Liverpool City Council

Liverpool Net Zero Carbon 2030

The Climate Challenge

CONTENT

FOREWORD

Mayor Joanne Anderson

My mayoral ambition is to create a fairer, greener, and brighter low carbon future for the people of Liverpool. And I believe that the reduction in carbon emissions – to be a Net Zero Carbon city by 2030 - will have multiple benefits across all sectors and is at the environmental core of our Triple Lock approach where we aim to ensure that social value, environmental impact and equality and inclusion are valued equally alongside the economy.

Liverpool is a forward-thinking, ambitious and above all, caring city, as we have all vividly seen during the pandemic. The past 18 months has brought pain and challenges to everyone, but it has also highlighted the best of our communities working together to deliver big changes.

Delivering the NZC30 Plan will need to harness this spirit of collective responsibility to shape our recovery. The work also forms part of our commitment to our City Plan partners.

The Plan sets out the radical actions needed from all of us if we are to achieve our ambition. We need a reset in how public services are delivered, how people heat their homes and how people travel and we need to ensure that we do that whilst keeping services accessible and fair to all.

As we develop this work people will be empowered to ask ‘what can I do?’ or ‘what action can we take?’ We will build relationships between communities, public services and private business by listening and supporting communities to use their strengths, resources, skills and ideas to deliver a lower carbon future.

Working together, I believe that local partners and communities will achieve much. But we will also need the backing of Government and we will challenge national policies and funding priorities where these delay progress.

The NZC30 Plan is the start of our accelerated journey. It sets out a path towards a low carbon, fairer social, environmental, future. By working with all communities across the city we seek to improve futures not just for our citizens but for all citizens and for the planet.

Cllr Barrington

Cabinet Member Climate Change and Environment

Reducing carbon emissions to net zero across all our activities is now essential to combat the threat of accelerating climate change on our planet. It won't be easy but we accept the challenge.

Since 2005 the city's emissions have reduced by 42% and this NZC30 Plan sets out what we now need to accelerate to further reduce carbon emissions across the city in the shortest possible time.

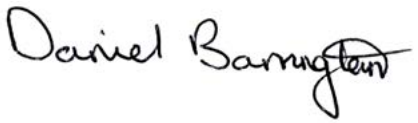
Not all the necessary technical solutions have yet been tested at scale across a UK city. But we will use this 2021 baseline position to direct, accelerate and monitor the city's progress and to engage with our citizens, businesses and civic society to build the consensus needed for lasting change.

Cleaner, greener new transport routes will provide more equable access to jobs; cleaner, greener homes will help reduce fuel poverty; energy efficient building will save business costs on energy; reduced road traffic brings additional local health benefits from reduced air pollution; and our green spaces will help not only reduce carbon but support peoples' health and well-being. New jobs will be created by investing in a low carbon economy and we will help people re-skill as jobs change from fossil-fuel based jobs.

Liverpool also needs to develop resilience to those impacts of climate change that we know are already happening, such as hotter summers; more extreme rainfall; and stronger winds. It is a huge challenge and one that can only be met with a true alignment of partners; significant changes to national government funding and policies and access to new methods of funding.

The scale of the changes will be transformative and it is important that the transition to the low carbon economy is a fair one. A part of my role will be to lobby for fairer energy priced, affordable solutions and for the costs of carbon reduction to be targeted at those that are emitting the most carbon and not shared disproportionately across the poorest in our society.

This is our analysis of what we need to do, it will remain a live document, and as we engage with more people, action plans will develop for each topic area that will reflect your experiences, good practice and ideas, and progress will be reviewed on an annual basis.



EXECUTIVE SUMMARY

A 2030 Net Zero Liverpool

This Plan sets out the actions that Liverpool can take to become a net zero city in 2030. It is a hugely challenging target, but one that can bring many benefits.

A 2030 Net Zero Liverpool is a thriving, fair and sustainable city. Climate action will have stimulated the local green economy and placed Liverpool at the forefront of new industries which will form the backbone of our future economy. The city will have also stopped all contributions to climate change and have demonstrated leadership to other cities in the UK and globally. The city will also be more resilient to the climate changes we are already experiencing.

Key Challenge and Solutions

To become a 2030 Net Zero City, Liverpool needs to address several key challenges across four major themes. The proximity of the 2030 target means that actions taken must be using proven technologies and solutions. The key challenges and approaches to tackling them are shown here.

Collaborating for Success

The NZC30 Plan has been developed by Eunomia Research and Consulting Ltd and the Centre for Sustainable Energy for Liverpool City Council as the lead organisation, but the Council only has direct control over a very small amount of the city's emissions. To be successful this plan needs to be the foundation of city-wide action and as such it has been designed as the foundation for collaboration by the whole of Liverpool's civil society.

Buildings	Decarbonise heating of buildings (both domestic and commercial)	Insulation of 170,000 buildings in the city to enable use of lower intensity heat
		Connection of 70,000 buildings to heat networks where waste heat or new heat can be efficiently supplied
		Installation of 203,000 individual heat pump systems
Energy	Increased capacity of electricity network to cope with increased demand	Upgrade of the local network
		Energy efficiency measures to minimise demand increase
		Smart meters in every building to enable dynamic management of energy demand
	Decarbonisation of electricity supplied to the network	Support installation of 77,714 individual solar PV installations in Liverpool
Transport	Reduce travel demand	A variety of demand reduction measures such as incentivising home working
		Consolidate freight activities
	Shift the mode of remaining journeys	Provision of infrastructure to make active travel, car-sharing and public transport journeys more attractive and simpler
	Electrify journeys that are still reliant on vehicles	Provision of charging infrastructure (and other alternative fuels)
Waste	Reducing waste that is generated	Waste prevention measures such as awareness campaigns
	Increasing the amount of waste that is recycled	Provision of collection services for waste types such as food waste
		Make it easier and simpler for residents to provide waste so it is easy to collect for recycling

APPROACH

This work has analysed Liverpool's GHG Protocol Scope 1 and 2 emissions in detail. Further work will be needed to analyse Scope 3 emissions. This section details both the guiding principles and the process used to develop the NZC30 Plan.

GUIDING PRINCIPLES

This work was guided by five key principles. These are detailed below.

TRIED AND TESTED

With a 2030 net zero deadline, only tried and tested technologies have been considered. This does not rule out the development of other technologies as net zero is an ambition that needs to be sustained. How the Plan is sustained in future may differ from how the city first moves to net zero.

DEMAND REDUCTION

Wherever possible, reduction of demand has been prioritised. Once this has been achieved, action to move to cleaner technologies is considered. This helps keep the resources needed to make the change as low as possible which has both a financial and greenhouse gas (GHG) benefit. For example, moving up the transport hierarchy to active travel was prioritised before electrification of vehicles.

A WIDER VIEW

Where there is a choice over which solutions can be taken, solutions with the best co-benefits and added social value have been prioritised.

COUNCIL AS LEADER

The Council only directly contributes approximately 1% of the city's emissions but has a role to play in leading by example and facilitating and encouraging innovation and change wherever possible. The Plan therefore focuses on actions the Council, and lead organisations, can realistically take a lead in delivering or galvanising change.

DON'T LEAN ON OFFSETTING

Liverpool has very limited scope to remove GHGs from the atmosphere in 2030 due to its tight urban boundaries. Therefore, this plan does not focus on an offsetting approach to reach net zero, instead focusing

DEVELOPMENT PROCESS

This Plan has been developed by the Council in consultation with local City Plan partners and organisational stakeholders. The actions that follow focus on those that the Council can lead and where partners have already indicated they are willing to take action. However, net zero action cannot be achieved through council action alone. This document will form the basis of a wider discussion with civil society to stimulate wider actions by other key stakeholders, building on this Plan to develop city-wide engagement and actions.

Supporting this Plan is a suite of technical appendices which are also publically available. These documents provide further detailed analysis, including the methodology behind the aims, and more detailed action plans for actions the Council can take. The solution reference numbers provided in the solution tables in this Plan correspond to the detailed solution and action tables provided in the appendices.

THE JOURNEY TO NET ZERO

This section looks at what Liverpool has achieved so far and what major challenges need to be addressed to reach net zero in 2030.

PROGRESS TO DATE

Liverpool's carbon footprint for the year 2017 (scope 1 and 2 emissions) totals 2.6 million tCO_2e. This equates to 5.36 tCO_2e per capita, which is roughly the weight of an elephant. Figure 1 shows how the total emissions per capita for Liverpool compares to three neighbouring core cities.

This data has been produced using the SCATTER tool. This tool is widely used by local authorities to calculate baseline emissions and is funded by the Department for Business Energy and Industrial Strategy (BEIS). The SCATTER tool provides a footprint for the latest year for which input data is available, which at the beginning of this project was 2017. Updates to Liverpool's carbon footprint provided by the SCATTER tool will be included in future updates to this work.

Figure 1: Total Emissions per Capita

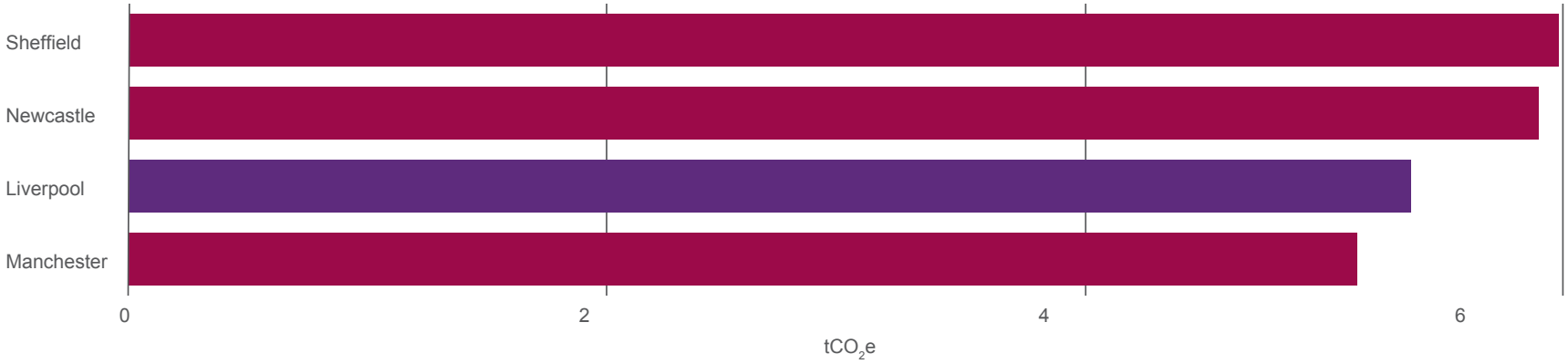
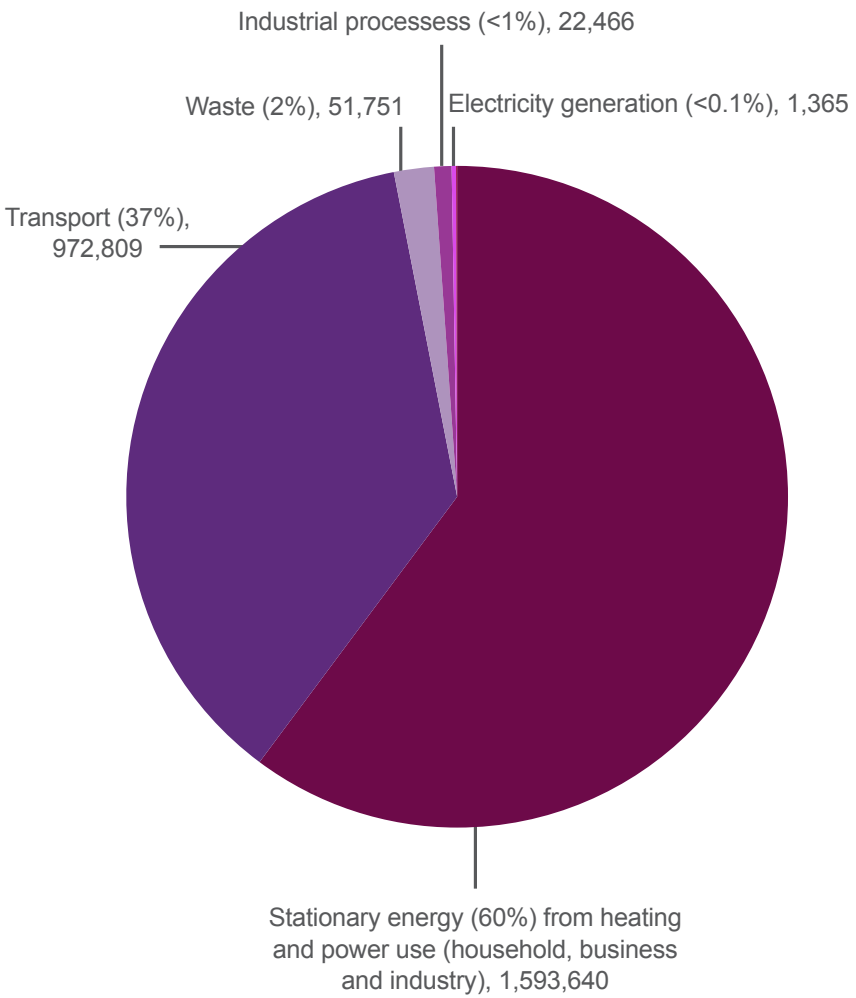


Figure 2: High Level Emission Breakdown



Liverpool has achieved significant emissions reductions in recent years, however there is still a long way to go to reach net zero and the easiest wins, such as installing LED street lighting, have already been achieved.

Figure 2 shows Liverpool's current footprint (in tonnes CO_2e) broken down into five key sectors and the contribution of each to the total footprint.

Due to methodological differences, this footprint is not directly comparable with the previous footprint calculated by Anthesis in 2016. Emissions from Agriculture, Forestry and Other Land Use (AFOLU) are not included as this sector delivers a net sequestration of emissions.

Liverpool's carbon footprint clearly indicates that, as with other major cities, the major challenges to decarbonisation come from the building and heating and transport sectors.

THE SCALE OF THE CHALLENGE

BUILDINGS AND HEAT DECARBONISATION

The majority of space and water heating demand in the city is met through a combination of natural gas and resistive electrical systems i.e. electric heating, such as storage, convection or infrared heaters. To reach net zero, almost all of the addresses in Liverpool will need to have a decarbonised heating supply. This means replacing the heating systems in almost all of the city's 275,000 addresses. This is estimated to have a total capital cost of approximately £1.5 billion. In addition to decarbonising supply, buildings will need to be made more energy efficient. The insulation of 170,000 buildings in Liverpool is estimated to have a capital cost of £1.5 billion. To ensure fuel poor households are protected from the risk of higher heating costs, investment focus will need to be placed on the building and retrofitting of lower energy performance dwellings.

TRANSPORT

Transport is the second largest contributor to carbon emissions in Liverpool, with most of this due to road transport. Overall transport emissions in Liverpool stand at 972,809 tCO_2e. This includes emissions from waterborne navigation, rail, aviation and on road and off road transport. This highlights the importance of addressing the emissions of this sector. To reach net zero, as many journeys as possible need to be moved to active travel, shared mobility and public transport, with those remaining in vehicles moved to electric or other non-fossil fuelled vehicles. The analysis focused on on road transport as this can be controlled at the local level.

