Dundee City Council

Local Area Energy Plan

Supported by Scottish & Southern Electricity Networks

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Document verification

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		Name	Meg Wilks Signe Swarttouw Francesca Gentle-Shepherd	Stuart Hallett	Andy Mace
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		Name	Meg Wilks Signe Swarttouw Francesca Gentle-Shepherd	Stuart Hallett	Andy Mace
		Signature			

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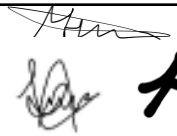
		Name	Meg Wilks Signe Swarttouw Francesca Gentle-Shepherd	Stuart Hallett	Andy Mace
		Signature			
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		Name	Signe Swarttouw	Stuart Hallett	Andy Mace
		Signature			

Contents

ARUP

This Plan was prepared by Arup on behalf of Dundee City Council and Scottish & Southern Electricity Networks

Executive summary

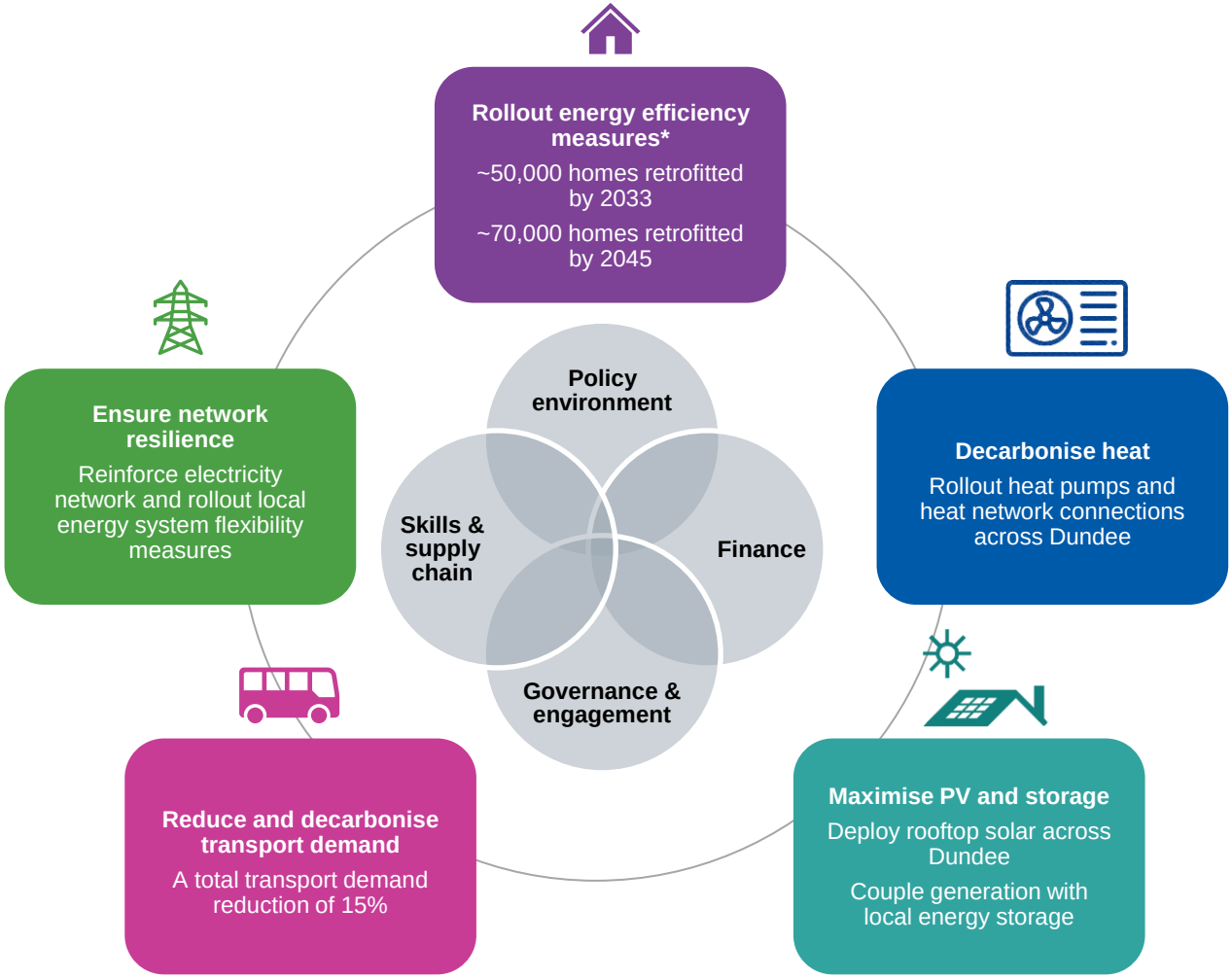
Overview

This Local Area Energy Plan (LAEP) sets out a vision of what a net zero carbon energy system could look like for Dundee and describes priority interventions and recommendations for actions that will support the City in delivering its 2045 net zero target.

Dundee's vision for a future energy system is:

Dundee will be Scotland's pioneering net zero city, establishing an energy system that drives innovation while ensuring accessible and affordable clean energy for all.

To develop this plan, whole systems modelling across heat, electricity and transport was conducted to test various scenarios for the radical transformation necessary to decarbonise Dundee's local energy system fully. Numerous decarbonisation pathways were analysed to identify opportunities and constraints. While the results of this analysis should not be interpreted as an exact prediction for the city's future, they have supported the identification of priority intervention themes for the local energy system. This plan sets out key recommended actions for the initial phases of implementation. Continued support from a wide range of stakeholders and partners will be crucial to deliver this ambitious plan successfully.



**To meet regulatory standards, 50,000 homes need retrofitting by 2033. By 2045, retrofitting an additional 20,000 homes could further increase the energy efficiency of the building stock.*

Figure 0.1: LAEP priority intervention themes

Executive summary

Pathways to net zero

