed in order to achieve Net Zero.

Policy: Similar to other city-regions, policy readiness is particularly low because of the disadvantages to setting local standards. Participants agreed the need to set national building standards at a higher level as local authorities has no incentive to, and Combined Authorities could not make local authorities adhere to higher standards. Even if standards were higher, developers could find exemptions due to the cost of zero carbon buildings. Participants cited an example of a district heat network being taken out of planning requirements because developers proved it was economically unviable. They noted landowners in Combined Authority areas waiting for the area to be redeveloped so have no incentive to retrofit, but there is no policy to prevent this.

Community: The community often do not see the value in retrofitting commercial buildings. Office workers were cited as often being resistant to change if they do not see the value. For example, their company may see a reduction in energy bills but may have to accept lower heating levels. Participants felt that younger generations tended to be more accepting, but more people needed to take it seriously. They noted that the Public Sector Decarbonisation Fund was massively oversubscribed, showing people were willing to make the change.

Financial: Financial readiness is low, it was seen to be less of a challenge for the cultural and public sub-sectors. Participants felt that financial readiness may be less of a barrier for the cultural and public sub-sectors if they are less pressured to justify their spend. Similar to other city-regions, commercial and retail sub-sectors faced challenges because building owners must pay for the retrofit, and it is the tenants who benefit. The need to coordinate end dates could mean leaving a unit unoccupied, which would represent a revenue loss. Private sector providers noted they are building their first zero carbon building, but prices are likely to be significantly higher than a standard build and so will earn a lower return.

Delivery: Skill shortages along the supply chain and varying lease lengths make delivery coordination challenging. The need for more Net Zero skills, for example engineers and consultants, are needed to be able to recommend Net Zero solutions. The shortage of skills also meant suppliers were able to charge their services, pushing prices up further.

Technical readiness is Glasgow scored lowest in the transport sector, however it is still the highest readiness category

Table 22: Readiness scores for transport in Glasgow

	Active travel			Cars, vans and lorries			Public transport			Average		
Readiness category	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition
Technical	5.0	4.0	4.0	4.0	3.0	2.0	4.0	3.0	2.0	4.3	3.3	2.7
Policy	4.0	3.0	3.0	4.0	2.0	2.0	4.0	2.0	2.0	4.0	2.3	2.3
Community	3.0	3.0	2.0	3.0	3.0	2.0	3.0	3.0	2.0	3.0	3.0	2.0
Financial	3.0	2.0	1.0	4.0	2.0	2.0	3.0	2.0	1.0	3.3	2.0	1.3
Delivery	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0
Average	3.6	2.8	2.4	3.6	2.4	2.0	3.4	2.4	1.8	3.5	2.5	2.1

Participants from Glasgow highlighted a need for better policy coordination and more enabling infrastructure to improve the readiness of transport

Technical: Technology readiness is lower in transport compared to other sectors. Although there are some technologies that are ready to be adopted, participants thought that they are often only a partial solution. For example, electric vehicles can only decarbonise transport if people have access to driveways or extensive public charging infrastructure. As a result, technology readiness is lower for cars, vans and lorries as well public transport in comparison to active travel.

Policy: The devolution of powers relating to transport makes achieving policy readiness difficult. Some parts of transport policy are devolved to local government whereas others sit within central government. Participants felt that the difficulty of coordinating between central and local or devolved governments meant that options for interventions are constrained based on the policy levers they had available. However, they recognised the impact that bold policy statements by central government had had, for example banning petrol and diesel vehicles. As a result, policy readiness is higher than many other readiness categories.

Community: Community readiness is lower than technology and policy readiness. In particular, participants noted that there had been significant community push back to reducing road capacity for cars by installing cycle lanes.

Financial: The most significant barriers to decarbonisation are associated with finance across all sub-sectors. Participants noted the difficulty of accessing finance for buses and the supporting infrastructure for active travel. For example, there is a need for infrastructure to support the uptake of cycling, and electric bicycles in particular. As a result, financial readiness for active travel and public transport is lower than cars, vans and lorries. However, they cited challenges around who is responsible for paying for on street charging infrastructure for electric vehicles that was preventing this infrastructure from being delivered.

Delivery: Delivery was seen as less of a challenge compared to the housing sector. Participants felt that the private sector had most of the skills needed in order to deliver. There was more of a concern around the lack of skills in local authorities to design and deliver the necessary infrastructure.

Readiness to decarbonise transport in Liverpool scored similarly to readiness in Glasgow

Table 23: Readiness scores for transport in Liverpool

	Active travel			Cars, vans and lorries			Public transport			Average		
Readiness category	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition	Low ambition	Medium ambition	High ambition
Technical	5.0	4.0	4.0	4.0	3.0	2.0	4.0	3.0	2.0	4.3	3.3	2.7
Policy	4.0	3.0	3.0	4.0	2.0	2.0	4.0	2.0	2.0	4.0	2.3	2.3
Community	3.0	3.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.3	2.0
Financial	3.0	2.0	1.0	4.0	2.0	2.0	3.0	2.0	1.0	3.3	2.0	1.3
Delivery	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0
Average	3.6	2.8	2.4	3.6	2.2	2.0	3.4	2.2	1.8	3.5	2.4	2.1

Participants from Liverpool also highlighted a need for national reforms and the resistance from drivers to any changes

Technical: The technology is not ready to electrify transport at scale. Similar to other city-regions, participants raised concerns about the technology readiness for public transport and cars, vans and lorries. In Liverpool in particular, they highlighted the large number of diesel lorries entering the city to unload cargo ships in the port. They felt that there was no technological solution to decarbonising these journeys.

Policy: Participants identified a need for national policy to improve policy readiness. Local government has put in place lots of policies but participants felt that certain interventions needed to be done at the national level. For example, road user charging zones should be done at a national level to prevent negative impacts on local economies.

Community: Similar to other city-regions, participants noted there had been some backlash to policies that disadvantage drivers even though most of the population is in favour. Participants had found that people want to use the bus and active travel modes more often, however any policies that disadvantaged drivers were faced with significant backlash from a vocal minority. As a result, it was seen as difficult to make changes that might reduce road capacity.

Financial: Financial readiness is the lowest category for all transport sub-sectors in Liverpool. While participants recognised that money was available, it was often dispersed in different funding pots which made large scale projects difficult to deliver. They noted a need to identify revenue streams in potential business models in order to deliver interventions that would make behaviour change happen.

Delivery: Participants cited the lack of skills in local government, which led to delivery being one of the lowest readiness categories. Participants identified the lack of local skills and availability of staff in local government as a major problem. As a result, they were not able to attract the planners and civil engineers necessary to design the required interventions. Access to pre-development money was identified as a potential solution in order to develop plans that could then make delivery happen.

Online survey responses from Cambridgeshire and Peterborough participants scored community readiness as the biggest challenge for transport

Table 24: Readiness scores for transport in Cambridgeshire and Peterborough

	Overall transport		
Readiness category	Low ambition	Medium ambition	High ambition
Technical	5.0	4.0	3.0
Policy	4.0	3.7	3.3
Community	3.0	2.0	1.0
Financial	4.0	3.0	2.0
Delivery	4.0	4.0	3.5
Average	4.0	3.3	2.6

Participants from Cambridgeshire and Peterborough felt that more enabling infrastructure was needed to improve the readiness of transport

Technical: Similar to other city-regions, participants felt that technology was ready. Participants noted that the technology to decarbonise transport was broadly available, however the enabling infrastructure was lacking.

Policy: Participants felt that policies still prioritised cars over active travel or public transport. In particular, participants felt that investment was often aimed at improving roads whereas there is a need to invest in cycleways and the supporting infrastructure for electric vehicles that has previously been lacking. For public transport, participants recognised a need to subsidise some routes in the short term to encourage adoption as well as investing in more routes and more regular timetabling. In particular, they recommended better planning to identify policies that could support how we move about city-regions now and in the future.

Community: In contrast to other city-regions, participants felt that community readiness was the most significant barrier to adoption. They highlighted the need to change people's routines towards fast, reliable and affordable sustainable transport which would require a significant cultural shift and a change in perceptions. A particular barrier was noted to be the stigma around cycling and the status associated with car ownership. Separately, public safety and perception of safety for active travel was cited as a barrier that would need to be addressed to improve community readiness, especially for people traveling in the dark and winter months.