WASTE

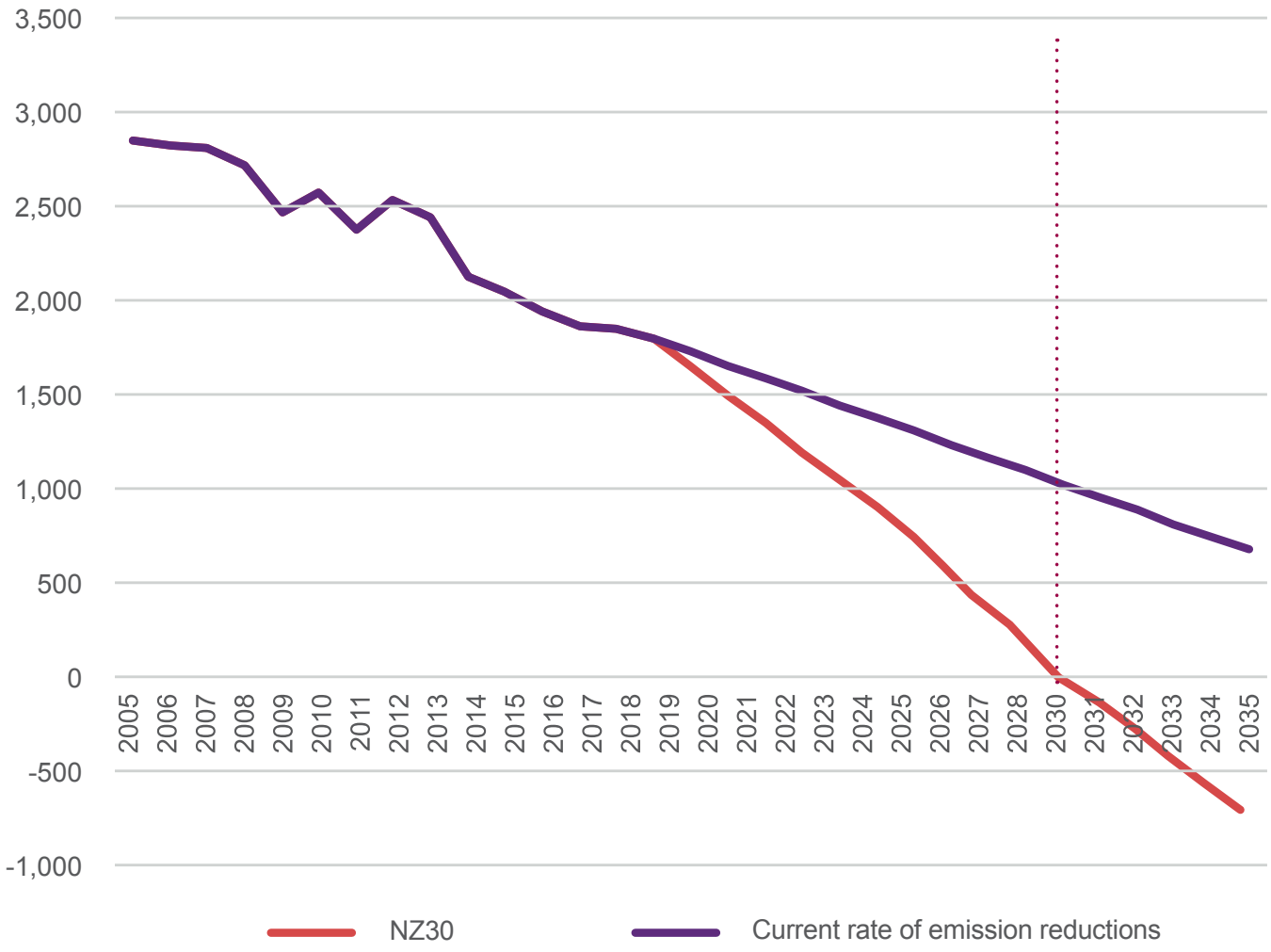
In this work a key focus for waste was emissions from incinerators. Liverpool's household waste that is not recycled is sent to an energy-from-waste facility in Teesside which incinerates the waste, to recover energy, but which also results in the release of GHGs. This is the single largest source of emissions from waste. To meet net zero goals, the primary challenge is to stop materials with high carbon content from being incinerated. This means reducing the amount of this type of waste generated where possible and creating effective recycling approaches. This is particularly important for mixed plastics, textiles and food waste.

ENERGY SUPPLY

The generation of new electrical energy supply in the city produces minimal emissions in Liverpool, but Liverpool's ability to meet its net zero target will ultimately depend on an incoming energy supply system that:

1. Is able to meet much higher demands for electricity; and
2. Has a decarbonised electricity supply feeding into it. This mostly relies on the decarbonisation of the whole of the British electricity system.

Figure 3: Speed of Change Required



Despite Liverpool achieving significant emissions reductions in recent years, there is still a long way to go. Progress to date is commendable but the speed of change must increase to reach net zero by 2030.

This graph is purely illustrative to demonstrate the scale of change required to reach net zero by 2030 vs the average speed of reduction occurring in Liverpool from 2005-2017.

THE PLAN

Four key themes have been analysed:

- Buildings and Heat;
- Power Supply;
- Transport; and
- Waste.

The power supply section considers management of the supply and demand for power in the city. This is largely due to the expectation that grid electricity is likely to be the most abundant and accessible source of low or zero carbon energy within the Plan timeframe.

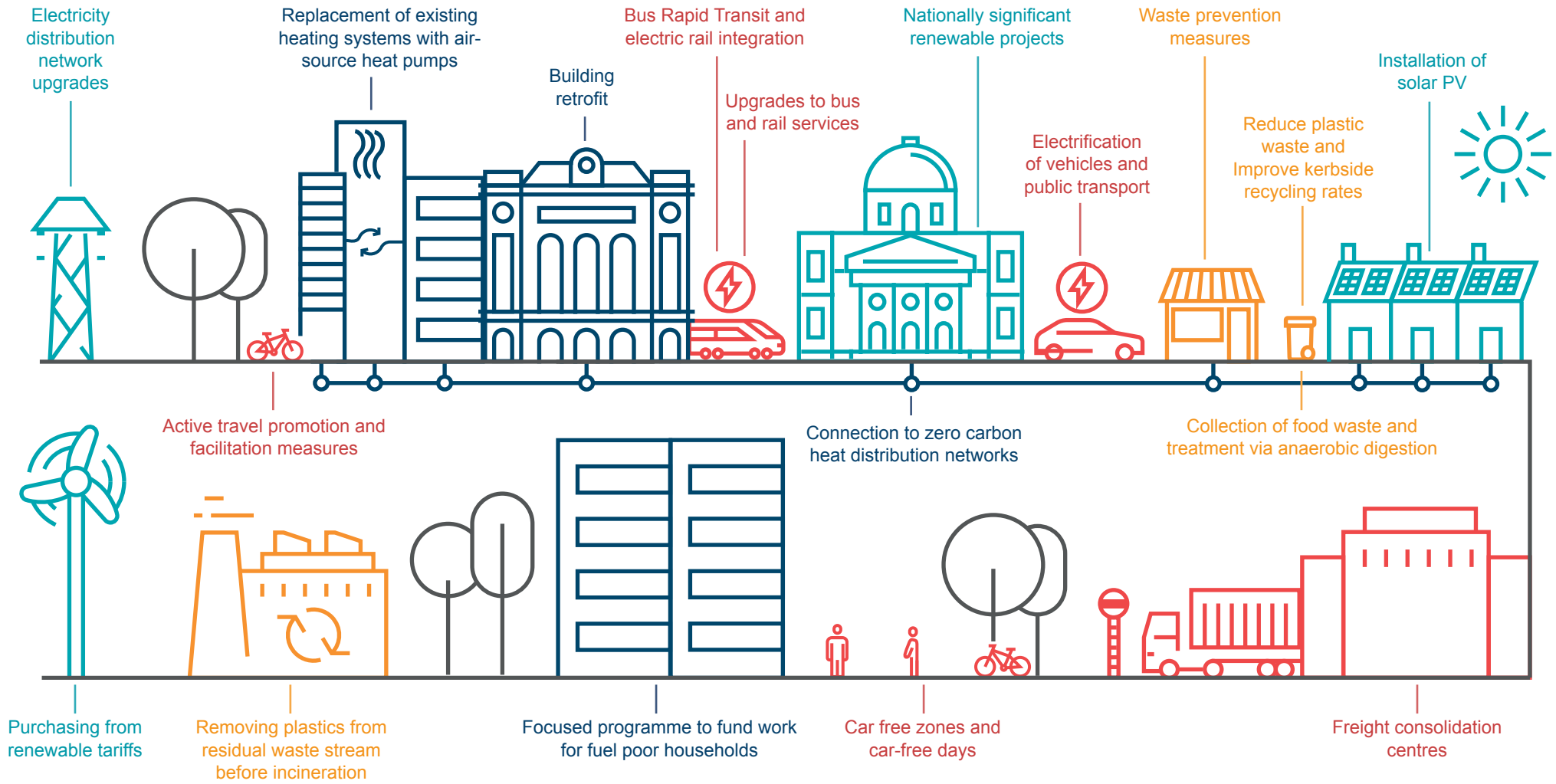
In these sections, the following structure is used:

- **The challenge:** A description of each theme's key challenges to reaching net zero are discussed.
- **Strategic approach:** The key principles for guiding decision-making in the theme are set out.
- **Aims:** This describes what aims need to be met to deliver a successful transition to Net Zero.
- **Solutions:** These are the city-scale solutions that are needed to deliver Net Zero. The potential impacts associated with each solution are also given. These are indicative impacts, demonstrating the scale of reduction each solution could have. The impact numbers are given as examples and the actual percentage impacts will vary depending on multiple factors.
- **Actions:** The actions described here are the specific actions that the Council can take to progress the Net Zero agenda. These are therefore only a relatively small number of the total actions needed as all stakeholders will need to engage to deliver a Net Zero Liverpool.

Three cross-cutting themes have also been analysed in this work and are reviewed in the following sections:

- Green Infrastructure and Carbon Sequestration;
- Low Carbon Economy; and
- City Resilience.

TOP-LEVEL VIEW



Whilst some solutions can be delivered on their own, in many cases it is important to see the opportunity to join them up. This is particularly important when considering significant building and street works. For example, if a neighbourhood undergoes construction for the purpose of heat network installation, active travel infrastructure and green infrastructure can be installed in the same timeframe to reduce both cost and disruption.

SECTOR 1:

BUILDINGS AND HEAT

THE CHALLENGE

The majority of space and water heating demand in the city is met through a combination of natural gas and resistive electrical systems i.e. electric heating, such as storage, convection or infrared heaters. There are approximately 275,000 addresses in Liverpool, in 185,000 buildings. Of these, the residential sector dominates with 180,000 buildings and almost 260,000 addresses. In total, this demand leads to current annual emissions of around 540,000 tonnes of CO2, the majority of which result from the use of gas (Table 1). There are several heat networks existing and under development in Liverpool, most of these currently rely on a gas-fired supply plant and are working to find a decarbonised solution; one has firm plans for a combined air/ground/water source heat pump system.

To reach net zero, almost all of Liverpool's addresses will need to have a decarbonised heating supply. This means replacing the heating systems in almost all of the 275,000 addresses.

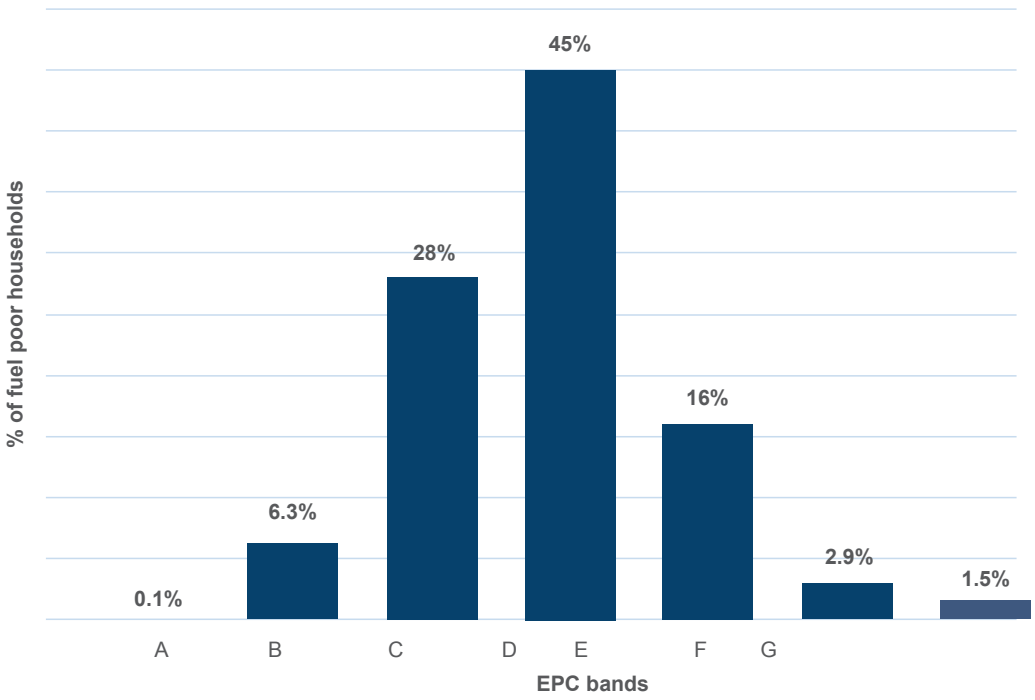
Table 1: Current heating in Liverpool

Sector	Buildings	Heat GWh	-> gas	-> electricity	tCO_2 gas	tCO_2 electricity	tCO_2 total
non-residential	6,085	630	510	120	98,988	21,618	120,606
residential	180,896	2,161	2,128	33	412,890	5,940	418,830
total	186,981	2,792	2,639	153	511,879	27,558	539,437

In addition to decarbonising supply, buildings will need to be made more energy efficient. This will enable use of decarbonised heat sources and reduce the ultimate demand for heat. This is an important component of a cost-effective decarbonisation strategy. Assessment of Liverpool's dwellings indicates that there are likely to be around 226,000 energy efficiency measures (predominantly solid wall insulation and floor insulation) needed across approximately 137,000 residential addresses in Liverpool.

A historic combination of poor-quality housing and low-income households presents particular challenges for Liverpool. Decarbonisation of heating requires investment in low carbon energy systems and in buildings. Investment in energy systems brings a risk of higher heating costs, which could increase fuel poverty if there are no major changes to national Government policies to protect the fuel poor from price increase. This risk needs to be addressed by reducing the amount of energy needed to heat each building. This is met through investment in buildings, an investment that will need a particular focus on lower energy performance dwellings. Fuel-poor households are much more likely to live in these lower-performing dwellings. As shown in Figure 1, 66% of fuel-poor households with an EPC live in dwellings with a rating of D or below. Overall about one in three Liverpool households is likely to be in fuel poverty.

Figure 4: EPC band percentages of total fuel poor households (A is best performing, and total excludes dwellings without an EPC)



STRATEGIC APPROACH

The most abundant source of zero carbon or very low carbon energy by 2030 will be grid electricity. Decarbonisation of the national electricity system is progressing rapidly with the continuing growth in renewable electricity generation. An average unit of electricity supplied in Great Britain now generates lower carbon emissions than a unit of natural gas. As outlined in the energy supply section, this trend in electricity decarbonisation is set to continue towards virtually zero by 2030 or shortly after, depending on the decarbonisation scenario taken into consideration. It therefore makes sense to draw on this source as much as possible, though it does mean that the solutions outlined here are largely dependent on continuing grid decarbonisation.