As Scotland's fourth largest city, Dundee predominantly comprises urban areas with a high density of buildings. These urban areas contain a high proportion of flats and tenement buildings, and the availability of land for new or additional low carbon energy generation infrastructure is limited. These characteristics present distinct opportunities, challenges, and uncertainties for delivering a net zero energy system in the city.

This LAEP attempts to present these factors through the exploration of a series of potential pathways for the city's energy transition, examining how Dundee's energy system and emissions could change between now and 2045. These pathways are presented in Figure 0.2. The potential for reducing emissions, the social impact, and deliverability of these pathways have been assessed together with local energy system stakeholders, and an action plan for Dundee's energy transition has been developed.

The LAEP process has determined that the current, 'Business as Usual' pathway will not deliver the Council's vision for net zero, given its remaining impact on cumulative and residual emissions. The analysis has also shown that existing legislation is not sufficient to drive change. Even if the public sector leads by example and decarbonises its own assets, Dundee still depends heavily on private sector initiatives and investments, and government funding, to deliver truly noticeable change.

The LAEP suggests a pathway which leverages the area's unique opportunities for decarbonisation. This includes whole building retrofit to minimise energy use and heat networks to supply low carbon heat to buildings where it is most cost-effective.

Drastic reductions in transport emissions should be enabled through improvements to public transport, smart spatial planning to reduce travel distances, and enabling an uptake in EVs and active travel modes.

The local energy system will be supported by the installation of rooftop photovoltaics on buildings, supported by batteries and other flexibility measures to balance local supply and demand. This reduces pressure on local energy networks, making the whole system more resilient to change while aligning with net zero.

The full decarbonisation of Dundee's energy system will rely on the transition of the wider electricity grid. The delivery of the priorities set out in this LAEP should be coupled with supporting the decarbonisation of Scotland's wider energy supply. The new role of the Regional Energy Strategic Planner (RESP) will support the delivery of local energy plans and ensure alignment with national strategic planning by the National Energy System Operator (NESO).