Financial: Financial readiness was seen as less of a challenge compared to other city-regions. Participants noted that mode of transport use is predominantly linked to income and affordability. As such, there was a need to improve the affordability of some of the more sustainable options, such as electric cars or electric bikes. Alternatively, they suggested that locally-run, longer-term rental options could provide a solution. However these differences may be due to participating through an online survey rather than in an interactive workshop.

Delivery: Participants felt more ready to deliver than other city-regions, but with a need for some improvement in the private sector. Unlike participants from other city-regions, they did not cite a lack of capabilities in local government as a barrier to delivery - however this may be due to participating through an online survey rather than in an interactive workshop. The main concern for delivery was around the need to improve skills to maintain and service electric vehicles or bicycles.

5

Desk based research and stakeholder interviews

5.1

Complexity of Net Zero Challenge

This Section explains the complexity of the Net Zero challenge and the whole system principles that a solution needs to adhere to

What this section covers:

In this section we explain the features of the net zero challenge and the principles for designing a whole system response that can respond to that challenge. In particular, we discuss:

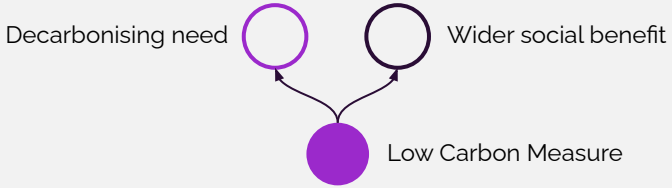
- What makes the Net Zero challenge complex
- Why this complexity necessitates a whole systems approach
- What principles a whole systems approach should adhere to.

This evidence is informed by:

- Desk research into current whole system thinking for Net Zero, in particular:
  - Council for Science and Technology (2020), A Systems Approach to Delivering Net Zero: Recommendations from the Prime Minister's Council for Science and Technology
  - HM Government (2021), Net Zero Strategy: Build Back Greener
  - Infrastructure and Projects Authority (2021), Transforming Infrastructure Performance: Roadmap to 2030
  - National Audit Office (2020), Achieving Net Zero
  - National Engineering Policy Centre and Royal Academy of Engineering (2020) Net Zero: A systems perspective on the climate challenge
- Stakeholder interviews to discuss the complexity of the Net Zero challenge

Widespread adoption of Low Carbon Measures will deliver significant wider social benefits as well as reducing emissions

Adoption of low carbon measures will both reduce Greenhouse Gas Emissions as well as delivering benefits for the local area



low carbon measures will have wider social benefits as well as addressing a decarbonising need

Whole-system principles:

- Select low carbon measures for each place based on the full costs and benefits of adoption

To achieve net zero we need to decarbonise large swathes of our economy, both by decarbonising the energy we use, or reducing our use of it.

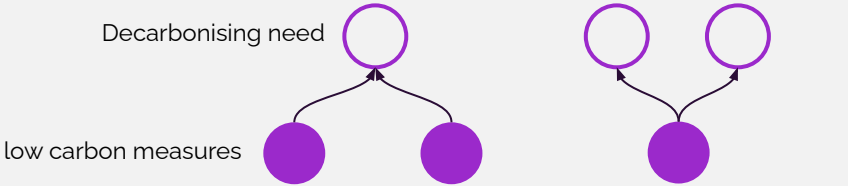
"low carbon measures" are new technologies or changes in behaviour that can meet our decarbonising needs in different ways. For instance, replacing a gas boiler with heat pump is a low carbon measure that decarbonises heat energy generation, while cavity wall insulation is a low carbon measure that reduces energy consumption.

Adoption of low carbon measures will deliver wider social benefits, as well as contributing towards decarbonising needs. For example, replacing ICE vehicle journeys with cycling reduces greenhouse gas emissions, and also provides health benefits to the local community through cleaner air. Similarly, adoption of heat pumps decarbonises heat energy generation but also creates opportunities for innovation in the supply chain.

When deciding what low carbon measures to prioritise there is the potential to consider the wider social benefits of the low carbon measures. They all have broader effects beyond simply contributing to a decarbonising need, meaning decision makers need to understand the trade-offs between options and select those that align to their priorities.

The same decarbonising need can be met by multiple Low Carbon Measures, and multiple needs can be met by the same Low Carbon Measure

Decarbonising needs can be met in different ways, by different low carbon measures



Whole-system principles:

- Ensure that a wide range of options for meeting the same need are considered when designing and selecting low carbon measures
- Ensure that low carbon measures are designed considering the full range of decarbonising needs

A single decarbonising need can sometimes be met in multiple different ways. In some cases, different low carbon measures can be complementary to each other, for example, cavity wall insulation and draft excluders can be used together to improve the energy efficiency of households. When complimentary low carbon measures are identified, it is important to consider opportunities to leverage synergies to improve the cost effectiveness of meeting decarbonisation need. In some cases, low carbon measures can be alternatives. For example, travel using private ICE vehicles can be replaced by cycling, public transport, electric vehicles or some mix of these modes. Where low carbon measures are alternatives, decision makers will need to appraise the options to understand their relative trade-offs before selecting the one that best meets their objectives.

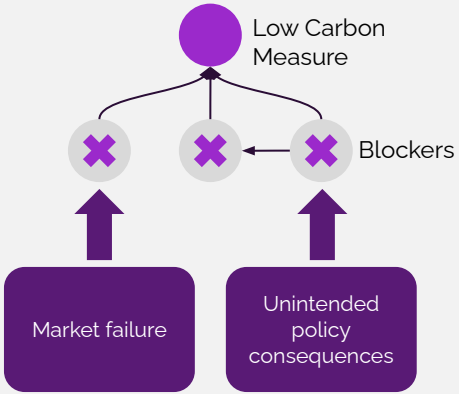
A single low carbon measure can address multiple decarbonising needs. Some low carbon measures are large scale, such as a district heat network, and can cater to the decarbonising needs of multiple people at once. Similarly, some low carbon measures are diverse in scope and can decarbonise and reduce energy consumption together. For example, whole house retrofit can meet both of these needs for a household. low carbon measures that address multiple needs are often more cost effective because they benefit from economies of scale and scope.

Adoption of Low Carbon Measures is being inhibited by a system of blockers, which will need government intervention to resolve

Adoption of low carbon measures is often blocked by multiple blockers, which are caused by market failures and unintended policy consequences

Adoption of a low carbon measure is often blocked by multiple blockers, which will all need to be resolved for adoption to happen...

... these blockers can cause other blockers, and are ultimately caused by market failures and the unintended consequences of government policies, which justifies government intervention.



Whole-system principles:

- Ensure that the root causes of every blocker to a Low Carbon Measure are understood

The adoption of low carbon measures is being inhibited by a complex system of "blockers". These blockers include institutional, social and financial factors.

All of the blockers to a low carbon measure need to be removed to ensure adoption. For example, adoption of heat pumps is being blocked by both a lack of awareness of the need to adopt them, and their costliness. While a subsidy scheme like the proposed Clean Heat Grant will address their costliness, adoption will not happen unless homeowners are also aware of the need to switch to heat pumps instead of gas boilers.

Blockers can cause other blockers. A blocker can in turn cause other blockers which exacerbate the problem. For example, low awareness of heat pumps may be causing low adoption, which in turn means that the supply chain is not well developed to supply them, which makes it harder for those who want to install a heat pump to source one. In order to effectively remove all the blockers to a low carbon measure, it is important to target their root cause.

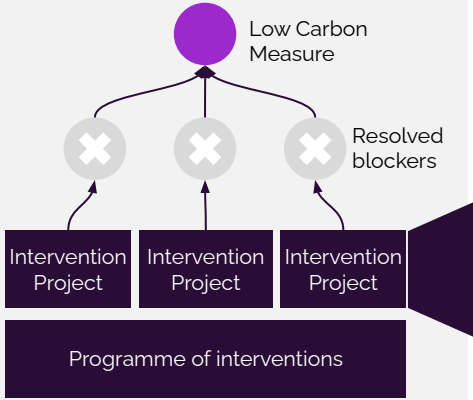
Government intervention is needed and justified to resolve the blockers. Consistent with HMT Green Book principles, the fact that the blockers are being caused by market failures and the unintended consequences of policies justifies government intervention to remove them.