To address buildings and heat challenges, two principles were identified to guide the Plan.

Strategic Principle	Justification
Least regrets	With a 2030 net zero target, it is not practical to rely on unproven technologies. In addition, priority should be given to approaches which maximise fuel flexibility and minimise the risk of exposure to energy price increases. This 'least regrets' approach will maximise the chance of meeting the target, and minimise potential negative impacts for households and businesses.
Least cost	Decarbonisation may make heating more expensive than it is today. Pursuing the least-cost combination of decarbonisation options will mitigate this as far as possible and is vital to make the transition affordable.

AIMS

The aims that need to be met to decarbonise this sector are:

AIM 1

Reduce demand for space heating

By reducing the amount of energy needed to heat each building, the cost of new systems can be kept as low as possible, and the ongoing running costs can also be kept relatively low. Energy efficient buildings also make it possible to install heat pump systems which are more efficient when they can deliver heat at a lower temperature.

AIM 2

Replace gas heating systems in all buildings

Gas-fired heating systems must all be replaced with a zero-carbon alternative to achieve the required decarbonisation of space and water heating. Consistent with the principles set out above, this must be done in the most cost-effective way possible. In practice this means a mixture of solutions will have to be deployed across the city's buildings.

AIM 3

Mitigate increases in heating costs

Decarbonisation is likely to increase heating costs. The relative impact of this will be different for each household or business. This will have the biggest impact on low-income households and this needs to be addressed if the net zero journey is to be a just transition.

SOLUTIONS

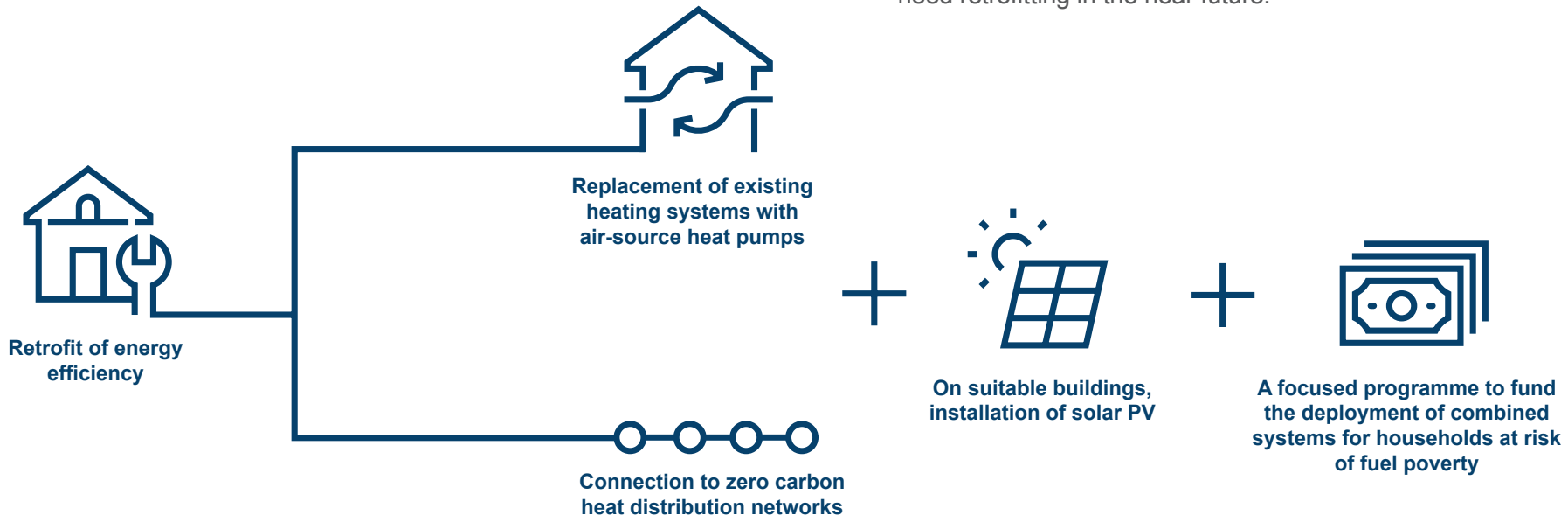
A number of solutions are available to meet these aims. The main solutions and their alignment with the strategic approach are shown in Table 3. Items shaded grey indicate where a solution does not align with the strategic approach.

Table 3: Solutions alignment with strategic approach

Solution	Description	Alignment with strategic approach	
		Least Regrets	Least Cost
Resistive Electric Systems	Electrical heaters such as storage heaters	Established technology	Running costs are four times as expensive as gas. The electricity network will need to be significantly upgraded to cope with demand.
Heat Pumps & Hot Water storage	Use of electricity to power heat pumps which take heat from the air or ground or water	Established technology (now ready to be deployed at scale in UK cities)	With proper insulation, prices will be only slightly higher than for gas (10-20%).
Zero carbon hydrogen	Replace natural gas with hydrogen	Not established technology (though in development). NB blue hydrogen is not zero carbon.	Prices for blue hydrogen likely to be significantly higher than for natural gas until technology matures significantly. Prices for green hydrogen are significantly higher than for natural gas, as stated in the UK Government's Hydrogen Strategy.
Heat networks	A system where many buildings are heated from a central source (e.g. heat pumps, waste heat, hydrogen, water)	The network is long-established technology.	Unit costs can be low due to economies of scale.
Building based PV as input to electrical heating	This provides the input energy from a local source rather than the grid	Established technology	Depending on installation context, can reduce cost of heating.
Demand reduction through insulating buildings	The amount of energy needed to heat a building is reduced through insulating to keep more heat in.	Established technology	Reduces ongoing heating costs regardless of heating source.

Taking into account how each of the solutions aligns with the strategic approach, the following solutions form the foundation of the Plan for buildings and heat:

- **Replacement of existing heating systems with heat pumps.** This needs to be done in combination with demand reduction, hot water storage and appropriately sized radiators. This should be implemented in buildings where this has a lower whole-life cost than connection to a heat network. In the majority of cases these will be air-source heat pumps. In some cases, ground-source systems will be viable, and in a small number of cases water-source heat pumps may be an option.
- **Connection to zero carbon heat distribution networks.** Heat networks enable the use of large-scale waste and environmental zero-carbon heat supply. They can provide an output similar to that provided by a gas combi-boiler. They should be deployed wherever they represent a lower cost solution than individual heat pumps.
- **Retrofit of energy efficiency measures such as insulation of external walls, lofts, roofs, floors, and installation of double-glazing.** Insulation reduces the total amount of energy required. This in itself is beneficial, but it also makes the installation of heat pumps more viable. It plays a large role in a long-term cost-effective solution. It also reduces exposure to future increases in energy costs and lowers the risk of fuel poverty.
- **On suitable buildings, installation of solar PV.** This will reduce the running costs of heat pumps; and
- **A focused programme to fund the deployment of combined systems for households at risk of fuel poverty.** The transition to net zero can only occur if every household is able to make the change, and in the case of many households this will mean dedicated support.
- **Develop carbon neutral and climate resilient new buildings.** This will ensure that new buildings meet high standards of insulation and will not need retrofitting in the near future.



OPPORTUNITIES AND BENEFITS

The steps taken to decarbonise buildings and heat will have broader positive impacts within Liverpool. These will include:

- Health benefits from improved local air quality thanks to the elimination of gas combustion;
- Health benefits from better housing conditions thanks to energy efficiency improvements; and
- Local economic growth in energy efficiency and heat pump supply chains (from the potential to manufacture and supply components to undertaking the installation of measures).

TARGETING THE SOLUTIONS

The two major heating systems in the Plan are heat networks and heat pumps. Detailed analysis of the relative cost-effectiveness of these two systems identifies across the entire city the least-cost option in each building, street and neighbourhood. Figure 5 summarises these findings. The red zones are the areas in which heat networks dominate in the least-cost solution.

Figure 5: Map of the heat network zones

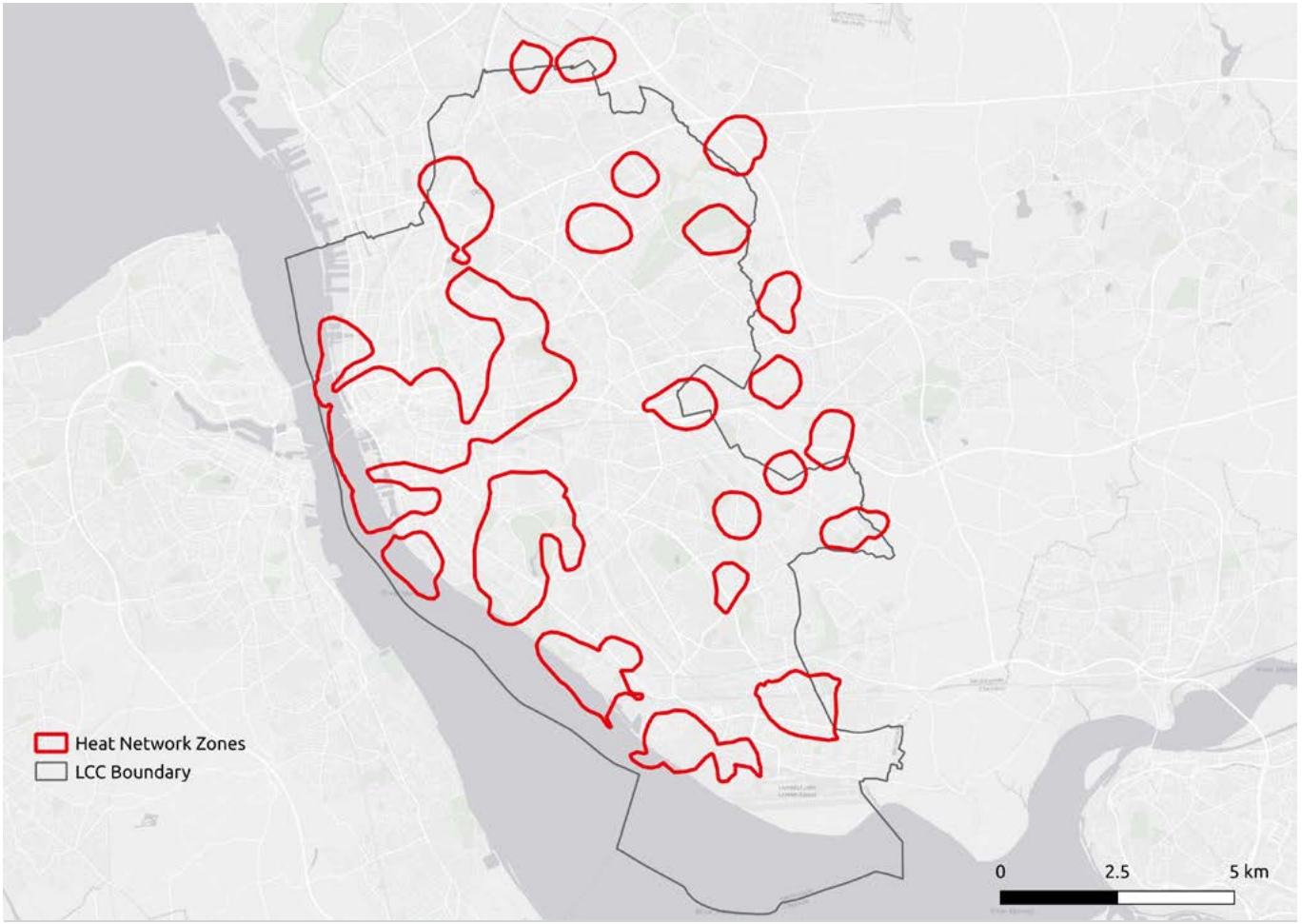


Table 4: Solutions

Solution No.	Solution	Relationship to Aims and Net Zero Target	Conditions for Success	Co-benefits	Potential Impacts
BS01	**Replacement of existing heating systems with air-source heat pumps** Air source heat pumps (ASHP) installed in up to 85% of residential buildings, covering up to 75% of heat demand. Air source heat pumps installed in up to 75% of non-residential buildings, covering up to 70% of heat demand. These figures are based on identifying the least-cost option, where the alternative is connection to a heat network itself supplied from a large-scale air source heat pump. The balance is likely to shift in favour of heat networks when lower-cost zero-carbon network supply options are identified. Note: whilst ASHP were modelled as a solution feasible for most locations, potential for ground source heat pumps (GSHP) in the suburbs and water source heat pumps (WSHP) near water bodies (e.g. along the waterfront) is also expected.	This directly delivers on Aim 2. Heat pumps are a key component of the Plan for eliminating gas as a space and water heating fuel in Liverpool. Efficient electrification of heat means that the associated carbon emissions will fall to zero as the national electricity system decarbonises.	**Commercial:** Current cost differential between installing heat pump and replacing gas boiler significantly reduced, initially through grants or subsidies. Operating cost support for more vulnerable homes. **Supply chain skills:** Significant numbers of qualified installers for heat pumps, principally by retraining and redirecting gas heating engineers and focussing all new training & apprenticeships on new market **Public engagement:** building owners understand need to phase out gas use and access to advice about the alternatives and how they can be funded and installed. Plus they need to have a sense that this is becoming 'normal' across the city, including e.g. acceptance of sound and aesthetics of heat pumps. Energy advice and technical support must be available to enable people to make the most of their new heating system. **Policy and regulation:** clear national policy timetable for phasing out gas boilers to signal future need to change. **Technical:** solutions for zero carbon heating of individual buildings will need to be designed on a building by building basis. Electricity network reinforcement and smart management systems to deal with additional demand and peaks of heat pumps will need to have been undertaken.	Air quality improvements from the elimination of gas combustion.	171.5 $ktCO_2$ per year by 2030, equating to around 35% of heat-related emissions, rising to 229.2 ktCO2/year and a 48.5% reduction in emissions with zero carbon grid electricity by 2033.

Solution No.	Solution	Relationship to Aims and Net Zero Target	Conditions for Success	Co-benefits	Potential Impacts
BS02	Connection to zero carbon heat distribution networks Zero carbon heat networks serve at least 15% of residential buildings, and 25% of non-residential buildings. Share of heat demand is at least 25% of residential sector, and 30% of non-residential sector. These figures are based on large scale air source heat pumps as the heat supply for the networks. The proportions for which heat network is optimal solution are likely to increase, once lower-cost bulk zero-carbon heat supply options are identified.	This directly contributes to Aim 2. Heat networks enable the use of large scale heat resources. In high density areas, and where bulk zero carbon heat supplies are available, they represent a more cost-effective solution than ASHPs, which means they are able to deliver lower cost heat to end users.	**Commercial:** Cost differential largely removed through grants for builder owners installing heat connections (cf replacement gas boiler) and support for capital costs of heat mains installation (as per Heat Networks Delivery Unit (HNDU)). **Policies and regulation:** local powers to require suitable buildings to connect to heat networks plus (national) consumer protections in place to deal with 'lock in' risks with heat network. **Supply chain skills:** requires more heat network design engineers, installation contractors and system operators. **Public engagement:** awareness and buy-in of building owners and residents where heat networks are being proposed/compelled. Energy advice and technical support must be available to enable people to make the most of their new heating system. **Technical:** heat network designs will need to be drawn up, sources of heat assessed and delivery plans put in place and executed. Electricity network reinforcement and smart management systems to deal with additional demand and peaks of heat pumps will need to have been undertaken.	Long term fuel flexibility: heat networks can be supplied from a range of fuels, including hydrogen should it become available at competitive prices. Scale economies mean lower cost heat when deployed in the right areas.	58.1 $ktCO_2$ per year by 2030, equating to around 12.3% of heat-related emissions, rising to 77.7 ktCO2/year and a 16.5% reduction in emissions with zero carbon grid electricity by 2033.