Different interventions to resolve these blockers need to be carefully designed, delivered and coordinated with each other

A single low carbon measure will often need a coordinated programme of different interventions to unblock it.

Where a low carbon measure is blocked by multiple blockers, multiple interventions are required, which depend on the success of each other to accelerate adoption of the low carbon measure...

... these dependencies mean that the interventions should be designed and delivered as part of a common programme.



Whole-system principles:

- Ensure that interventions are designed to address the root causes of every blocker to a low carbon measure
- Manage and plan for dependencies between interventions

Individual low carbon measures typically face multiple blockers, and so will often require a number of different interventions to enable successful adoption. Successful adoption of the low carbon measure in turn will depend on the successful coordination of the delivery and design of all of the required interventions, best managed as part of a common programme.

Intervention Project

Design Intervention

- Identify all the blockers facing a low carbon measure and their root causes
- Develop options for interventions to address every blocker and quantify their costs and benefits
- Appraise options for interventions and the trade-offs between them

Deliver Intervention

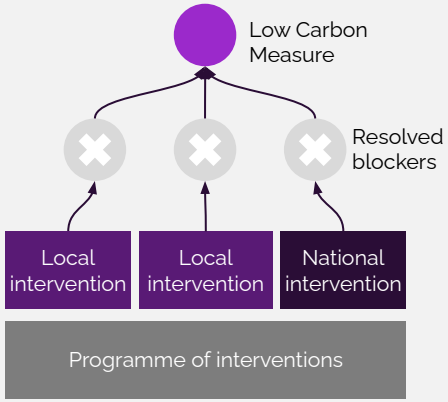
- Plan and manage delivery, including managing cross-programme dependencies.
- Secure local user participation.
- Coordinate local stakeholders.
- Secure funding and finance and develop commercial strategy.

National, devolved and local government will need to work together as part of common programmes of interventions to resolve all the blockers for some Low Carbon Measures

A programme of interventions may need to coordinate different interventions across different tiers of government

Some blockers are best resolved locally, others nationally or by devolved administrations..

...for low carbon measures that face multiple blockers, this will often mean different tiers of government needing to act in a coordinated way to achieve the desired adoption.



Whole-system principles:

- Involve relevant teams from all tiers of government in the design of programmes of interventions.
- Ensure that responsibility for interventions is at the appropriate level of government
- Establish ways of managing dependencies between interventions across different organisations.

Some blockers are best resolved by nationally-led interventions. Where a blocker is consistent across many parts of the country, for example the high cost of heat pumps relative to their energy savings, it will often be more cost effective to resolve that blocker with a single, national intervention, such as the Boiler Upgrade Scheme. The powers to implement interventions (e.g. regulatory change) may also sit with national-level organisations, and so will need to be led by those organisations.

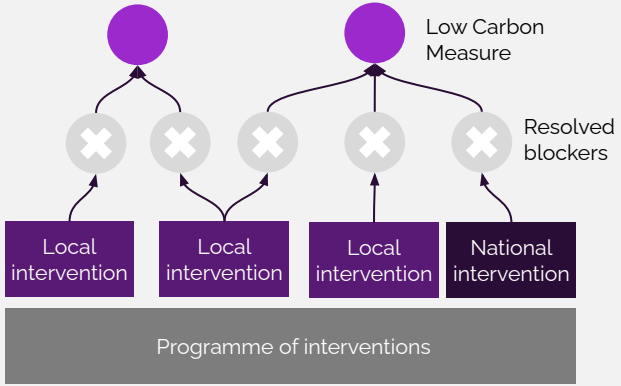
Some blockers are best resolved by more locally-led interventions. Some interventions will require rich knowledge of the local area or strong relationships with the local community; in these cases the intervention is often better led locally, where that knowledge and those relationships sit. For example, a Local Authority installing heat pumps in properties across an area this will require local knowledge to identify viable locations, and trust from the community to agree to the installations. Furthermore some of the powers needed to implement interventions will sit locally, for instance, decisions about planning permission and adult education spending.

Single interventions that resolve multiple blockers are likely to be more cost effective at stimulating adoption, but require more complex programmes to deliver

A programme of interventions might involve single interventions that address multiple blockers across multiple low carbon measures

Some interventions can address multiple blockers to multiple low carbon measures...

...but they require more complex programmes.



Whole-system principles:

- Ensure that interventions are designed considering the full range of blockers to all the low carbon measures

Some interventions can resolve multiple blockers to adoption of multiple low carbon measures. These interventions are likely to be more cost effective because they can benefit from economies of scale or scope, but including them increases the complexity in delivery.

Case study 1: Greater London Authority (GLA) Retrofit Accelerator

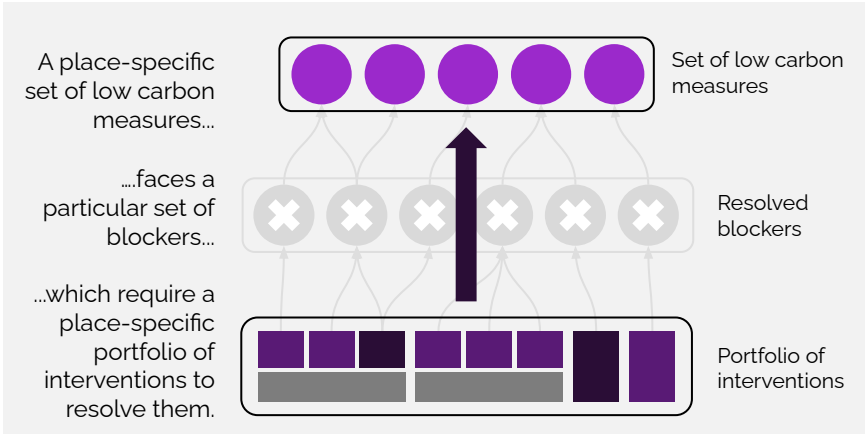
This programme provides housing associations and Local Authorities with technical expertise, project development and finance support for business case development for the Social Housing Decarbonisation Fund. This intervention addresses blockers for social housing providers who do not know how to identify and develop opportunities for different types of retrofit. By building a pipeline of projects it also provides incentives for the supply chain to upskill, which will address blockers relating to supply chain constraints.

Case study 2: Project LEO (Local Energy Oxfordshire)

This project involves designing and delivering a Smart Local Energy System and identify technical, commercial and social insights on how different energy assets, including solar PV, battery storage and Electric Vehicle charging points, can be coordinated in a flexible way to respond to over or under supply in the grid. This project addresses blockers associated with delivering a Smart Local Energy System, including the need for coordination and lack of implementation knowledge and experience.

Places will need to make a portfolio-level choice about what Low Carbon Measures to pursue and what interventions are needed

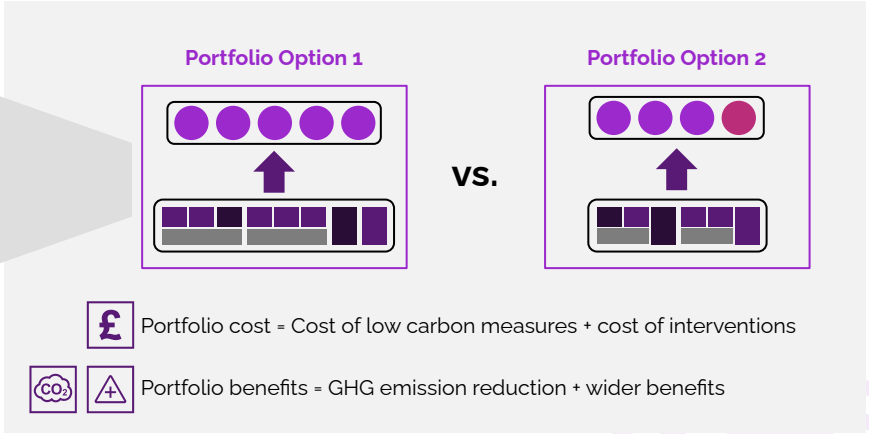
Each place will need their own portfolio of interventions that is tailored to the set of low carbon measures in that place.



Whole-system principles:

- Select the set of low carbon measures for a place on the basis of their full costs and benefits
- Optimise the portfolio of interventions for the target set of low carbon measures
- Establish systems and process for sharing data and lessons learned between places

Each place will need to choose a portfolio that delivers a set of low carbon measures based on the overall costs and benefits



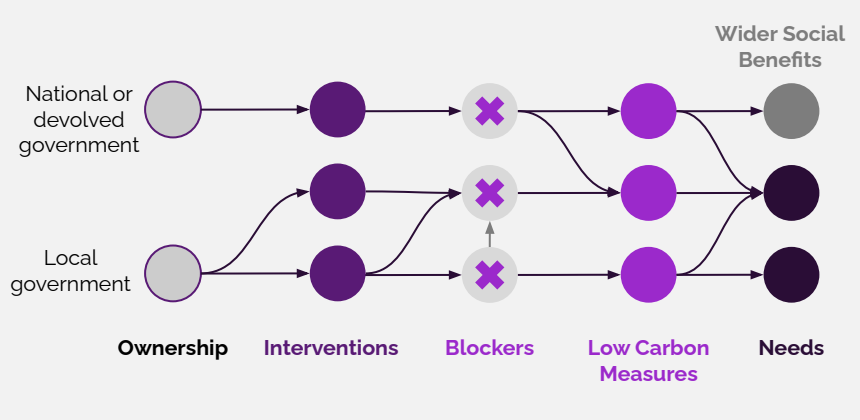
Places will need to choose which low carbon measures to prioritise both for practical reasons and to get the best outcomes for that place. Different sets of low carbon measures require different portfolios of interventions. In order to decide what low carbon measures to prioritise, the whole portfolio cost will need to be compared with the whole portfolio benefits. This would involve calculating the costs and benefits of the low carbon measures, as we have done in our economic modelling, as well as the costs and benefits of the interventions needed to address their blockers.

We have described the key whole system principles that are need to meet the complexity of the net zero challenge

The previous slides have set out the different elements of the net zero challenge that make it complex, and the whole system principles that follow from that complexity.

This slide brings together those principles that should inform the design of a whole-system approach to design and delivery of interventions.

The net zero challenge is complex and needs a whole system approach to solving it



Whole-system principles

When designing low carbon measures	• **Consider the full range of decarbonising needs and a wide range of options for addressing them** (to exploit opportunities for synergies) • **Select low carbon measures for each place based on the full costs and benefits of adoption** (i.e. including both the cost and wider social benefits of the low carbon measure, and the cost of interventions needed to support its adoption).
When designing interventions	• **Ensure that the root causes of every blocker to a low carbon measure are understood and that interventions are designed to address them** • **Consider the full range of blockers** to low carbon measures (to exploit opportunities for synergies) • **Optimise the portfolio of interventions for the target set of low carbon measures** • **Manage dependencies between different interventions and across organisations** to ensure all blockers will be addressed • **Ensure that the right tiers of government are responsible for and involved in intervention design**
When delivering interventions	• **Manage dependencies between different interventions and across organisations** across the portfolio to ensure all blockers are addressed in a coordinated manner. • **Establish systems and process for sharing data and lessons learned between places**

5.2

Innovation Interventions

This Section provides case studies of innovative interventions being delivered by local governments through partnerships with local stakeholders

What this section covers:

In this section we provide case studies of innovative interventions being delivered by local governments and explain why these interventions would only be possible at the local level. In particular:

- These interventions address multiple blockers for different low carbon measures at once, which means they are likely to provide a more cost effective solution to these blockers
- These interventions require in depth local knowledge, community trust and the ability to coordinate multiple local stakeholders in order to be successful
- These capabilities are often concentrated at the local level, which means that local government is better placed to design and deliver them than central government

This evidence is informed by:

Desk based research into each case study. The case studies are:

- GLA Retrofit Accelerator - Homes
- Solent Future Transport Zone
- Project LEO (Local Energy Oxfordshire)
- WMCA Regional Energy System Operator

Introduction

Despite the problems in the current policy and delivery landscape, there are many interventions underway to stimulate the adoption of low carbon measures. Many of these interventions are designed to address multiple blockers for different low carbon measures at once, which means they are likely to provide a more cost effective solution to these blockers.

Many of these interventions require in depth local knowledge, community trust and the ability to coordinate multiple local stakeholders in order to be successful. These capabilities are often concentrated at the local level, which means that local government is better placed to design and deliver them than central government.

The following case studies present four examples of innovative interventions being delivered by local governments through partnerships with local stakeholders, and explain why these interventions would only be possible at the local level.

The case studies are:

1. GLA Retrofit Accelerator - Homes
2. Solent Future Transport Zone
3. Project LEO (Local Energy Oxfordshire)
4. WMCA Regional Energy System Operator

Case study: GLA Retrofit Accelerator - Homes

The Greater London Authority (GLA) **Retrofit Accelerator – Homes** is a programme aiming to transform the way London delivers retrofits to its ageing and inefficiency housing to achieve warm, affordable, and low-carbon homes across the capital. Additional aims of the programme are to: initiate 1,600 whole-house retrofits in Greater London; create a market for low carbon and environmental goods and services sector; unlock funding for retrofit projects; save over 4,000 tonnes of CO_2 per annum; and tackle fuel poverty.

The £3.6m programme is funded on a 50:50 basis by the Mayor of London and the European Regional Development Fund (ERDF). The lead delivery partner is Turner & Townsend, with other delivery partners including Energiesprong UK, PA Consulting and the Carbon Trust.

Work on this Retrofit Accelerator has formed the foundation for the GLA's delivery role alongside Turner and Townsend and other partners on the BEIS-funded Social Housing Retrofit Accelerator (SHRA), which provides support to local government in both the application process and capacity building to apply for the Social Housing Decarbonisation Fund (SHDF).

GLA is linked to the London Councils' **Retrofit London Housing Action Plan** is a comprehensive retrofit strategy, developed by the GLA and London Councils who represent all 33 boroughs and district councils in London. GLA played a critical funding and steering role in the project, and the Retrofit Accelerator – Homes programme is referenced throughout as a key initiative to build upon.

GLA's involvement in such initiatives as the Retrofit Accelerators – both for Homes and Workplaces – and the Retrofit London Housing Action Plan is part of a suite of programmes under the umbrella of the Mayor's Energy for Londoners Programme and includes innovation, support, delivery and funding initiatives across housing, public and commercial buildings, and energy. These Retrofit Accelerator programmes are helping to drive innovation across the retrofit market, supporting the need to increase the pace of decarbonising heat and buildings to achieve net zero by 2030.

Case study: GLA Retrofit Accelerator - Homes

Successful design and delivery relies on a high level of local knowledge, local stakeholder buy-in, commercial expertise and technical capabilities

The Retrofit Accelerator for homes will provide the technical expertise needed for housing associations and London boroughs to kick-start retrofit projects, supporting them in all stages from identifying projects through to delivery.

The programme will also help to build the supply chain and its capacity in two important ways. Firstly, it will support local authorities and housing associations in developing tangible pipelines of projects that directly support investment in the supply chain. Secondly, it will provide support in delivering whole house, and quality assured projects, requiring the supply chain to upskill. It will also directly support project development and finance including business case development and presentation for internal sign off, helping to accelerate delivery of retrofit, addressing related blockers through the application of local and sectoral expertise and knowledge, for example of the local supply chain, costs and benefits of retrofit, housing stock, and stakeholders. Delivery partners provide technical and economic background, while the GLA, local boroughs and housing associations bring local knowledge Both supply chain development and finance and innovation workstreams will help build demand and resolve blockers within the system.- Technical expertise gained from various local stakeholders and partners have informed the Retrofit Accelerator; it takes a whole-house approach treating a home holistically, facilitating phased delivery, optimising performance, and avoiding risk.

Effectively this will be a 'service design' process which designs the process based on the needs of users and stakeholders, including a mixture of local government, housing providers, supply chain, and tenants, with 'technical expertise' referring to design, engagement, delivery, and finance. These aspects of expertise have specific local characteristics around housing stock, existing supply chain capacity and housing provider activity, available funding, and community demographics; this approach is only possible with the local knowledge of partners and stakeholders.