Solution No.	Solution	Relationship to Aims and Net Zero Target	Conditions for Success	Co-benefits	Potential Impacts
BS03	**Retrofit of energy efficiency measures.** Energy efficiency retrofit covering over 90% of buildings, and reducing overall space heat demand by approximately one-third. Modelling suggests that emissions saved through external solid wall insulation (a relatively expensive measure) is cheaper than the cost of heat provided by an air source heat pump, and similar in cost to that provided by heat networks. Lower unit costs can be expected for less expensive measures such as loft and cavity wall insulation.	This directly delivers Aim 1 and facilitates Aims 2 and 3. This solution is essential for the efficient functioning of heat pumps and is a key component in preventing unmanageable increases in heating costs.	**Commercial:** high upfront costs of retrofit measures like solid wall insulation addressed through mix of grants/ subsidies, low cost loans, 'heat as service' offers etc, for all building owners. **Supply chain skills:** building contractors and associated trades trained in the necessary technologies and techniques. **Policy and regulation:** Clear timetable of future requirements for building upgrades Higher targets and spending caps for Minimum Energy Efficiency Standards & strong enforcement locally (backed by BEIS/MHCLG). **Public engagement:** Building owners understand (and have access to advice about) what's involved and costs and funding. Plus they need to have a sense that this is becoming 'normal' across the city.	Health benefits from improved thermal conditions. Reduced exposure to electricity price increases. Reduced running costs.	35% reduction in overall demand for space heating, equating to 165.3 $ktCO_2$ per year by 2030
BS04	Targeted installation of solar PV alongside insulation and heat pumps where all three approaches are technically appropriate in residential buildings with high probability of fuel poverty. Building-level modelling of PV, insulation and heat solutions suggests the following opportunities to combine these measures in households at risk from fuel poverty: • Social housing: 1,500 dwellings, • Privately rented: 9,500 dwellings • Owner occupied: 13,500 dwellings	Addresses Aims 1, 2 and in particular 3. In a typical residential setting, around 30% of annual PV output can be consumed by the heat pump. This improves the economic justification for the solar PV installation, and reduces running costs for the heat pump by reducing electricity imports.	Funding: median cost per residential installation is approximately £4,500 for a median installation size of 3.5kW. Requires support and engagement from residents.	Complementary technology for air source heat pumps, with the potential to reduce running costs through reduced electricity imports, without the need for battery storage.	Reduction in electricity imports of around 1,600 kWh per address per year, with associated carbon emission reductions. This would equate to an annual bill reduction of around £320, meaning that the installation cost would be recovered within approx. 14 years.

ACTION TO DELIVER THE SOLUTIONS

To deliver these solutions a number of actions need to be taken. These will need to be taken by a number of city stakeholders. The actions that follow focus on those that the Council can take and where partners have already indicated they are willing to take action. The technical appendix to this Plan sets out a more detailed action plan relating to these actions. Net zero action cannot be achieved through council action alone.

The actions are provided in three categories:

- **Next step actions:**
  These are actions that can be taken immediately;
- **Preparatory actions:**
  These are actions that can be taken now that pave the way for further actions in the future; and
- **Exploratory actions:**
  These are actions that need to be taken to understand a situation better to enable decisions to be made and future actions determined.

Key Council actions which will contribute towards delivering the solutions include:

Next step actions

- Establish a working partnership with the Registered Providers and the Combined Authority to deliver residential stock improvements;
- Establish a local low carbon retrofit training programme for builders to 'upskill' in complex measures such as solid wall insulation: consult local businesses and organisations skilled and experienced in a 'whole house' approach to retrofitting to develop the local skill base and supply chain required to effectively and sustainably lower heat demand in older housing;
- Ensure every property that still requires loft and/or cavity wall insulation has it installed: Ensure all 'easy wins' in reducing heat demand are exploited through ECO and other sources of funding where needed;
- Identify funding for and establish a local training programme for gas engineers to switch to high quality heat pump / network system design, installation and maintenance: Work with reputable businesses to develop the local skill base and supply chain in net zero heating systems, so they can be delivered at scale; and
- Ensure all Council's new buildings and Council related development are carbon neutral and climate resilient.

Preparatory actions

- Establish a programme for households at risk of fuel poverty to install solar PV and/or insulation alongside a heat pump (Preparatory): Where heat pumps are the least cost heating option, bills and hence fuel poverty can be reduced by combining with solar PV and insulation;
- Produce a zoned heat decarbonisation plan to develop and adopt a zoned approach to rolling out heat networks and heat pumps: This should identify specific strategic heat supply and transmission opportunities, as well as prioritising areas for heat pump rollout; and
- Through planning, prevent the construction of new buildings that will need retrofitting in the near future: Work with central government to call for the transformation of the planning system to deliver carbon neutral and climate resilient new buildings.

Exploratory actions

- Ensure all potential low-cost sources of heat for networks are identified and characterised in terms of cost and technology: Engage with asset owners to develop necessary relationships. This includes e.g., waterways, data centres, industry, mine workings; and
- Ensure that the Local Plan is consistent with, and supportive of, the emerging national Heat Network Zoning proposals.

SECTOR 2:

POWER SUPPLY

THE CHALLENGE

Liverpool's ability to meet its net zero target will ultimately depend on two main factors:

- The ability of the electricity network to deliver much higher demands - The city's electricity demand is likely to increase approximately 130% by 2030 from 2019 levels (Figure 6) as a result of both population growth and, principally, the electrification of heat and vehicles to reach net zero carbon emissions, after which growth in electricity demand should level out. Meeting these new demands will require both a significant upgrade to the electricity distribution network and the widespread use of smart demand management systems across the city. While making these changes, work must be done to ensure the electricity system is also resilient to the impacts of climate change (such as higher summer temperatures, stronger winds and increased risk of flooding).
- The decarbonisation of the electricity supply into this network - This largely relies on the decarbonisation of the whole of the British electricity system. The National Grid has a number of decarbonisation scenarios (Figure 8), the most optimistic of which indicates net zero carbon electricity could be available by 2030 or shortly afterwards, having become almost zero carbon by 2030. Liverpool can play a role in this by realising local opportunities to generate renewable energy through solar PV installations and by supporting the development of offshore wind and tidal power. In addition, every household, business and public building in Liverpool that is powered by genuine 100% renewable energy tariffs will help to support the acceleration of national grid decarbonisation.

Should Liverpool successfully overcome these challenges then, under the National Grid 'Consumer Transformation' scenario (Figure 8), which is the most closely aligned with this Plan, carbon emissions for the city are projected to reach net zero shortly after 2030, when zero carbon grid electricity has become available (Figure 7).

Figure 6 - Projected electricity demand for Liverpool, GWh

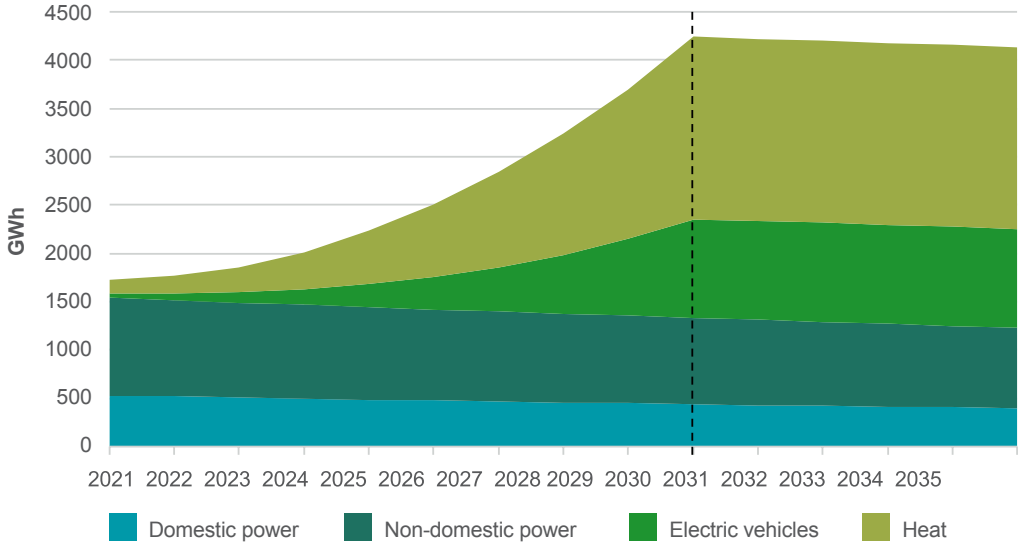


Figure 7 - Carbon emissions projections for Liverpool, kt CO_2e

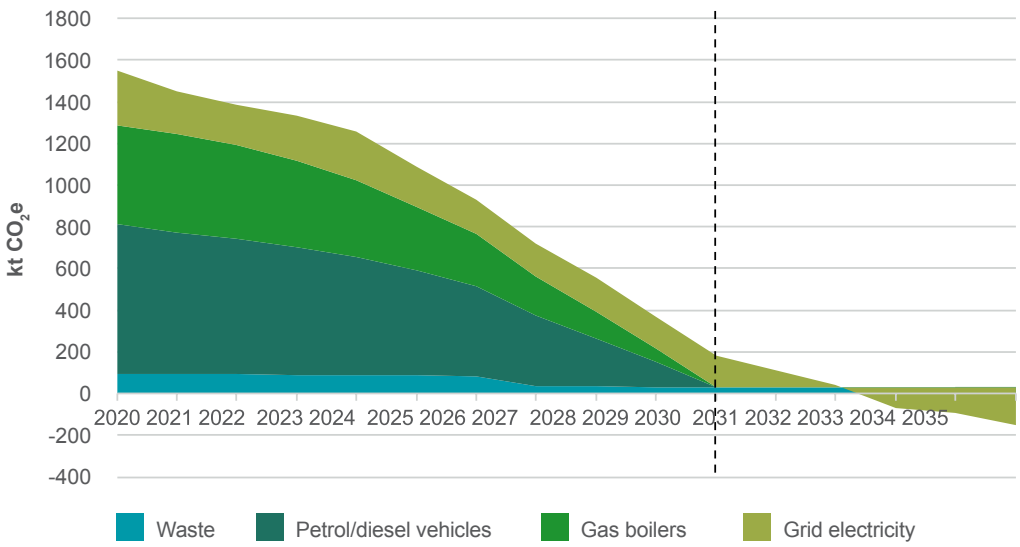
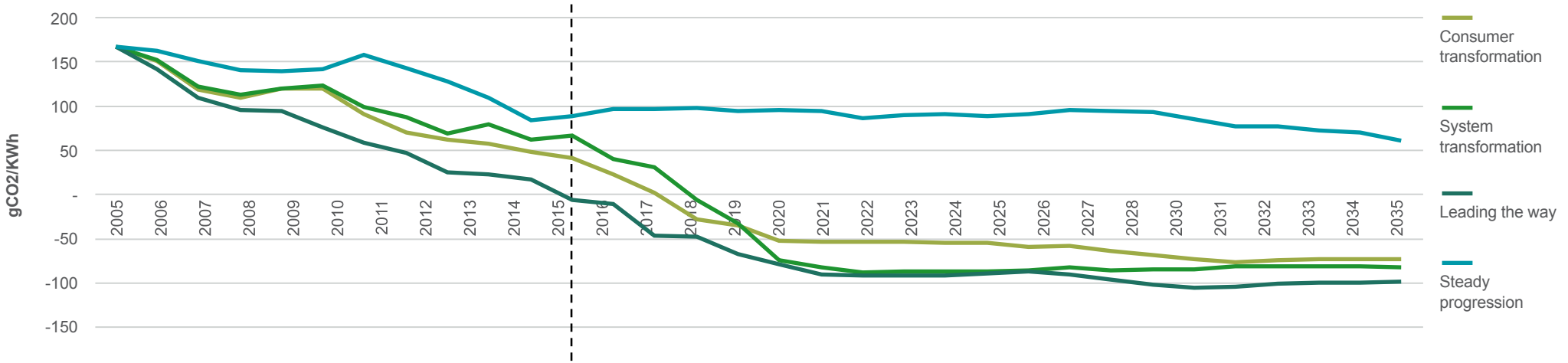


Figure 8 - National Grid carbon intensity scenarios for Great Britain



STRATEGIC APPROACH

To address energy supply challenges, two principles were identified to guide the Plan.

Strategic Principle	Justification
Cross-boundary action	Decarbonising power in Liverpool is directly linked to the decarbonisation of the national electricity grid. Every city has a part to play in ensuring that national targets are met and so Liverpool should seek to do all that it can within its own administrative boundary. Liverpool should also look to influence progress towards net zero targets elsewhere to increase the pace of change at a national level. Such action will also increase the potential for the city to capture a share of the economic benefits associated with grid decarbonisation.
Upgraded, smart, flexible and fair	Rising electricity demand will need to be met in an efficient way. To achieve this it will be necessary to upgrade and modernise the city's electricity network infrastructure and introduce more active demand management through the use of flexibility services and peak reduction initiatives. Support for residents and businesses will be needed in order to enable participation in flexibility schemes to ensure that vulnerable customers in particular do not get left behind.

AIMS

The aims that need to be met to decarbonise this sector are:

AIM 1

Maximise local generation

Become an exemplar urban model for the development of net zero electricity by maximising renewable generation within the city boundary through the development of a city wide solar PV installation programme and supporting the development of nationally significant renewable energy projects in the Liverpool City Region (particularly in the bay – offshore wind and tidal projects).

AIM 2

Limit energy demands

In addition to an acceleration of domestic retrofitting (see Buildings and Heat section), energy demand should be reduced through a continuation of energy efficiency improvements in industry, appliances and lighting.

AIM 3

Increase demand flexibility

Increase electricity storage capacity through commercial-scale battery installations and domestic battery and EV take up, an accelerated smart meter rollout and large scale uptake of smart energy offers such as time-of-use tariffs, peer-to-peer trading and vehicle-to-grid charging tariffs.

AIM 4

Source genuine 100% renewable electricity supply

To underpin the commercial viability of renewable projects wherever they are based, thus accelerating national grid decarbonisation.

SOLUTIONS

The core solutions required by the city to achieve these aims are:

- **Installation of 760MW of solar PV integrated with storage and demand flexibility** - Detailed analysis carried out in support of this Plan estimates that this is the technical potential for installations in Liverpool city, at a cost of around £775 million, assuming electricity generated is valued at 10p/kWh and that only arrays capable of achieving an internal rate of return of 5% are considered deployable.

- **Nationally significant renewable projects** - Developing offshore wind and tidal power in the Liverpool City Region will help the national grid decarbonise, reducing the emissions associated with electricity consumption in Liverpool (as well as elsewhere). Though would not necessarily count towards local decarbonisation targets within the current national accounts.