Given the insufficient technical knowledge and expertise held internally at GLA, the Programme Delivery Unit (PDU) provides public sector organisations with the kind of technical, financial and procurement advice they require for scaled-up retrofitting programmes. In previous Retrofit Accelerator programmes, Turner & Townsend have operated the PDU, and it appears that the Retrofit Accelerator – Homes will build on this partnership.

Case study: GLA Retrofit Accelerator - Homes

Local knowledge and the ability to coordinate with local stakeholders is most concentrated in local government

GLA is an active member of various national initiatives including the Green Finance Institute's (GFI) Coalition for Energy Efficient Buildings (CEEB), whose remit is to develop the market for financing a net-zero carbon and climate-resilient built environment in the UK.

GLA is also part of the UK Green Buildings Council's (UKGBC) 'Accelerator Cities' programme along with Greater Manchester and West Yorkshire Combined Authorities which produced the Retrofit Playbook and is developing a coalition to unify national and regional initiatives on retrofit and develop a local government led delivery and finance model. This approach is about developing a trusted resource signposting best practice for routes to market for social housing, owner-occupied, and private rented sectors, and cross tenure area-based approaches.

It is also about the collaborative development of an active regional/local programme taking a systems approach to tackling the barriers to retrofit, enabling the scaling of routes to market as proposed by the IPA, utilising social housing investment to catalyse market transformation. A central capacity challenge is also present; we must therefore develop a delivery model that supports the upfront investment in resource and capacity building.

The GLA's suite of programmes provide benefits around high profile commitment and messaging to all relevant stakeholders, tackling the whole problem, sharing resources and approaches across initiatives, community engagement and wider regeneration through their Future Neighbourhoods programme. The Mayor's Energy for Londoners Programme has top level commitment, and the programmes within it therefore seek to engage the 33 boroughs and district councils, social housing providers, businesses, the public, NGOs and more.

Case study: GLA Retrofit Accelerator - Homes

In terms of local stakeholders, GLA make use of Turner & Townsend's experience in engaging organisations in initiatives of this nature to help with supply chain coordination. Indirectly, this engagement with organisations helps local supply chains build skills and capacity, while the Retrofit London Housing Action Plan places significant emphasis on direct support of supply chain development. Moreover, the Retrofit Accelerator – Homes programme will play a vital role in upskilling the retrofit supply chain at a local and national level, with one new job generated per £50-60k spent.

This programme's links to the Retrofit London Housing Action Plan mean that it can take advantage of collaborative working approaches to delivery, connecting the GLA with the 33 councils that are well-placed to drive forward locally delivered retrofit, at scale. These connections with local stakeholders include residents, private landlords, and housing associations.

Source: London City Hall (2021), Retrofit Accelerator - Homes

Sources: GLA Retrofit Accelerator - Homes

- London Borough of Barking and Dagenham (2020), Retrofit Accelerator Programme for Corporate Assets
- London City Hall (2021), Retrofit Accelerator - Homes
- London Councils (2021), Retrofit London Housing Action Plan
- Turner and Townsend (2021), Greater London Authority - Retrofit Accelerator Programmes, UK
- UK Parliament Committees (2020), Response from the Mayor of London - EEH0071

Case study: Solent Future Transport Zone

Solent Transport is partnership formed of four local transport authorities, providing leadership, strategy and direction that helps to deliver transport infrastructure, networks, and system improvements, supporting the sustainable development of the Solent area.

Solent Transport's flagship project, the Solent Future Transport Zone (FTZ) is a comprehensive approach to delivering a fully integrated regional transport system. It facilitates the real-world testing of innovative ways to transport people and goods, working closely with local organisations and alongside other local authority-led schemes. This allows for the introduction of new transport solutions as new technologies emerge, with the scale of the FTZ and nature of the partnership providing a roadmap for testing and deployment of innovative solutions as part of an integrated approach.

The Solent FTZ is supported by £28.8m of funding from the DfT's Future Mobility Zones Fund, part of the Future of Transport programme delivered collaboratively by the DfT, OLEV, and the Centre for Connected and Autonomous Vehicles, aiming to shape transport innovation in the UK.

Solent Transport is developing a suite of projects and programmes, and works in partnership with the Partnership for Urban South Hampshire (PUSH) to deliver the transport objectives of PUSH's plans to promote economic regeneration in the sub-region.

The wider ecosystem of reports and initiatives which will help to deliver the remainder of the identified integrated approaches to delivering low carbon measures include the RTPI's Net Zero Transport report, which shares and aligns with many of the system elements of the Solent FTZ.

Successful design and delivery relies on a high level of local knowledge, local stakeholder buy-in, commercial expertise and technical capabilities

The Solent FTZ programme incorporates many of the integrated approaches to delivering low carbon measures as presented in the Net Zero Transport report, and provides a system of enablers required to underpin them, consisting of several interlinked and synergistic projects, many of which build upon established partnerships, and act as demonstrators of new transport innovations. The report is a critical presentation of the whole transport landscape including a comprehensive list of low carbon measures and their relative carbon impacts. Moreover, by taking a spatial planning approach, the report presents an opportunity for measures to be joined up on a regional, city/town, community, and neighbourhood basis.

Case study: Solent Future Transport Zone

It recognises the benefits of collaboration between local authorities and on schemes, aiming to share data and insights on new mobility services, build on existing partnerships and schemes, and undergo extensive local stakeholder engagement to develop and deliver the programme. Taking a human-centred design approach, enablers are better targeted at end users, accounting for their lives and specific aspirations, and their existing and potential travel habits, and the design solutions which enable these. As such, stakeholders are also more likely to be bought into enablers.

Solent Transport themselves publish research, and policy and strategic documents that inform a strategic approach to transport schemes across the Solent region, supporting delivery and helping to remove blockers through the sharing of insights, tools and approaches.

Local knowledge and the ability to coordinate with local stakeholders is most concentrated in local government

The Solent Transport partnership has also planned and coordinated investment in cross-boundary transport infrastructure, securing funding for several transport projects and programmes across the Solent area, and has regularly supported partner organisations in the submission of funding bids.

By supporting the four member authorities in the submission of funding bids through provision of expert knowledge and advice, and through use of tools such as the Solent Sub-Regional Transport Model (SRTM) to provide supporting evidence on potential transport interventions, Solent Transport plays a key role in removing blockers at the local level.

Sources: Solent Future Transport Zone

- Department for Transport (2019), Future of Mobility: Urban Strategy
- Department for Transport and Department for Business, Energy & Industrial Strategy (2020), Future of Transport regulatory review: call for evidence on micromobility vehicles, flexible bus services and Mobility-as-a-Service - Consultation outcome
- O'Rourke (2020), £90 million fund for Future of Transport zones (formerly FMZ) as wider consultation launched, TransportXtra
- Portsmouth City Council (2020), Cabinet Member for Traffic and Transportation Decision Meeting - Solent Future Transport Zone
- Solent Transport (2019), Solent Mobility Zone: Future Mobility Zone Fund - Expression of Interest
- Solent Transport (2021), Solent Future Transport Zone - Programme Overview
- Solent Transport (2021), The Solent Transport Future Transport Zone, Spring / Summer 2021

Case study: Project LEO (Local Energy Oxfordshire)

Project LEO is taking a regional approach to building a broad range of reliable evidence of the technological, market and social conditions needed for a greener, more flexible, and fair electricity system for Oxfordshire and beyond.

Its primary aim is to 'deliver a transformative integrated smart local energy system to maximise prosperity from local energy systems and demonstrate new value creation opportunities'.

This project is a broad, innovative, and holistic smart grid trials ever conducted in the UK and is delivered by a team of project partners including Oxford City Council and Oxfordshire County Council, alongside various energy companies, social enterprises, and universities.

By working on a range of diverse and innovative project areas and activities, Project LEO's learnings are accelerated to develop practical guidance informed by a strong evidence base that will support the UK's transition to a clean, secure, and affordable energy system. They are developing technical, commercial, and social insights about how different energy assets such as renewable generation, storage, and demand, can be coordinated in a flexible way to respond to respond to over or under supply in the grid. These assets range from solar farms and hydro schemes, bus company and district batteries, as well as Electric Vehicle charging and electric heat pumps. The innovation considers the technology required to manage the flexibility and the associated business models that generate income from the network operator.