- **Electricity distribution network upgrades** - The network will need to be able to cope with higher peak loads and so greater capacity needs to be built in to be able to cope with approximately 130% greater demand.

- **Energy efficiency measures** - Ongoing energy efficiency improvements in industry, appliances and lighting will keep the demand for electricity as low as possible, minimise the expansion needed in grid capacity and ongoing running costs and reduce the additional renewable generation capacity required to meet net zero.

- **Roll out of smart meters across the city** - Smart meters provide the data that enables households to participate in flexibility tariffs and services and that is needed for flexible demand management at grid level.

- **Demand Flexibility** - Electricity storage, smart meter data and flexible energy tariffs will enable the electricity network to cost-effectively accommodate the extra demand associated with electrification of heat and transport.

- **Purchasing from renewable tariffs** - By ensuring that every household, business and public building in Liverpool is powered by genuine 100% renewable energy tariffs.

OPPORTUNITIES AND BENEFITS

The steps taken to decarbonise energy supply will have broader positive impacts within Liverpool. These will include:

- Raising the city's profile as being at the forefront of innovation and the fight against climate change;
- Local economic growth in the wind power and tidal sectors, as well as further development of existing strengths in the digital sector through the development of smart products and systems;
- Enabling consumers – both domestic and non-domestic – to participate in in smarter energy offers, securing for themselves the benefits of the shift to a zero carbon electricity system and helping to reduce overall costs of the transition to all consumers; and
- Reducing demand for grid electricity by generating and using PV on site, thus reducing the exposure of participating households and businesses to volatility in wholesale electricity prices.

A note on Hydrogen

HyNet North West is a project that plans to produce 'blue' hydrogen in the region for multiple end uses, including as a replacement for natural gas for heating. The hydrogen is extracted from methane using steam reformation, a process that produces carbon dioxide as a by-product, which means 'blue' hydrogen is not a zero-carbon fuel. While the HyNet project is being deployed and is thought to be capable of scaling up, the first users will likely be large industrial and transport operations and it is not considered that hydrogen could be available for distribution to buildings as heating fuel before the mid-2030s at the earliest. In addition, if deployed for residential properties, it is likely to cost significantly more than natural gas per unit of heat delivered to someone's home. Therefore, while hydrogen may soon be appropriate for other uses (e.g. high-temperature industrial processes, long-range heavy transport and backup power generation), its future as fuel for heating buildings in Liverpool is uncertain and long term, past 2030. As a result, it is considered unlikely that hydrogen will be able to play any significant part in enabling Liverpool to achieve its 2030 net zero target, and it should therefore not delay or stand in the way of efforts to electrify heat and upgrade the electricity network across the city.

Table 6: Solutions

Solution No.	Solution	Relationship to Aims and Net Zero Target	Conditions for success	Co-benefits	Potential impacts
ES01	Install 760MW from 77,714 individual solar PV installations (inclusive of all opportunities with IPP >5%), integrated with storage and demand flexibility	Aim 1 will be addressed by increasing the capacity and generation of renewable energy within the city boundary, maximising the city's own contribution to achieving decarbonisation of the national electricity network.	The solar PV installation sector in Liverpool will have rejuvenated and scaled up in response to the emerging viability for subsidy-free installations. A co-ordinated city-wide approach taken to promoting and realising the opportunities for solar PV across both the domestic and non-domestic markets. The investment case for 'subsidy-free' solar PV will have been established early in 2020 because the price 'floor' available from the Smart Export Guarantee will create confidence in longer-term value of generation. Subsidies and tax breaks for fossil fuels will have been removed. Any planning constraints on PV in conservation areas will have been lifted with a more relaxed approach to installations on listed buildings where not material to heritage value. Increased numbers of solar PV installations will have made it normal and desirable.	Domestic solar PV combined with individual air source heat pumps will reduce peak demands for heat, particularly for hot water in spring to autumn. Domestic solar PV combined with battery storage and/or EVs will reduce peak demand. Reduced energy bills when the electricity generated is used onsite rather, or income generated from exporting to the grid. Solar PV is a highly visible measure that will boost Liverpool's image as a national leader in decarbonisation. Driving cost reduction in solar PV through mass adoption. Job creation in solar PV.	26 kt CO_2 / year by 2030, or 122 kt CO_2 cumulative emissions. Note that savings relative to grid electricity will decline over time, but this measure speeds up progress in decarbonisation and provides other benefits such as local resilience and reducing grid demand.
ES02	Nationally significant renewable projects	To meet Aim 1 Liverpool can maximise its impact on decarbonisation of the national electricity network by working with regional partners on nationally significant renewable energy infrastructure within LCR.	All LAs in LCR and other relevant stakeholders ensure that all available tidal and offshore wind power resources are fully utilised. National support regime for tidal power is sufficient to make commercial development viable.	Multiple nationally significant contributions to decarbonising the electricity network. Job creation in the tidal power and offshore wind power sectors and the development of exportable skills. A boost to Liverpool's credentials as an exemplar city and region for renewable energy and higher value skills and jobs.	Whilst there is scope for significant renewable power generation within Liverpool Bay, the carbon savings cannot be accounted for at city-level.

Solution No.	Solution	Relationship to Aims and Net Zero Target	Conditions for success	Co-benefits	Potential impacts
ES03	Electricity distribution network upgrades	To meet Aim 1 the local electricity distribution network will need to be upgraded to accommodate larger electricity loads to ensure the electrification of heat and transport and the additional PV capacity can be accommodated.	SPEN will have successfully developed and made the case to Ofgem for regulatory support for investment in upgrading Liverpool's network and introducing more active management. SPEN will have recruited and trained sufficient power system engineers to enable accelerated progress towards a 'network for net zero' for Liverpool by 2030. The costs and benefits of the upgrade to the local distribution network will have been shared fairly.	Job creation for power sector engineers. Liverpool would be a pioneer in upgrading the local grid enable electrification of heat and transport, allowing deep cuts to carbon emissions much sooner than could be achieved by waiting for hydrogen to be available for these purposes at scale, which would be 10-15 years later at the earliest.	This would enable the impacts from other solutions such as solar PV and the decarbonisation of heat and transport.
ES04	Energy efficiency	Aim 2 requires energy efficiency to continue improving in industry, appliances and lighting to limit the expected rise energy demand.	Public sector bodies will have used procurement power to drive continuing efficiency improvements in electricity-using equipment and appliances, including IT and, in particular, LED lighting.	A reduction in the amount of renewable energy capacity and storage that would otherwise have been required. Lower energy bills for households and businesses.	14 kt CO_2 cumulative emissions saved in 2020-2030 if recent trends in energy efficiency continue. Additionally, reduced bills and reduced demand from the grid.
ES05	Smart meters	Aim 3 entails having much greater flexibility in energy demand in Liverpool so peaks in demand can be reduced. Smart meters are needed for the data to achieve this and for people to take part in flexible services.	Public acceptance of and engagement with smart meters will be strong enough to enable full deployment. Smart meters will have been installed in all businesses and households in the early 2020s.	Householders and businesses can learn how much energy they are using for heating, appliances and lighting, and make savings to their usage and bills. The more households with smart meters means more people have a chance to keep up with flexibility services and avoid being left behind. The national grid will benefit from high resolution data from smart meters in Liverpool, not just the local network.	Smart meters will facilitate the demand management required to gain the carbon savings from electrifying heat and transport at scale.

Solution No.	Solution	Relationship to Aims and Net Zero Target	Conditions for success	Co-benefits	Potential impacts
ES06	Demand flexibility	Aim 3 requires that energy demand, in particular peak demands, can be managed and reduced effectively through the use of electricity storage, smart meter data and flexible energy tariffs. This will enable the electricity network to accommodate more cost-effectively the extra demand associated with electrification of heat and transport as well supporting national grid balancing to enable higher renewable generation levels.	Granular energy data from smart meters and associated data analytics will be available locally (potentially via SPEN) to drive the development of and participation in demand flexibility services and storage Domestic-scale flexibility and storage services will be developed and available in the market, alongside services for commercial consumers. Consumer protection will have been put in place to cover flexibility services. Households and businesses will have been supported with advice to navigate and engage with the various opportunities to participate in demand flexibility services. Battery storage will have been installed at scale, commercially, domestically and through EVs on flexible charging tariffs.	Householders will find new ways to save on their energy bills and/ or generate income through smart energy services such as time-of-use or vehicle-to-grid charging tariffs, or peer-to-peer trading. Used alongside solar PV battery storage will reduce energy bills. By investing in energy storage and facilitating the rollout of demand flexibility services Liverpool will also be helping the national electricity network to manage demand and decarbonise effectively.	Demand flexibility and storage will facilitate the accommodation by the grid of electrification of heat and transport at scale, in turn facilitating the associated carbon emission reductions. In the SPEN Manweb area by 2030, industrial and commercial peak electricity demand can be reduced by 12%, home EV charging by 28% and ASHP and GSHP by 9% each.
ES07	Renewable tariffs	This supports Aim 4. Liverpool does not have the space to generate all of its own power from renewable resources, so any power imported to Liverpool from the grid should be zero carbon in order to support decarbonisation at a national level.	Starting with all tariffs under council control in Liverpool and moving on to all businesses, public sector bodies and households; they will have, en masse, signed up for genuine 100% renewable electricity tariffs, creating strong demand for additional deployment and underpinning decent prices paid to new renewable generators in a 'post-subsidy' world. People need to understand the difference between a genuine 100% renewable tariff and greenwashed tariffs that claim to be 100% renewable by in fact are not.	Householders, businesses and public sector bodies in Liverpool will contribute to the decarbonisation of the national electricity network. Individuals will have the satisfaction of making a personal contribution to decarbonising the electricity supply.	No direct savings – helps speed up the decarbonisation of the grid.

ACTION TO DELIVER THE SOLUTIONS

To deliver these solutions a number of actions need to be taken. These will need to be taken by a number of city stakeholders. The actions that follow focus on those that the Council can take and where partners have already indicated they are willing to take action. The technical appendix to this Plan sets out a more detailed action plan relating to these actions. Net zero action cannot be achieved through council action alone.

The actions are provided in three categories:

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  These are actions that need to be taken to understand a situation better to enable decisions to be made and future actions determined.

Key Council actions which will contribute towards delivering the solutions include:

Next step actions

- Support installation of nationally significant renewable energy projects in LCR;
- Review public procurement policies; and
- Work with other local authorities to lobby central government for more ambitious policy with consistent long-term goals.

Preparatory actions

- Zoned heat decarbonisation plan with District Network Operator, SPEN;
- Zoned EV charging plan with SPEN;
- Provide information, advice and leadership support to businesses and residents; and
- Identify opportunities to share low carbon skills and experience with other local authorities, City Plan partners and related stakeholders.

Exploratory actions

- Develop large-scale solar PV installation programme; and
- Build on work with SPEN to develop proposals for local demand-side flexibility projects.

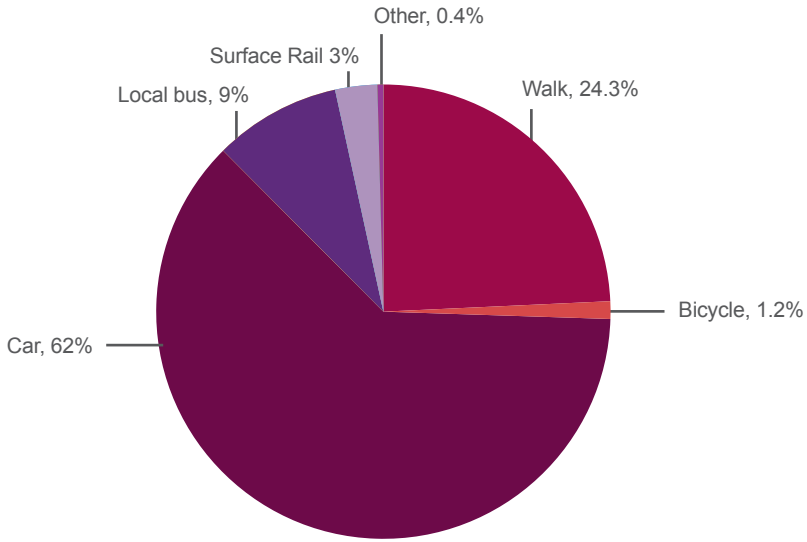
SECTOR 3:

TRANSPORT

THE CHALLENGE

Transport is the second largest contributing sector to carbon emissions in Liverpool, with most of this due to road transport. Overall transport emissions in Liverpool stand at 972,809 tonnes of CO_2 equivalent (tCO_2e). This highlights the importance of addressing the emissions of this sector. This includes emissions from waterborne navigation, rail, aviation, on-road, and off-road transport. When considering only on-road travel emissions, private vehicle transportation is generating approximately 414,958 tCO_2e in Liverpool. Freight emissions are also likely to contribute significantly to Liverpool's transport emissions, though separate freight data is not currently available for Liverpool.

Merseyside trips by percentage of modal share



Liverpool's walking levels are below the national average with walking accounting for 24.3% of trips in Merseyside compared to 26.2% in England

Cycling accounted for 1.2% of trips made in 2019 in the LCR meaning that the average LCR citizen took 9 cycle trips in 2019

Car travel (including taxi) is the most common mode of transport in Merseyside, accounting for 62% of trips. Most local car trips are short distances that could be covered by active travel and public transport.

42% of Liverpool City Region Combined Authority (LCRCA) citizens have stated they "prefer driving" when asked why they drive rather than take the bus.

Merseyrail is used by approximately 34 million passengers a year and passenger demand is predicted to grow by approximately 37% by 2043

- Travel demand data indicates that many Liverpool trips, taken by both Liverpool's citizens as well as commuters arriving from outside of Liverpool, are currently taken by car - addressing this will be key to achieving net zero transport carbon emissions;
- The main challenge for Liverpool's road-based freight transport emissions is ensuring the minimisation of freight transport;
- Until alternative propulsion technologies are developed for air travel and waterborne navigation these modes will be highly dependent on carbon offset schemes. During consultation for the Department for Transport's Decarbonisation Plan in 2020 it was recognised that insufficient research and funding has been committed to air and water transport to currently enable decarbonisation of the sectors;
- Port plug-in technologies could have potential to decarbonise the waterborne navigation sector when this becomes feasible;
- Air travel and waterborne navigation (11.7% and 6.4% of Liverpool's total footprint, respectively) are not included within the scope of this strategy as these are emissions sources that cannot be directly addressed by the city itself, requiring national and international action. However, it was felt important to include them in the emissions footprint to demonstrate the full emissions associated with Liverpool. Emissions associated with travel to ports and airports are, however, included in the plan.

LCR citizens are almost three times as likely to use bus services compared to the rest of England with the average English citizen using their local bus for approximately 3.3% of trips made in 2019 and the average LCR citizen using it for 9% of their trips in 2019

STRATEGIC APPROACH

To address transport challenges, two principles were identified to guide the strategy.

Table 7: Strategic Principles

Strategic Principle	Justification
Efficiency	To make the most of limited national and local resources, it is vital that the city's approach maximises the energy efficiency of transport. Taking a principle of efficiency will maximise the possibility of delivering net zero. In practice the efficiency principle means moving up the travel hierarchy, going from more carbon intensive journeys to less carbon intensive journeys, or fewer journeys.
Accessibility	Accessibility is important as a balance to efficiency. It is vital that citizens have access to important services, workplaces and communities. Ensuring that there is an ability to access these places must also sit at the core of the city's decarbonisation efforts and will in some instances mean that fewer journeys are moved up the travel hierarchy than technically possible.

AIMS

The aims that need to be met to decarbonise this sector are:

AIM 1

Reduce travel demand.

Demand reduction, particularly in the case of car travel, is the first step towards reducing CO_2e emissions from transport. Demand reduction, such as car-sharing, reduces emissions in itself by eliminating unnecessary trips and it also makes the following interventions, modal shift and electrification, easier as fewer trips require intervention. Demand reduction in terms of freight means that there are less freight transport trips taken. There are modes of transport and purposes of travel which would not benefit from demand reduction such as active travel for the purpose of leisure or exercise. Demand reduction in these areas would result in a reduction in health and wellbeing benefits without yielding other benefits. For instance, a demand reduction of 10% in car travel to work could result in a saving of 12,924 tCO_2e per year.

AIM 2

Modal shift – Increase active travel for remaining travel demand.

A modal shift towards active travel and micro-mobility, particularly in the case of trips with a distance under 5 km, allows citizens to travel in less energy consuming ways whilst also achieving co-benefits such as improvements in air quality, health, wellbeing, and social mobility. A modal shift also minimises the need for electrification therefore reducing the burden on the energy grid which results from rapid vehicle electrification. For instance, walking interventions such as widening of pavements could result in a saving of approximately 7,361 tCO_2e per annum.

AIM 3

Modal shift – Increase public transport as the mode for journeys that are not undertaken as active travel.

A modal shift towards public transport similarly minimises the need for electrification whilst reducing pollution. Public transport provisions are essential for those instances in which active travel is not feasible.

AIM 4

Bring emissions from remaining transport modes to as close as possible to 0 $kgCO_2e$ per km through transport electrification and efficiency gains.

The final step in reducing transport CO_2e emissions is making the remaining vehicles as efficient as possible and replacing the remaining combustion engine vehicles with vehicles that utilise alternative propulsion technologies (predominantly, electric vehicles).

SOLUTIONS

The core solutions required by the city to achieve these aims are:

- Demand reduction measures;
- Active travel, micro-mobility and car-sharing promotion and facilitation measures;
- Public transport measures such as upgrades to bus and rail services and potential introduction of Mobility as a Service (MaaS), On Demand Transport, and Bus Rapid Transit;
- Supportive modal shift measures such as reduced motorised private vehicle parking, transition to low-traffic neighbourhoods and car-free days;
- Electrification of vehicles and public transport (and other alternative fuels); and
- Freight consolidation through introduction of consolidation centres and freight delivery and service plans (DSP).

OPPORTUNITIES AND BENEFITS

The steps taken towards low carbon transport will have broader positive impacts within Liverpool. These will include:

- Improving air quality through the reduction of air pollution from combustion engine vehicle trips;
- Making active travel safer due to a reduction in motorised private vehicle trips and introduction of bicycle safety initiatives such as BikeRight and Bikeability;
- Increasing health and mental wellbeing through an increase in active travel; and
- Reducing social inequality through an increase in active travel and public transport – both would allow those that do not have access to a private motorised vehicle to reach places of employment, education, and essential services in an affordable way whilst also tackling social exclusion.

Table 8: Solutions

Solution No.	Solution	Relationship to Aims and Net Zero Target	Conditions for success	Co-benefits	Potential impacts
TRS01	Demand reduction	Contributes to Aim 1. Includes incentives for remote working and sustainable spatial planning. Analysis indicates that remote working has the potential to reduce CO_2e emissions considering that travel to work is the most common purpose for trips made in LCR (travel to work represents 27% of trips) and that it accounts for 33.9% of LCR's car journeys. Sustainable spatial planning enables low-traffic neighbourhoods and contributes to demand reduction by allowing communities to reach everyday essentials near where they live.	• Availability and access to suitable homeworking offices • Dissemination of remote working best practice • Planning policy changes	• Reduces the number of private vehicle trips therefore making the roads safer for those that participate in active travel • Increases in air quality • Reduction in social inequality due to increase in active travel	• A demand reduction in car travel to work of 10% would result in a saving of 12,924 tCO_2e per year. Emissions reduction is proportionately linked to vehicle-kilometres travelled. Therefore, a 10% reduction in vehicle kilometres travelled for work purposes will yield a 10% reduction in transport related emissions.
TRS02	Active travel measures	Contributes to Aim 2 and includes walking and cycling interventions and infrastructure upgrades. Good examples of walking interventions are the recent pedestrianisation of Bold Street (Living without Walls project) as well as the widening of pavements and implementation of shorter pedestrian crossings (in places where full pedestrianisation is decided against). Other recommended initiatives include expansion of Bike Right and Bikeability, Walk to School outreach expansion, implementation of MaaS.	• Citizen engagement • Disincentives for private vehicle use to ensure private vehicle users are prompted to switch to active travel • Following up-to date guidance when designing walking, and particularly cycling, paths in order to develop effective infrastructure as well as access government funding	• Reduces the number of private vehicle trips therefore making the roads safer for those that participate in active travel • Reduction in social inequality • Increases in air quality • Increases in health and wellbeing	• Cycling infrastructure upgrades and interventions, such as expansion of Bike Right and Bikeability, could result in a saving of approximately 3,989 tCO_2e per annum. Walking interventions could result in an average reduction of 7,361 tCO_2e per annum. Emissions reduction is proportionately linked to vehicle-kilometres travelled. Therefore, a 10% modal shift in vehicle kilometres to active travel will yield a 10% reduction in transport related emissions.

Solution No.	Solution	Relationship to Aims and Net Zero Target	Conditions for success	Co-benefits	Potential impacts
TRS03	Public transport measures	Contributes to Aim 3. Includes upgrades to bus services and any necessary upgrades to Merseyrail. The Council can address issues associated with citizens not having access to the rail network by introducing initiatives such as MaaS which uses Merseyrail as the backbone. On Demand Transport may prove successful if implemented again once supportive modal shift measures (see TRS04) are in place to encourage its use. On Demand Transport has been trialled in Liverpool previously by Arriva Click. However, it has not proved sustainable due to low uptake. Bus Rapid Transit (BRT) can be used to provide a comprehensive bus system.	• Making use of Bus Back Better funding availability by publishing an ambitious Bus Service Improvement plan by the end of October 2021 • Supportive modal shift measures to ensure private vehicle users are prompted to switch to public transport where feasible • Considering advice stated in Bus Back Better and the Big Bus Debate • Overcoming opposition from bus operators if bus franchising is chosen as the governance option	• An increase in public transport use may result in a reduction in private vehicle travel therefore making active travel safer and increasing its uptake • Increases in air quality • Increase in health and wellbeing • Reduction in social inequality	A modal shift of 10% from car to bus travel could result in a per annum saving of 38,124 tCO_2e if all combustion engine buses currently operating in Liverpool switched to zero emission vehicles. A modal shift of 10% from car to rail travel could result in a saving of 30,019 per annum. Emissions reduction is proportionately linked to vehicle-kilometres travelled. Therefore, a 10% modal shift in vehicle kilometres to less carbon intensive transportation will yield a reduction in transport related emissions.
TRS04	Supportive modal shift measures	Enables Aims 2 and 3. Includes transition to low-traffic neighbourhoods, car-free days and reduced private vehicle parking.	• Overcoming the challenge of private vehicle user opposition • Engagement with businesses that travel through the area • Overcoming the challenge of Council revenue loss generated by parking pre-intervention	• Increases in air quality • Health and wellbeing • Reduction in social inequality	The listed interventions and the associated potential vehicle traffic reduction of 45% could result in a saving of 288,246 tCO_2e per annum. Emissions reduction is proportionately linked to vehicle-kilometres travelled. Therefore, a 45% reduction in vehicle kilometres travelled will yield a 45% reduction in transport related emissions.

Solution No.	Solution	Relationship to Aims and Net Zero Target	Conditions for success	Co-benefits	Potential impacts
TRS05	Electrification	Contributes to Aim 4. Includes electrification of private vehicles in Liverpool, the public transport network, and Council fleet through vehicle replacement and charge point installation. It is important to consider hydrogen vehicle possibilities for public transport and how they may complement wider public transport electrification.	• Availability of funding (either whole or match funded in collaboration with central government and / or private sector investments) • Citizen and stakeholder engagement • Overcoming challenges associated with the high price point of electric vehicles • Electric vehicle charging grid capacity constraints must be overcome	• Increases in air quality	An electrification of 20% of Liverpool's current combustion engine private vehicles and taxis could result in a saving of 76,249 tCO_2e. An electrification of 50% of Liverpool's current combustion engine private vehicles and taxis could result in a saving of 190,621 tCO_2e per annum. The electrification of vehicles in Liverpool is proportionally linked to a reduction in transport related emissions. The elimination of emissions through the electrification of transport is dependent on the wider decarbonisation of the electric grid
TRS06	Freight consolidation	Contributes to Aim 1 as consolidation and optimisations of freight would reduce the need for freight transport. Includes introduction of consolidation centres and freight delivery and service plans. Introduction of consolidation centres has been observed to reduce road-freight traffic amongst participating retailers by 76%. Implementation of freight delivery and service plans has also been identified as a way to reduce freight emissions.	• The Council likely to have to provide initial funding • Overcoming the challenges of businesses being reluctant to change operating practices and to share facilities with competitors	• A reduction in freight vehicles within the city centre may make active travel safer therefore increasing its uptake	A 10% reduction in the estimated freight emissions would result in a saving of 31,130 tCO_2e per annum.

ACTION TO DELIVER THE SOLUTIONS

To deliver these solutions a number of actions need to be taken. These will need to be taken by a number of city stakeholders. The actions that follow focus on those that the Council can take and where partners have already indicated they are willing to take action. The technical appendix to this Plan sets out a more detailed action plan relating to these actions. Net zero action cannot be achieved through council action alone.

The actions are provided in three categories:

- **Next step actions:**
  These are actions that can be taken immediately;

- **Preparatory actions:**
  These are actions that can be taken now that pave the way for further actions in the future; and

- **Exploratory actions:**
  These are actions that need to be taken to understand a situation better to enable decisions to be made and future actions determined.

Key Council actions which will contribute towards delivering the solutions include:

Next step actions

- Expansion, enhancement and acceleration of Liverpool Cycling and Walking infrastructure Plans (LCWIP);
- Continuation and potential enhancement of Council support for Liverpool schools' Walk to School Outreach programme and School Streets project;
- Continuation with the LCRCA and Sustrans Liveable Neighbourhood programme development: This is a step towards the creation of low traffic neighbourhoods which include reduced private vehicle traffic, but increased active travel and public transport traffic;
- Set up a delivery and servicing plan (DSP) scheme: The setup of a DSP scheme would require and help businesses and organisations to consolidate their freight trips therefore reducing road-based freight emissions within Liverpool. A delivery and servicing plan (DSP) sets out how building occupiers (e.g. businesses and organisations that occupy a building) will enable safe, clean and efficient deliveries to their site.

Preparatory actions

- Support LCRCA's decision making regarding bus network governance options and subsequently make use of Bus Back Better funding availability by publishing an ambitious Bus Service Improvement plan by the end of October 2021;
- Identify parking spaces for removal and plan phase out of parking spaces managed by the Council; and
- Strategic and targeted development of infrastructure for future propulsion technologies: A strategic and targeted development of an EV charging network and hydrogen refuelling stations.

Exploratory actions

- Exploration of ways in which the council could support remote working: Consultation with businesses and organisations, exploration of best practice examples of remote working, and identification of ways in which the Council can support a long-term shift to remote working;
- Working with the LCRCA to assess consolidation centre feasibility and funding opportunities.

SECTOR 4:

WASTE

THE CHALLENGE

Liverpool's household waste that is not recycled is sent to an energy-from-waste facility in Teesside which incinerates the waste, to recover energy, but which also results in the release of GHGs. This is the single largest source of emissions from waste. To meet net zero goals, the primary challenge for household waste is to ensure that the material that continues to be incinerated releases minimal GHGs. This primarily means removing mixed plastics which have a high carbon content, but also ensuring other waste types like textiles and food waste are recycled. This can be achieved by:

- Reducing the amount of waste created in the first instance. By reducing the amount of material needing to be treated in the first instance, the amount of material with high carbon content sent for incineration will be reduced.

- Increasing the proportion of waste that is recycled. Increasing this recycling rate is an effective method for reducing the amount of material that goes to incineration.

The household recycling rate in Liverpool is currently 27% arising from kerbside collection and Household Waste Recycling Centres. For household-like commercial waste this is estimated to be 36%. These are significantly lower than the EU Waste Framework Directive target of 50% by 2020. Whilst the UK has now left the EU, it has published its own commitments on recycling which predominantly match EU targets and has re-affirmed its commitment to achieving a 65% recycling target by 2035. Moving towards such a target will go a long way to reducing emissions to achieve net zero.

The major obstacles to be overcome in increasing household recycling rates include:

- A lack of a food waste collection system means that food waste cannot yet be diverted from incineration;
- Liverpool is a dense urban area, with a high proportion of back-to-back terraces or “hard to reach” properties. These properties are associated with lower recycling rates and will require particular attention to achieve higher recycling rates; and
- Local authorities have only a limited control over packaging design and use which contributes to mixed plastic waste and do not have direct control over many aspects of household waste generation. It is therefore not solely a local authority responsibility.

The major obstacles to increasing levels of commercial waste recycling are:

- The financial incentive for businesses to recycle is not strong enough;
- Waste / recycling services are not a high priority for many businesses;
- Local authorities have only a limited control over the practices of commercial waste collectors; and
- There are difficulties in measuring success as there is a lack of data on commercial waste.

Reducing incineration levels of plastic waste represents the most significant challenge to Liverpool’s waste sector, in addition to other high-carbon waste streams with low levels of recycling such as textiles. Food waste is currently not collected separately from households and represents a significant opportunity for increasing recycling levels. The target of 65% recycling by 2035 will be challenging to meet without collection and treatment of these waste streams.

STRATEGIC APPROACH

To address waste challenges, two principles were identified to guide the Plan.

Table 7: Strategic Principles

Strategic Principle	Justification
Move up the waste hierarchy	Moving up the waste hierarchy, for example by prioritising waste reduction and recycling, leads to the most efficient use of resources and reduces the amounts of materials that need to be treated. It directly links to reduced CO_2e emissions.
Efficiency	As there are limited resources available for improving the Council's waste infrastructure, it is vital that the efficiency of any measures taken should be maximised, from partnership building with other Local Authorities, to ensuring that the necessary preparatory steps are taken in order to achieve the most positive outcome for any measures taken.

AIMS

The aims that need to be met to decarbonise this sector are:

AIM 1

Removing fossil fuel-based waste from the residual waste stream.

Liverpool's GHG emissions from waste largely result from the incineration of plastic packaging, waste textiles and miscellaneous combustibles. To fully decarbonise, Liverpool must completely remove these materials from the residual waste stream - either by preventing it from being generated in the first place or through recycling (including pre-treatment). Otherwise, carbon capture technology at the Teeside incinerator must be used in order to avoid the associated emissions.

AIM 2

Maximise the benefits of energy generation from waste which is compatible with meeting the net zero target.

The incineration of fossil carbon (found in plastic and some textiles) without carbon capture for waste management is not compatible with the climate emergency. However, energy can be recovered from alternative waste streams such as food waste via low carbon methods, such as anaerobic digestion (AD).