The project is part-funded by UKRI and Industrial Strategy's Industrial Strategy Challenge Fund (ISCF) which has provided a grant of £14m via the Prospering from the Energy Revolution (PFER) programme. A further £24m was provided by project partners.

Successful design and delivery relies on a high level of local knowledge, local stakeholder buy-in, commercial expertise and technical capabilities

Project LEO is made possible by its working partnership approach, with partners including Low Carbon Hub, SSEN, University of Oxford, Oxford Brookes University, Piclo, EDF Energy, and Nuvve, gaining a wealth of academic knowledge, commercial expertise, and technical capabilities from its broad range of partners and stakeholders.

It also has links to OxFutures, another Oxford-based innovation partnership; Project LEO sits within the 'Green Lab' aspects of this system, as a key project investigating methods of integrating technologies into local, regional and national energy grids. These links to the wider ecosystem allow for resolution of blockers through the use of local commercial and technical capabilities.

Case study: Project LEO (Local Energy Oxfordshire)

This joined-up ecosystem including local stakeholders and infrastructure is key to the delivery of Project LEO and the removal of blockers; Oxfordshire is an ideal testbed as it has, among other factors, high levels of social capital and public engagement aligned with the idea of Distributed Energy Resources, high levels of skills and knowledge among project partners, and an innovative network operator managing a power system close to capacity.

Capitalising on existing skills, knowledge and expertise of project partners and allowing specific partners to lead and participate in the different activities means that both commercial and local partners can be effectively brought into the process of designing and delivering enablers. This engagement with local stakeholders means that they are bought into the process, local knowledge of capacity and expertise, and existing, trusted working relationships are tapped into, and enablers are therefore better designed to meet local needs.

In terms of building individuals' capability and motivation to engage in the energy transition, the approach promotes participation and 'prosumerism' whereby people are given stakes in the energy system and can earn and save money while retaining the benefits, improving their homes, and tackling climate change. At the community level, community investment schemes can create and retain economic value locally. Taking prompts from Community-Based Social Marketing (CBSM), which effects behaviour change through direct contact with people and is enhanced by a trusted organisation such as local government, neighbours and community members act as role models and encourage others to involve themselves in projects.

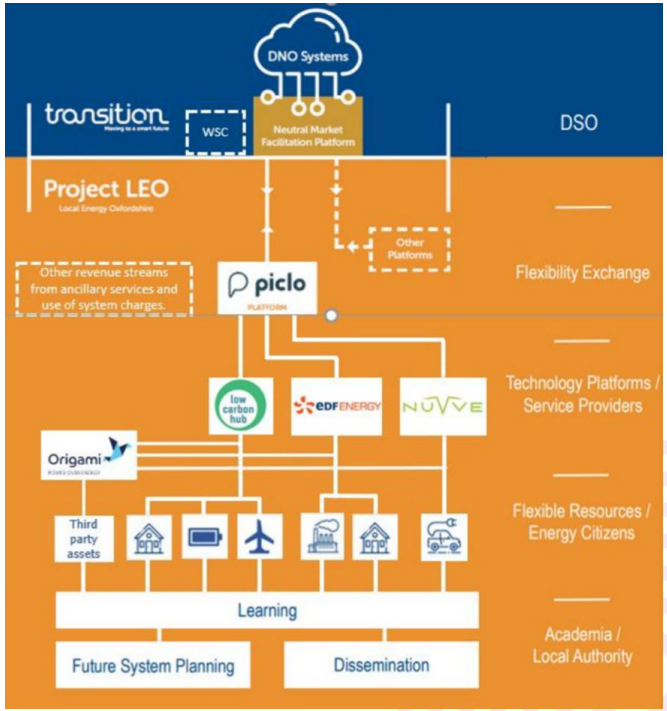
Case study: Project LEO (Local Energy Oxfordshire)

Local knowledge and the ability to coordinate with local stakeholders is most concentrated in local government

Emphasis is placed by Project LEO on stakeholder buy-in, having carried out workshops involving stakeholder mapping to bring together partners from all work packages and building knowledge and understanding across issues like business model canvases, site selection, and market rules.

Project LEO categorises its stakeholders as: network operators; local authorities; supply industry and market-enabling partners; and local network anchors who allow access to low carbon community groups. A stakeholder engagement strategy sets out routes for dialogue that will attempt to influence and learn from stakeholders, helping with the design of enablers.

Project LEO's projects are coordinated by the programme management and governance resources of SSEN and the University of Oxford, with robust governance arrangements designed to ensure successful delivery and sufficient representation of internal and external stakeholders.



Source: Local Energy Oxfordshire (2020), Project LEO first year synthesis report - WP6 Deliverable 6.3.4

Sources: Project LEO (Local Energy Oxfordshire)

- EnergyREV (2020), Review of technical barriers to upscaling SLES
- Local Energy Oxfordshire (2020), Project LEO first year synthesis report - WP6 Deliverable 6.3.4
- OxFutures, Project LEO
- Project LEO, About the Project
- Project LEO (2021), The First Year of Project LEO with Melanie Bryce of SSEN - YouTuveSSEN Transition, LEO
- Rae, C., Kerr, S. and Maroto-Valer, M. (2020), Upscaling smart local energy systems: A review of technical barriers, Renewable and Sustainable Energy Reviews, Vol 131

Case study: WMCA Regional Energy System Operator

Energy Capital is the West Midlands' smart energy innovation partnership, aiming to make the region one of the most attractive locations to build innovative clean energy technology companies by responding to the needs of the region's vibrant manufacturing economy and local markets.

The partnership combines academic expertise with local authorities, businesses, innovators, and entrepreneurs, and provides a single point of contact for investors, funders and partners.

Energy Capital are responsible for delivering the Regional Energy Strategy and supporting the WMCA with their decarbonisation agenda.

Another objective of Energy Capital is to ensure that the West Midlands' economy is supported by a competitive, flexible and secure modern energy system providing low cost, clean and efficient power to its industries and people.

The Regional Energy Strategy consolidated work carried out by the Regional Energy Policy Commission, Arup, AECOM and the Black Country LEP, setting out an investment plan for £500m to direct more than £15bn of wider investment in local energy projects over the next decade.

Energy Capital are facilitating and co-ordinating collaborative public-private investment projects across the region, and working with the local communities, public bodies and national government.

Successful design and delivery relies on a high level of local knowledge, local stakeholder buy-in, commercial expertise and technical capabilities

One of Energy Capital's key projects is the 'Regional Energy System Operator' (RESO), looking at how to explore the advantages of a new kind of energy system operating at city scale, producing a detailed design for a smart local energy system (SLES) with a clear governance structure and commercial operating model that produces local benefits.

The West Midlands RESO is a partnership project funded by UKRI and Western Power Distribution (WPD), bringing together key infrastructure stakeholders and energy innovator organisations to design a SLES for Coventry, establish an operating model for this design, and demonstrate a framework for securing and support the necessary long-term investment.

Case study: WMCA Regional Energy System Operator

Key to Energy Capital's work on projects such as the RESO, is the concept that working together synergistically is best achieved by increased collaborative control and planning at the local level.

Critical to the development of the RESO is incentivising multi-level participation in a fully integrated local energy system, ranging from householders and small businesses to large scale energy generators or operators of heat networks. This is because of the diverse range of stakeholders involved at all levels of the energy system, the specific behaviour change required of them, and the influence which they have on each other within the system,

Energy Capital predicts that empowering and involving local stakeholders in the project development of the RESO allows them to benefit from reduced energy prices, as well as local jobs and future development investment. SLES may help to deliver economies of scale and scope – such as flexibility – therefore minimising the individual and socialised cost of infrastructure, thus including multiple vectors within an energy system's design and operation can help to achieve cost savings.

Energy Capital identify that local leadership is vital to the success of clean energy investments, as it taps into regional identity to build enthusiasm for energy innovation, overcome nimbyism and distrust of the big six utilities, and provide democratic accountability.

Delivering projects such as Energy Innovation Zones (EIZs) – which WMCA make the case for in their Powering West Midlands report – can address blockers around lack of local authority capacity to deliver local energy projects; these local authorities are likely to value an EIZ as a trusted arms-length organisation.