SOLUTIONS

The core solutions required by the city to achieve these aims are:

- Waste prevention measures. Reducing the materials sent for treatment directly reduces CO_2e emissions and is one of the most impactful changes that can be made. This is particularly relevant for fossil-fuel based waste;

- Improve kerbside recycling rates. Increasing the amount of material that is recycled starts at the point of collection. Making it easier for material to be collected in a form that can be recycled is a crucial step to increasing recycling rates. Once again this is particularly relevant for fossil-fuel based waste;

- Removing more plastics from residual waste stream before incineration. Even with waste prevention and higher recycling rates, some plastics will enter the residual waste. In the absence of carbon capture technology being used at incineration facilities, removing the plastic waste before incineration is necessary to avoid the associated emissions; and

- Collection of food waste and treatment via anaerobic digestion. The collection of food waste will remove another major portion of waste from incineration whilst also providing low-carbon energy.

OPPORTUNITIES AND BENEFITS

The steps taken to decarbonise waste management will have broader positive impacts within Liverpool. These will include:

- Reduced costs on the Council for waste collection;
- Food waste collection will produce more biogas which could assist in decarbonising the transport and heat sectors that are challenging to decarbonise;
- Further opportunity for financial savings from improved, more efficient recycling systems with greater participation;
- Improved air quality around the Teeside incinerator due to less plastic being burned;
- Potential for behaviour change to prevent food waste as the amount of food waste for each household becomes more apparent to them, leading to cost savings.

Table 10: Solutions

Solution No.	Solution	Relationship to Aims and Net Zero Target	Conditions for success	Co-benefits	Potential impacts
WAS01	Waste prevention measures	Contributes to Aim 1. Waste prevention is the first step towards reducing GHG emissions from waste. Reducing the amount of waste generated reduces emissions by eliminating the waste to begin with.	• Changes in national legislation to allow local authorities to implement Pay As You Throw (PAYT) collection systems will make prevention measures more successful. • The Council will need to make use of levers of influence to change the behaviour of residents. For example, limiting residual waste collection, fines, building relationships with communities who are not participating in recycling.	• Opportunities for local businesses to offer shopping options with reduced plastic packaging (i.e. growth of refill/reuse shops). • Reduced costs on the Council for waste collection.	• Plastic waste prevention can reduce emissions by 3 tonnes CO_2e per tonne of plastic waste. • Food waste prevention can reduce emissions by four tonnes of CO_2e per tonne of food waste prevented. • Textiles waste prevention can save 20 tonnes CO_2e per tonne of waste textiles.
WAS02	Measures to improve kerbside recycling rates	Contributes to Aims 1 and 2. In order to increase recycling rates significantly, food waste must be separately collected and treated and there should be increased collection of recyclable materials such as steel, aluminium, rigid plastics and paper/cardboard.	• The introduction of PAYT schemes is likely to deliver higher kerbside recycling rates more quickly. • The Council will need to make use of levers of influence, for example, limiting residual waste collection, fines, building relationships with communities who are not participating in recycling. • The Council also extends current waste collection services to commercial waste generators, offering a range of recycling services. • Sufficient food waste treatment capacity in the region and an end-use for any biogas produced.	• Improved food waste collection will produce more biogas which could assist in decarbonising the transport and heat sectors that are challenging to decarbonise. • Further opportunity for financial savings from improved, more efficient recycling systems with greater participation.	• Increasing household recycling rate from 27% to 50% could reduce GHG emissions by 7,000 tonnes CO_2e per annum by 2030, or equivalent to a 15% reduction of territorial waste emissions.

Solution No.	Solution	Relationship to Aims and Net Zero Target	Conditions for success	Co-benefits	Potential impacts
WAS03	Removing more plastics from residual waste stream	Contributes to Aim 1. Territorially, the majority of GHG emissions resulting from waste management are from the incineration of plastic in residual waste. Kerbside recycling of less dense plastics is less likely to be cost effective. In the absence of kerbside collections, pre-treatment of household waste to remove plastic film before it goes to incineration is required to reduce emissions.	• Investment in waste pre-treatment facility may be required from National Government. • Partnership working with Merseyside Recycling and Waste Authority (MRWA) to make the additional investment in pre-treatment infrastructure viable.	• The Council can develop its reputation as a leading UK authority in environmental services. • Improved air quality around incinerator due to less plastic being burned. • Increased recycling rates as more material is removed at the pre-treatment facility.	• Removing plastic from the residual waste stream could reduce territorial emissions by approximately 27,000 tonnes CO_2e per annum - equivalent to a 58% reduction in territorial waste emissions.
WAS04	Collection of food waste and treatment via anaerobic digestion	Contributes to Aim 2. If the Council is to meet its recycling targets, the collection and recycling of food waste is vital. Biogas is the product of anaerobic digestion; it can form a low carbon source of energy used for the generation of electricity, heating, or as a transport fuel.	• As with WAS01, PAYT may bring about high recycling rates more quickly. • The Council will need to make use of its existing powers to enhance kerbside collection participation, including ongoing communications campaigns. • Additional collection infrastructure for the collection of food waste (e.g. food waste caddies). • Support for communities where communal bins are the only option as secure, hygienic food waste storage is the biggest challenge in these areas.	• Improved recycling rates. • Potential for low carbon heating and transport fuel. • Potential for behaviour change to prevent food waste as the amount of food waste for each household becomes more apparent to them.	• If the Council were to capture 65% of the food waste produced by residents, this alone could boost recycling rates by 17% and reduce territorial emissions by almost 2,000 tonnes CO_2e by 2030 or approximately 4%.

ACTION TO DELIVER THE SOLUTIONS

To deliver these solutions a number of actions need to be taken. These will need to be taken by a number of city stakeholders. The actions that follow focus on those that the Council can take and where partners have already indicated they are willing to take action. The technical appendix to this Plan sets out a more detailed action plan relating to these actions. Net zero action cannot be achieved through council action alone.

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Key Council actions which will contribute towards delivering the solutions include:

Next step actions

- Develop coalition of Local Authorities to advocate for change at a national government level to gain access to funding for development of pre-treatment facility;
- Communication campaigns to educate public and businesses on waste prevention and recycling;
- Expanding the use of fines on householders not participating in recycling system; and
- Advocate for change at the national level for the introduction of Pay-as-you-throw (PAYT) scheme.

Preparatory actions

- Feasibility study for development of pre-treatment facility, to be considered alongside the potential for applying CCUS to the Teesside EfW facility;
- Assessment of current waste collection and treatment contractual arrangements to understand what aspects need to be amended; and
- Identify strategy for introducing residual waste restrictions.

Exploratory actions

- Exploration of textile recycling initiatives; and
- Assess what options are available for the collection and management of food waste, including the use of any by-products resulting from its treatment, such as biogas.

GREEN INFRASTRUCTURE AND CARBON SEQUESTRATION

WHAT IS GREEN INFRASTRUCTURE, AND WHY DOES IT MATTER?

Liverpool is a green city, with green infrastructure accounting for approximately 62% of the total area of the city. Green infrastructure refers to areas of trees, parks, allotments, gardens and planters. Green infrastructure is important as it provides a number of benefits:

Carbon sequestration

The plants and soils that make up green infrastructure have the ability to take small amounts of carbon dioxide out of the atmosphere and store it.

Flood mitigation

The impacts of serious flooding can be reduced by the effects of vegetation intercepting rain and by soils providing permeable surfaces that water can infiltrate.

Summer cooling

Plants and trees cool the surrounding area through a process called evapotranspiration. Combined with the shading from trees, this can have a significant impact in reducing high temperatures in urban areas, including during summer heatwaves.

Support for biodiversity

Green infrastructure often provides additional habitat and wildlife corridors for insects (including pollinators), birds, mammals and aquatic creatures.

Health & equality

Evidence shows that access to green infrastructure leads to improved physical and mental health through better local air quality and increased opportunities to exercise and spend time outdoors. This can mean a reduced cost to the NHS, especially where new green infrastructure is located to target inequalities in access to green spaces.

Economic activity

Where green infrastructure is present, there are usually increased revenue for businesses and tourism and greater investment in developments due to improved aesthetics and quality of life.

Green infrastructure is very important for Liverpool for all these reasons. It is not just a 'carbon sequestration' tool; in fact, its other benefits are much greater than the potential for removing carbon from the atmosphere.

THE POTENTIAL

Should 10% of the general amenity spaces, public parks and areas of derelict land that are identified in the Green Infrastructure Strategy be planted with broadleaved trees, then by 2030 around 600 additional tonnes of carbon could be sequestered. If this was increased to 20% of this land area, then this could double to 1,200 tonnes of carbon. This compares to Liverpool's current emissions footprint of 2.6 million tCO_2e, indicating that the potential is in the region of 0.02-0.05%. This is a very small proportion of Liverpool's carbon emissions, but given all the additional benefits of green infrastructure, these planting targets should still be pursued.

THE CHALLENGE

Maintaining and expanding the coverage of both green and blue infrastructure entails many co-benefits that make it a no-regrets investment. However, the amount of carbon that can be stored by these systems in Liverpool is relatively small compared to the carbon footprint of its energy generation, buildings, transport, industry and waste. The challenge is to maximise the value of the green infrastructure that is present in Liverpool in light of its benefits for improving health and wellbeing, reducing inequalities and climate change adaptation.

Better use of existing green infrastructure

Within the city, the biggest area of green infrastructure is private gardens, which cover 16% of land area. This area is a major asset for the city, but not easily influenced directly by policy due to being privately owned, and will therefore require coordinated action in terms of public awareness and behavioural changes.

Many of Liverpool's parks and open spaces annually receive Green Flag status to promote their standards of good management and best practice, however their geographical distribution and quality is not consistent across the City. These spaces serve a number of purposes and generate benefits other than carbon sequestration. Therefore, where there is potential for improvements, these should be sought.

Creating new green infrastructure

Creating new green infrastructure would require repurposing land that is currently used in other ways, which could present several challenges, including:

- Issues with land ownership and value;
- Need for political support;
- Housing pressure in high density areas;
- A lack of resources for tree and woodland management; and
- A potential maintenance burden.

SOLUTIONS

Better use of existing green infrastructure

Using existing green infrastructure better is likely to provide the greatest gains due to its high coverage (62%) of the city area. Solutions that will make the most of these areas include:

- Tree and shrub planting on existing green spaces where this is possible without limiting the current uses of the area;
- Increasing connectivity of parks by planting more urban trees and biodiverse corridors;
- Taking opportunities to restore natural watercourses and floodplains; and
- Changing land management practices for larger areas of green infrastructure, for example by choosing mowing schedules that promote vegetation growth or replacing suitable large areas of amenity cut grass with pollinator planting.

Creating new green infrastructure

The creation of new infrastructure can be challenging, but there are number of solutions that could be applied at both small and large scale, including:

- Including sustainable urban drainage systems (SuDS) in new developments or replacing existing drainage schemes with SuDS, where possible;
- Creating new water bodies;
- Designing corridors for wildlife migration;
- Tree and shrub planting in new areas in accordance with the Mersey Forest Plan, for example in streets which have had active travel measures installed; and
- Establishing a tree canopy cover target for the city in line with the Mersey Forest Plan.

ACTIONS

Whilst its potential impact in bringing about carbon emissions savings in Liverpool up to 2030 is relatively small, green infrastructure should be promoted and enhanced considering all its additional benefits for the city and its residents.

To deliver the solutions outlined above, a number of actions need to be taken by a number of city stakeholders. The following key actions focus on those that the Council can take to contribute towards delivering the solutions:

- Update the Green Infrastructure Strategy and reinforce its weight in future decision making, for instance with regards to planning decisions;
- Explore the best approach to inform and incentivise owners of private gardens to maximise the quality of their green spaces;
- Work with neighbouring authorities to explore more ambitious green infrastructure projects in the rural neighbouring areas;
- Integrate considered green and blue infrastructure as a priority in future regeneration and development proposals; and
- Engage with the private sector to promote the use of green walls and roofs on existing and/or new buildings.

LOW-CARBON ECONOMY

A Low-carbon Economy (LCE) is a term for an economy that is based on low carbon energy sources and emits small amounts of greenhouse gases. An LCE is both a challenge and an opportunity for Liverpool. The challenge is that it means making the transition from currently high-emissions activities which will require changes to behaviours, equipment and training). The opportunity is that there are new industries and services growing to deliver the LCE and there is an opportunity to develop these in Liverpool, bringing new high-quality jobs to the area.

Elements of the LCE that are directly relevant to net zero action are:

- Developing the skills and expertise for installing and managing the low carbon technology and infrastructure for transport, buildings and heat, energy supply and waste;
- Developing the ability to manufacture or process specific components or products that are required, for example batteries or heat pumps;
- Developing the expertise to guide and support people and businesses in decision-making and planning for change; and
- Creating the new technologies and services that will underpin future infrastructure and product advances, for example systems or apps that enable real-time energy management, or environmental monitoring.

THE POTENTIAL AND CHALLENGE

In 2017 the UK government anticipated that the LCE would grow by 11% each year up to 2030, much faster than the economy as a whole. This demonstrates the potential for developing new, high-quality jobs in Liverpool that service and deliver the LCE.

Some of these jobs will necessarily replace existing jobs as there is a transition from one technology to another. Others will be new jobs, especially where these jobs are related to industries where Liverpool is a leading player, and these skills are required across the UK or even internationally.

The most recent report prepared for the NetZeroNorthWest Economic prospectus estimates the potential value of a low carbon economy in the North West at £285bn GVA and identifies the unique role for Liverpool and the City Region in the further development of tidal and offshore wind developments. With the potential for 140,000 new jobs in the Liverpool City Region by 2040.

Liverpool as an existing centre of excellence

With the government's 2050 net zero target and associated policies such as the ban on gas boilers in new homes from 2025 and the ban on the sale of new internal combustion engine cars from 2030, the development of the LCE will only continue to accelerate. The more that Liverpool and the broader Liverpool City Region can create expertise in these areas the more jobs will be brought to the city and region.

The Climate Change Committee identifies six key areas of the LCE where there are major opportunities. Liverpool already holds expertise in a number of these, with a particular advantage in those highlighted in bold.

- Energy efficient products
- Energy from waste and biomass
- Low carbon electricity
- Low carbon services
- Low emission vehicles, infrastructure, fuel cells and energy storage
- Other products and services

In "low carbon electricity", Liverpool is a successful hub for offshore wind activity due to the servicing of Burbo Bank for "low emissions vehicles, infrastructure, fuel cells and energy storage", the development of the HyNet North West hydrogen and carbon capture and storage project gives Liverpool a strong edge in what is an emerging area of the Low Carbon Economy. This has been identified as a key priority for the City's work at the City region level.

These are not the only areas for development but serve to show that Liverpool already holds an advantage in some areas which can be built upon.

Developing new City-level action

Taking advantage of the LCE is not just about developing and maintaining expertise in sectors that are of national and international importance, but also about ensuring local services and products are aligned with the net zero ambition of Liverpool. In fact, the development of an LCE within Liverpool is critical to the delivery of net zero as many of the solutions require local skills to deliver.

The net zero plan highlights a number of areas where there is both a need and opportunity to develop skills and jobs to deliver net zero. These are:

Low carbon heating

- Installation of heat pumps
- Design and construction of heat networks
- Building energy efficiency retrofit

Energy supply

- Solar PV installation
- Electricity distribution network upgrades
- Development and adoption of smart energy platforms, smart sensors and professional advisory support to businesses

Transport

- Design and installation of active travel infrastructure
- Design and implementation of alternative low carbon mobility solutions
- Design and installation of electric charging networks

Waste

- Construction and operation of an anaerobic digestion facility
- Construction and operation of additional pre-treatment to remove plastics from incineration

SOLUTIONS AND ACTIONS

To take full advantage of the opportunity, the following pieces need to be accelerated:

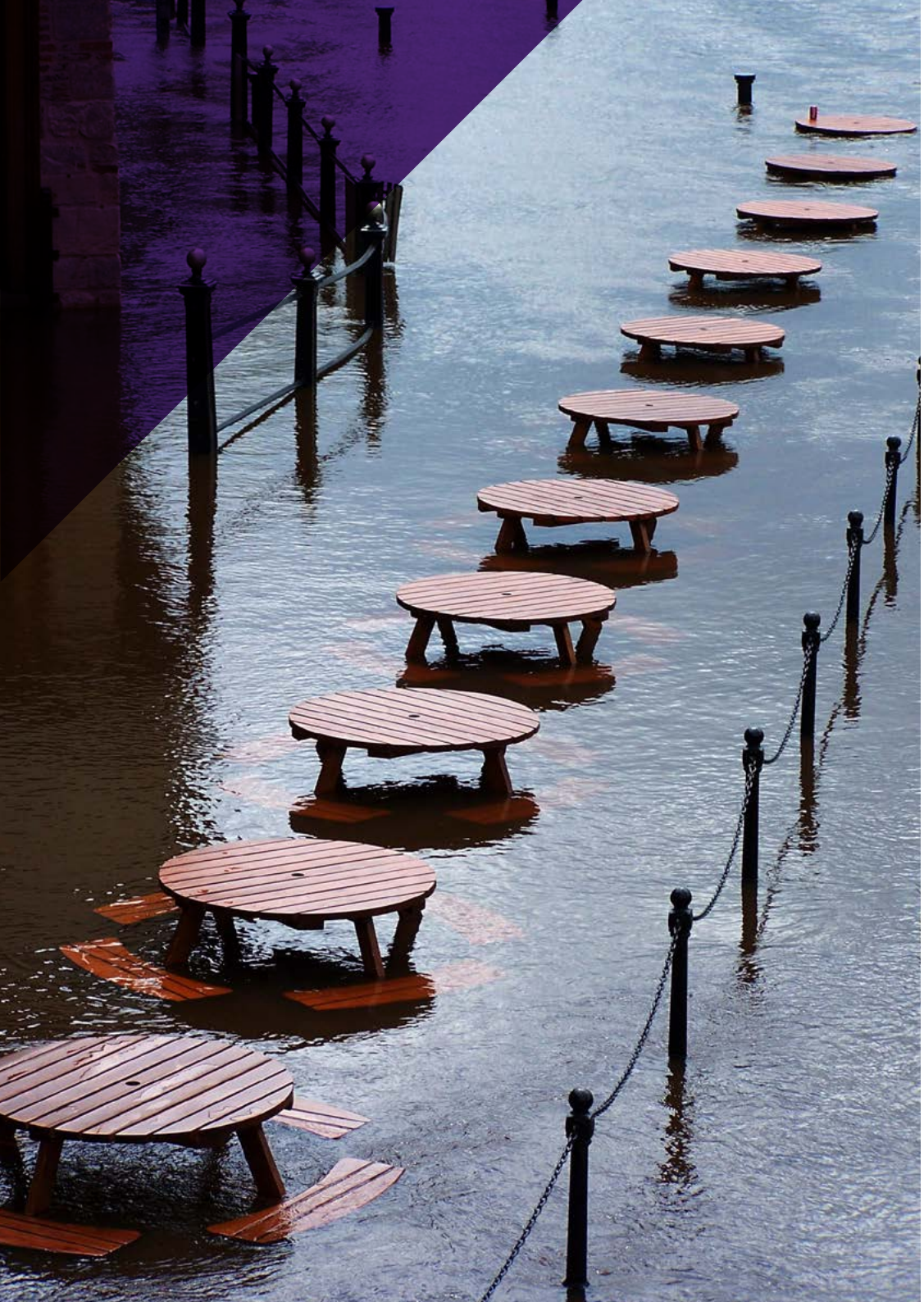
- **Providing high-quality education and training for people so that they are ready to enter in to or develop further in the LCE across all disciplines.** The pace of change in technological development is rapid, and so the education system will need to be able to support people to develop new skills in a responsive and rapid manner. This is true for people entering the job market for the first time, for people retraining, and for people already in the LCE but seeking to, or needing to, develop their skills further. A flexible, highly skilled workforce is one of the major criteria that will be assessed when location decisions are made by investors.

- **Attraction of investment into Liverpool and the Liverpool City Region.** Organisations will invest into the LCE and, in many cases, will have a choice where to locate their investment. Attracting as much of this investment as possible into Liverpool or the Liverpool City Region will contribute to further developing the LCE. This is already the focus of work by organisations such as the CA Growth Platform, the LCRLEP Low Carbon Economy board and the Council's Investment Team.

- **Collaboration between LCE organisations.** One of the most powerful drivers for the LCE is the partnerships that can be forged between different organisations to develop new and innovative solutions. Making space for these partnerships to form can accelerate this process and lead to more rapid innovation. The CA Growth Platform, the LCRLEP Clean Growth Board and the Council inward investment team need to be working more closely together to attract new LCE companies and support supply chain opportunities for existing companies.

- **Entrepreneurship and growth for existing LCE businesses.** Expansion of the existing LCE in Liverpool is a critical piece in the puzzle. Building on the work of the Higher Education Low Carbon Eco-Innovatory and the lessons from the Liverpool Good Business Festival 2021 will enable the delivery of appropriate business support to drive clean growth.

- **Business Decarbonisation.** Support is needed for all businesses to de-carbonise their operations. This should include working with key city economic sectors such as the culture and visitor sector to develop and share best practice and exemplar projects.



CITY RESILIENCE

CLIMATE-RELATED RISKS IN LIVERPOOL

As with the rest of the UK, as climate change continues, Merseyside and Liverpool should expect hotter summers and wetter winters with more frequent and severe flood events arising from increased intensity of rainfall.

The 2020 Merseyside Community Risk Register identifies eight climate-related risks associated with these changes:

- drought
- wildfires
- surface water flooding
- coastal flooding
- river flooding
- low temperature and snow
- heatwave
- storms

However, some of these are more or less relevant to the Liverpool city context. For example, Liverpool city has higher average wind speed than the UK as a whole. A local study carried out by Liverpool University in 2012 identified: storm surges from the Irish sea and high winds, when combined with heavier rainfall, as particular local risks. These are highlighted in the list above. The 2008 City Adaptation Plan also identified the aging subterranean infrastructure across the city to be at particular risk from heavy rainfall flooding events.

BUILDING CITY RESILIENCE

Merseyside Resilience Forum

Liverpool city's risks – including climate-related risks - are assessed and managed as part of the Merseyside Community Risk Register, which is overseen by the Merseyside Resilience Forum.

The National Integrated Review of risk published in March 2021 identified improving the UK's ability to anticipate, prevent, prepare for and respond to risk from extreme weather as a key objective. The Integrated Review calls for the strengthening of the roles of the Local Resilience Forums to help manage this risk. However, it also acknowledges that a whole society approach to resilience is needed.

The third national Climate Change Risk Assessment (CCRA3) is due in 2022 and this will provide an informed basis for Merseyside Resilience Forum to prioritise, plan and prepare for future climate risks in the region.

Particular Challenges

A resilience baseline assessment using the Rockefeller City Resilience Index was trialled by Arup in the city in 2016. The assessment identified areas of city vulnerability (low resilience) including:

- Low levels of local food production
- Low levels of cycling
- High numbers of underinsured households
- High (council) dependence on central government funding and reductions in budget for disaster risk reduction work
- Lack of cross-sector strategic planning to deal with long term city stresses
- Poor condition of sea defences
- Poor systems for communicating with the public

Since 2016 and in particular since the advent of COVID-19, some of these vulnerabilities (such as cross sector strategic planning) may have been addressed whilst others will have been exacerbated. A number of these vulnerabilities relate closely to the solutions and actions in this Net Zero Plan and there are many co-benefits to be achieved, in turn reducing climate risks alongside accelerating carbon reduction measures.

LINKING CITY RESILIENCE TO DECARBONISATION

The Net Zero Plan provides an opportunity to raise awareness of the ability to build city resilience in parallel with taking action to decarbonise the city.

There are some areas of city resilience where benefits can be realised through the actions needed to decarbonise Liverpool city over the next nine years to 2030. These have been identified by using a "resilience lens" to review the full set of actions set out in this plan against the climate-related risks identified in the Merseyside Community Risk Register. The major benefits are focused on:

- **Buildings** – reducing the risks of extreme temperatures and poor air quality through improved insulation and replacement of fossil fuels with air source heat pumps;
- **Energy** – reducing the risk of critical infrastructure failure through increasing solar PV and renewables, managing demand and upgrading the distribution network;
- **Transport** – reducing the risk of poor air quality and critical infrastructure failure through reducing car trips, shifting to active travel and public transport and creating low traffic neighbourhoods;
- **Green Infrastructure** – there are significant resilience benefits to be gained through increased provision of green infrastructure, in particular resilience to heating and flooding events; and
- **Low carbon Economy** This Net Zero Carbon Plan will also contribute to greater economic resilience – in particular by creating new jobs in the domestic housing retrofit and renewable energy supply chains, and tackling fuel poverty.

There are two notable ways that resilience and net zero carbon do not align well:

1. Electricity demand will be driven up by the rapid transition from the internal combustion engine to electric vehicles, and gas boilers to heat pumps; and
2. There will be increased energy demand from air-conditioning for houses due to increasingly frequent heat waves.

These can be mitigated through intentional counteractions such as managing the public realm to encourage people to walk or cycle in preference to driving an electric vehicle, but these will require support from across the city and appropriate financing.

CREATING A SHARED PLAN FOR A RESILIENT CITY

There are many opportunities to increase city resilience by working through existing structures. In combination these opportunities provide the basis for shared actions to ensure that by 2030 Liverpool is a resilient net zero carbon city. The most important actions for the Council are around accelerating existing partnership working with the Combined Authority to:

- **Retrofit buildings for thermal efficiency**
  - Develop local and regional renewable energy sources; and
  - Promote active travel to reduce private car trips in the region.

- **Use the risk register procedures in the council to fit embed action into every officer's business as usual reporting.**

- **Review medium term financial planning to ensure net zero carbon and city resilience priorities in relation to buildings, energy and transport are reflected.**

- **Ensure that lessons learnt from COVID-19 recovery priorities and effective public engagement, are captured and built upon.**

This report has given a high-level summary of the analysis carried out to support Liverpool's route to NZC30. Further detail can be found in the technical appendices which will be made available at https://liverpool.gov.uk/communities-and-safety/action-on-climate-change/.

Technical appendices are available for:

- Buildings and Heat
- Power Supply
- Transport
- Waste
- Green Infrastructure and Carbon Sequestration
- City Resilience

Public and stakeholder engagement events will run throughout 2022 and there is also an email link available on the web site for you to make comments.

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GLOSSARY

Adaptation	Actions to reduce vulnerability to climate change impacts, reducing its effects on social, economic and natural systems
Anaerobic digestion	The process by which organic matter is broken down to produce biogas and bio-fertiliser. This process happens in the absence of oxygen in a sealed, oxygen-free tank called an anaerobic digester
BEIS	UK government department of Business, Energy and Industrial Strategy
Biodiversity	The variety of animal and plant life on Earth
Bus Rapid Transit	A bus service using dedicate lanes and ensuring more frequent and punctual services
Business as usual	Future emissions trend if the current state of affairs continue as they are today
Carbon dioxide (CO2)	A key greenhouse gas with a long-lifetime in the atmosphere and both natural and human sources.
Carbon neutral	Having no net release of carbon dioxide into the atmosphere
Carbon sequestration	A natural or artificial process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form
Carbon offsetting	Practices and technologies to neutralise remaining emissions that cannot be removed entirely.
CCUS	Carbon capture, utilisation and storage
Climate change mitigation	Efforts to reduce or prevent emission of greenhouse gases
Climate change	The long-term change of climate, typically measured over decades or longer. This is different to weather, which is now
Climate emergency	Climate change presents the greatest threat to life: on the economy, social well-being and the natural environment
CO_2e	Carbon dioxide equivalence; this includes all greenhouse gasses converted into the equivalent amount of carbon dioxide.
Co-benefits	The positive benefits related to the reduction of greenhouse gases
Decarbonisation	The reduction of carbon dioxide emissions through the use of low carbon power sources, achieving a lower output of greenhouse gasses into the atmosphere
Delivery and servicing plan (DSP)	Sets out how building occupiers (e.g. businesses and organisations that occupy a building) will enable safe, clean and efficient deliveries to their site.
Electricity distribution network	Electricity distribution networks deliver electricity from the high voltage transmission grid to industrial, commercial and domestic users
Energy-from-Waste (EfW)	The process of generating energy in the form of electricity and/or heat from the primary treatment of waste, or the processing of waste into a fuel source

EU	European Union
GHG Protocol	Supplies the world's most widely used greenhouse gas accounting standards
Greenhouse gas (GHG)	The Earth can maintain a regular average temperature (about 15°C) despite heat leaving the planet's surface because a layer of gases in the atmosphere absorb and release heat – a process known as the greenhouse effect. Greenhouse gases are those that have this effect, each with differing lifetimes and abilities to capture heat (infrared radiation).
Heat Distribution Network	A distribution system of insulated pipes that takes heat from a central source and delivers it to a number of domestic or non-domestic buildings
Household Waste Recycling Centre	A place provided by a local authority where residents in its area may deposit their household waste
Liverpool	This refers to the geographical area for which Liverpool City Council is responsible
Liverpool City Region (LCR)	This refers to the Mayoral Combined Authority and its constituent Local Authorities
Mobility as a Service (MaaS)	Allows users to view all available mobility services within their vicinity (active travel, public transport, taxi etc.) within an app and plan their journey accordingly
NZC30	This refers to Net Zero Carbon City 2030
On Demand Transport	Form of shared transport where the travel routes are altered based on transport demand
Pay As You Throw (PAYT)	A usage-pricing model for disposing of municipal solid waste. Users are charged a rate based on how much waste they present for collection to the municipality or local authority
Resilience	The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions
Resistive electrical systems	Electric heating, such as storage, convection or infrared heaters
Scope 1 Emissions	Greenhouse gas emissions from using owned or controlled sources (mainly energy related)
Scope 2 Emissions	Greenhouse gas emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling
Scope 3 Emissions	All other greenhouse gas emissions that occur as a result of activities taking place within wider operations, supply chains, investments etc
Smart demand management systems	Innovative technology that lets you automate when major appliances run during on-peak hours to make sure they don't run at the same time
Solar PV	Solar Photovoltaic
Sustainable Urban Drainage Systems (SuDS)	SuDS are designed to both manage the flood and pollution risks resulting from urban runoff and to contribute wherever possible to environmental enhancement and place making
tCO_2	Tonne of carbon dioxide
The Council	This refers to Liverpool City Council

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