While work to define the concept of an EIZ is still being carried out by Energy Capital and BEIS, EIZs are designed to stimulate clean energy innovation, driving local productivity, export, and growth. Their focus is to integrate low-carbon technologies across energy systems, while developing the business models and markets needed to support the transition to renewables at scale.

Case study: WMCA Regional Energy System Operator

Limited local resource to invest and develop energy systems can be a challenge to local authority delivery of energy projects, particularly in relation to understanding the specific needs of a local area. However, energy investment is an area which may well best and most efficiently be supported from the combined authority level, as local authorities and LEPs often lack full time staff with the necessary expertise. Programmes run at the combined authority level can provide technical, commercial and legal services to a variety of sectors in the development of energy projects, and benefit from the fact key infrastructure organisations operate at the regional level.

Energy Capital argues that local leadership of regional energy activity is fundamental to its success; this is a technical point as well as a political and logical one, as the more localised an energy project, the more sensitive its economics tend to be to customer engagement. Moreover, local authority and community control helps to de-risk projects and aid successful project delivery. Implementing an EIZ under Energy Capital allows local authorities to control and lead local energy investment in their areas, while establishing and providing the functions of a mechanism to manage risks, support partnerships, and access expertise from local organisations within the partnership.

Local knowledge and the ability to coordinate with local stakeholders is most concentrated in local government

WMCA has adopted the Regional Energy Strategy – which was developed by, and is the responsibility of, Energy Capital – following the approval and endorsement of the Black Country Consortium, Coventry & Warwickshire and Greater Birmingham & Solihull LEPs and the Strategic Economic Development Board.

The RESO project is being developed with a leading partner group led by Energy Capital, WMCA, Coventry City Council, University of Birmingham, University of Warwick, ENZEN Global Ltd, Electron Ltd, Camirus Ltd, Western Power Distribution (WPD), Cadent Gas, and Places in Common.

Including a clear governance structure and a commercial model motivated to produce local benefits, the RESO uses its partnership of local government actors and beyond to ensure local stakeholder buy-in.

Case study: WMCA Regional Energy System Operator

Within the partnership the three LEPs and WMCA focus largely on agendas where working together at the regional scale is logical, around economic development, transport, inward investment and skills; while the local authorities' focus is on running public services and maintaining their area.

To manage the risks and uncertainty of energy investments effectively, decision makers must be able to account for a broad range of interests and issues. This becomes very difficult (and can easily lose touch with political realities and voters) where decisions are taken at regional or national level, thus buy-in is more concentrated at the local authority level.

Energy Capital is accountable to the Mayor of West Midlands through the WMCA and SEP Strategic Economic Plan) Board, aiding the trust of local stakeholders.

Energy Capital identifies and addresses through its partnership and stakeholder engagement processes, that with local energy projects, the main issue is not understanding the opportunities, but securing the local political consensus, stakeholder support and finance to make them happen. This is because in the case of the West Midlands, most of the local authorities have existing maps and studies of local energy opportunities.

Energy Capital's work begins to deliver on several of Regen's recommendations on local leadership to transform our energy system, including: unlocking local authorities' role in energy network planning and investment; enabling local authorities to invest in the future energy system and support community energy projects; and supporting the development of SLES.

Sources: WMCA Regional Energy System Operator

- Energy Capital, Energy Innovation Zones
- Energy Capital, Home
- Energy Capital, RESO - Regional Energy System Operator
- Energy Capital (2018), A Regional Energy Strategy for the West Midlands
- Energy Capital (2018), Powering West Midlands Growth - A Regional Approach to Clean Energy Innovation
- Rae, C., Kerr, S. and Maroto-Valer, M. (2020), Upscaling smart local energy systems: A review of technical barriers, Renewable and Sustainable Energy Reviews, Vol 131
- Regen (2020), Local leadership to transform our energy system
- West Midlands Combined Authority (2020), Innovation investment will position the West Midlands as a global leader in smart energy
- Western Power Distribution, Projects - Regional Energy Systems Operator (RESO) project

5.3

Challenges identified with the current policy and delivery landscape

This Section provides further evidence for the problems we have identified with the current policy and delivery landscape

What this section covers:

In this section we provide more evidence to support the problems we have identified with the current policy and delivery landscape. In particular, we discuss:

- What is preventing different parts of government from **designing** the best portfolio of interventions for a place; and
- What is preventing different parts of government from **delivering** the best portfolio of interventions for a place.

This evidence is informed by:

- Climate Action Readiness Assessment workshops with representatives from the six city regions: Belfast, Glasgow, Liverpool, Manchester and Cambridgeshire & Peterborough. Further information, readiness scores and wider insights from each city-region provided in these workshops is detailed in Annex: CARA.
- Desk research into policy evaluations and assessments of the challenges facing Local Authorities.
- Interviews with Energy Systems Catapult (ESC) about their analysis of Local Area Energy Plans.

We have identified five key areas where the existing delivery framework could be improved

The current delivery framework is not set up to effectively design and deliver interventions that will stimulate the adoption of low carbon measures and accelerate the delivery of Net Zero. We have identified and categorised the areas where the existing delivery framework could be improved. These problems are aligned with each of the buildings blocks of local Net Zero delivery, as set out below.

The following pages present our evidence for the challenges in each of these areas.

System governance	Skills and capacity	Portfolio management	Funding & finance
Roles and responsibilities are not clear or well understood, and local authorities sometimes lack the required powers or influence.	Local authorities often lack either the expertise or the capacity to design and deliver interventions.	Existing processes often do not support a place-based, whole system approach; they are inconsistent and they leave key blockers unresolved. Technical data and information on best practice is widely dispersed and local authorities often lack the systems needed to access or process it.	Local authorities lack the funding needed to secure the right resources and the finance needed to deliver large-scale, long-term projects.

We found that roles and responsibilities are not clear or well understood, and local authorities sometimes lack the required powers or influence

System governance | Skills and capacity | Portfolio management | Funding & finance

Roles and responsibilities are not clear or well understood. The NAO found that that "central government has not yet developed with local authorities any overall expectations about their roles in achieving the national net zero target." This means that "without a clear sense of responsibilities and priorities we see a risk that local authority action on net zero is not as coordinated, targeted, or widespread as it might need to be." [98] Government has begun to address this challenge through the Net Zero Strategy. In particular, BEIS has been given responsibility for improving the coordination between central and local government in the design and delivery of interventions and a Net Zero Forum has been established to bring together national and local government officials on a regular basis to discuss net zero policy and delivery options.[99]

With regards to roles and responsibilities in developing LAEPs, ESC noted that "there is currently no clear obligation for local government to undertake a mandated form of LAEP". Additionally, the "cross-sector nature of Net Zero means that it is difficult to understand and define who 'owns' it". As a result, LAEPs are not always developed or may not be developed to comprehensively cover all sectors of the area.[100]

Local authorities sometimes lack the required powers or influence. UK100 found that local authorities had "insufficient powers to drive the big changes; and, where powers do exist, insufficient capacity to use them decisively".[101] This means that local authorities may not have all the powers they need to deliver the most desirable interventions. If local authorities are unable to influence the part of government with the necessary powers, then the desired interventions cannot go ahead. For example, local authorities are often unable to implement an area-wide strategy for the transport system because they do not have control over decisions or funding for the whole system, e.g. traffic commissioners control bus services and have no remit to consider transport planning as a whole. [101]

[98] Local government and net zero in England, National Audit Office, 2021
[99] Net Zero Strategy: Build Back Greener, HM Government, 2021
[100] The Future of Local Area Energy Plans in the UK, The Energy Systems Catapult, 2021
[101] Powershift, UK100, 2021

We identified a common theme that local authorities often lack either the expertise or the capacity to design and deliver interventions

System governance | **Skills and capacity** | Portfolio management | Funding & finance

Local authorities often lack the expertise to design and deliver interventions. Urban Foresight found that policymakers lack the skills to translate net zero ideas into practical plans or projects, for example, "the absence of skilled business modellers in natural capital and carbon sequestration was a recurring theme." [102]

Similarly, the NAO summarised findings of research by CCC, Green Alliance, Blueprint Coalition and concluded that local authorities do not have skills such as "low-carbon planning and development, developing low-carbon economies, financing and delivering low carbon projects".[103] CARA workshop participants also reported that local government often does not have the specialist expertise needed to design and deliver interventions. [104] As a result, local authorities are unable to design and deliver the interventions needed to achieve Net Zero.

Local authorities often lack the capacity to design and deliver interventions. The NAO found that capacity was a major issue for most local authorities: "In a Local Government Association climate change survey in 2020, 79 out of 90 respondents thought a lack of workforce capacity was a moderate or significant barrier to tackling climate change." [103] Similarly, Urban Foresight reported that "multiple interviewees for this project described being interested in new innovations, but simply not having the bandwidth to think about turning it from a promising idea into action." [102] CARA participants also highlighted that local governments often do not have the capacity to deliver on all of their priorities, for example Net Zero and the delivery of their statutory duties. [104]

The Government acknowledged the shortage of skills and capacity in the Net Zero Strategy, committing to build "capacity and capability at the local level to support ambition and share best practice, while also providing support in areas that may not have made as much progress to date." For example, support will continue for Net Zero Hubs, which "promote best practice and support local authorities to develop net zero projects that can attract commercial investment. The Hubs are currently supporting local authorities to develop projects with a potential capital value of over £2 billion." [105]

[102] Getting to net zero: bridging the innovation gap between places and companies, Urban Foresight, 2021
[103] Local government and net zero in England, National Audit Office, 2021
[104] CARA workshops, 2021
[105] Net Zero Strategy: Build Back Greener, HM Government, 2021

Previous reviews found that technical data and information on best practice is widely dispersed and local authorities often lack the systems needed to access or process it

System governance | Skills and capacity | **Portfolio management** | Funding & finance

Technical data is widely dispersed and local authorities lack the systems needed to access or process it. For example, the CCC found that "surveyed local authorities use a very wide range of sources to inform their activities on climate change. They get information primarily from BEIS data, APSE, Ashden, the Local Government Association (LGA), The Carbon Trust, the CCC, the IPCC, ADEPT, Salix, other local authorities, universities, consultants and sector specific sources, like WRAP. This pool of resources is constantly being added to. This means significant time and expertise is spent extrapolating from national to local data, dealing with contradictory information and working out what they should do." [106]

The CCC also identified difficulties in the way that central government communicates with local government: "Government communications directly relating to local authorities on climate change tend to be from specific government departments on narrow policy areas and information made available through narrow sector specific datasets. Apart from the BEIS local area emissions data a joined-up picture is not provided. Local authorities have to search around in strategy documents to work out where they fit in." [106]

These challenges also applied to LAEPs. ESC found that local authorities faced challenges "understanding who has what data, the quality of the data and where the gaps are". Additionally, some noted that they "lacked access to real-time data and that relying on "data snapshots" meant that they could not be as agile in spotting opportunities to update plans as they would like". [107]

Information on best practice is widely dispersed and local authorities lack the systems needed to access or process it. For example, the lack of information on project monitoring, such as on performance against spend, makes it difficult to identify best practice. In particular, the NAO found that "neither MHCLG nor HM Treasury track the funding that central government provides to local government linked with net zero. Information on available grants is not easily accessible as it is spread across several government websites." [108]

Even when information is available, local authorities reported that "the many sources of good practice can be difficult to work through, to filter out what might work in their area." [108] As such, local authorities struggle to access or process available best practice because it is not consolidated.

[106] Local Authorities and the Sixth Carbon Budget, Climate Change Committee, 2020
[107] The Future of Local Area Energy Plans in the UK, The Energy Systems Catapult, 2021
[108] Local government and net zero in England, National Audit Office, 2021

We also noted that existing processes often do not support a place-based, whole system approach; they are inconsistent and they leave key blockers unresolved

System governance | Skills and capacity | **Portfolio management** | Funding & finance

Existing processes are often inconsistent. For example, the NAO concluded that "there is little consistency in local authorities' reporting on net zero, which makes it difficult to get an overall picture of what local authorities have achieved".[109] This means a whole system approach is difficult to achieve because it is hard to identify the full range of decarbonising needs in a place. It also makes it difficult to identify examples of best practice, slowing the dissemination of information.

This challenge was also noted in the development of LAEPs. ESC found that differing approaches between plans made it hard for regional stakeholders to compare and aggregate plans for different areas, and so understand their role in the delivery of the LAEPs. [110]

Existing processes often leave key blockers unresolved. A whole system approach involves ensuring that all blockers to adoption are considered. Leaving blockers unresolved does not support a whole system approach. For example, homeowners could only used installers who were registered with TrustMark and certified to work to Publicly Available Standards or Microgeneration Certification Scheme. The NAO reported that "installers were reluctant to invest in gaining such accreditation in the expected six-month timescale of the Scheme". [111]

The Public Accounts Committee heard that complexity of the Scheme meant "46% of installers who applied to participate in the scheme were unable to be registered successfully".[112] The Scheme left blockers unresolved, and did not improve the supply of opportunities.

The NAO also found that public sector procurement processes could frustrate delivery of interventions. In particular, "progress from project inception to delivery could be significantly slowed by the public procurement process, as there are often no existing frameworks for new innovative business models or technology".[109] As a result, interventions to could be delayed and so hinder the success of other interventions, which goes against the whole system principle of managing dependencies.

CARA participants also noted that the process for policy development often worked in siloes, preventing coordination between national and local interventions and between different local interventions.[113] This means that some blockers may be left unresolved. For example, a heat network is being developed in Northallerton despite not having a LAEP in place. As such, decisions may have been made based on assumptions about opportunities and challenges in Northallerton, and so missed certain blockers that may need resolving.

[109] Local government and net zero in England, National Audit Office, 2021
[110] The Future of Local Area Energy Plans in the UK, The Energy Systems Catapult, 2021
[111] Green Homes Grant Voucher Scheme, National Audit Office, 2021
[112] Green Homes Grant Voucher Scheme, House of Commons Committee of Public Accounts, 2021
[113] CARA workshops, 2021

We found that local authorities often lack the funding needed to secure the right resources and the finance needed to deliver large-scale, long-term projects involving private investment

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Local authorities lack the funding needed to secure the right resources. The NAO reported that "local authority finances have been under pressure after a period of funding reductions and growth in demand for services".[114] As a result, local authorities prioritise funding the delivery of their statutory duties and long-established service rather than prioritising access to the right resources to design and deliver interventions. CARA participants reinforced this finding that the lack of local authority funding prevented them from accessing the skills they would need. In particular, they also gave the example of the Energy Hubs where a short term approach to funding prevented them from attracting specialist expertise.[115] Local authorities face a similar challenge in developing LAEPs. ESC found that local authorities often do not have the skills in house to develop LAEPs and so rely on external consultants. The cost of accessing these skills is hard to justify when there is no clear obligation for local authorities to produce a LAEP, which means that often they do not dedicate the resources towards doing so.[116]

Other challenges include small 'ticket sizes' for local projects with private and third party finance requiring aggregation which is why the portfolio approach is vital to attracting a scaling investment.

Local authorities lack the finance needed to deliver large-scale, long-term projects. In particular, the CCC found that the current project finance landscape tends to be "short-term competitive funding for narrowly specified projects with tight bidding times".[117] As a result, local authorities cannot access the larger scale, longer-term project finance needed to deliver certain interventions or, in particular, the actions set out in a LAEP. This challenge was reiterated by CARA participants.[115]

The NAO concluded that the fragmented nature of grant funding can hinder value for money because it makes "it can make it difficult for local authorities to plan for the long term" and makes it "more complex for local authorities to find funding and limits their ability to deliver across multiple objectives."[114]

The Net Zero Strategy has acknowledged the opportunity to improve the way in which project finance is delivered: "We recognise that longer term and more coordinated funding streams can enhance innovation and investment, reduce bureaucracy, and encourage more efficient and integrated decision making. We will explore how we could simplify and consolidate funds which target net zero initiatives at the local level where this provides the best approach to tackling climate change."[118]

[114] Local government and net zero in England, National Audit Office, 2021
[115] CARA workshops, 2021
[116] The Future of Local Area Energy Plans in the UK, The Energy Systems Catapult, 2021
[117] Local Authorities and the Sixth Carbon Budget, Climate Change Committee, 2020
[118] Net Zero Strategy: Build Back Greener, HM Government, 2021