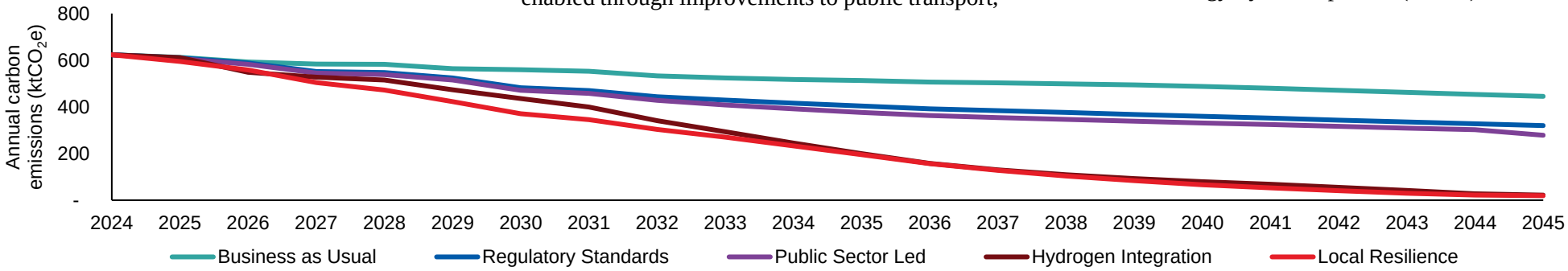


Figure 0.2: Carbon emission pathways

Glossary
Terms and acronyms

Table 0.1: Table of terms and acronyms

Term or acronym	Definition or meaning	Term or acronym	Definition or meaning
ASHP	Air source heat pumps	LAEP	Local Area Energy Plan
BaU	Business as Usual	LENZA	Local Energy Net Zero Accelerator
BECCS	Bioenergy with Carbon Capture and Storage	LHEES	Local Heat and Energy Efficiency Strategy
CO_2	Carbon dioxide	LDP	Local Development Plan
COSLA	Convention of Scottish Local Authorities	LPG	Liquefied Petroleum Gas
The Council	Dundee City Council	MSIP	Michelin Scotland Innovation Parc
DNO	Distribution Network Operator	MWe	Megawatt (electrical power)
EfW	Energy from Waste	MWth	Megawatt (thermal power)
EPC	Energy Performance Certificate	PSL	Public Sector Led
EST	Energy Saving Trust	PV	Photovoltaics
EV	Electric Vehicle	RESOP	Regional Energy System Optimisation and Planning
GSP	Grid Supply Points	RS	Regulatory Standards
GDN	Gas Distribution Network	SGN	Scotland Gas Networks
HES	Home Energy Scotland	SIMD	Scottish Index of Multiple Deprivation
HGV	Heavy Goods Vehicle	SSEN	Scottish and Southern Electricity Networks
HiB	Heat in Buildings Strategy	Tactran	Tayside and Central Scotland Transport Partnership
HNA	Heat Networks Act	TOUTS	Time-of-use-tariffs
ICE	Internal Combustion Engines	UK	United Kingdom

Chapter 1: Introduction

1. Introduction
Overview

Overview

Introduction

In June 2019, Dundee City Council (the Council) declared its support for the Scottish and UK Parliaments' declaration of a climate emergency. In 2019, the Council published its citywide Climate Action Plan, which set out initial actions required to transition Dundee to net zero carbon emissions by 2045. The Council has already established itself as a leading organisation in enabling the transition to electrified transport, and Dundee is well underway in becoming a city that plays a pioneering role in achieving net zero by 2045.

The Council and the Dundee Climate Leadership Group (DCLG) recognise the necessity to take an interdisciplinary approach to support the energy transition in the context of global, national and local climate trends, and are taking measured actions through the development of a Local Area Energy Plan (LAEP) for Dundee.

This plan not only contributes to the planning for decarbonising Dundee, but also contributes to wider local net zero energy planning efforts for local authorities across Scotland and the UK. This LAEP was produced alongside the development of a Local Heat and Energy Efficiency Strategy (LHEES) for Dundee and draws on findings and analysis outcomes from the development of the LHEES.

What is RESOP?

Dundee's LAEP was produced as part of SSEN's Regional Energy System Optimisation and Planning (RESOP) project. The project aims to consolidate data about energy systems components into SSEN's Local Energy Net Zero Accelerator (LENZA) tool, which will be used to facilitate collaboration between Distribution Network Operators (DNOs), local authorities and other stakeholders to take targeted and considered action. By modelling the outcome of future scenarios and considering the whole energy system, the LAEP provides evidence-based scenarios and recommendations to transition Dundee to a net zero city.

What is a LAEP?

A LAEP provides an understanding of the nature, scale, rate, and timings of changes needed for the transition to a net zero energy system within a defined area, such as a city.

The LAEP process takes a whole energy systems approach, considering the complex interdependencies of different energy vectors from generation through to demand. Following Ofgem's methodology, the LAEP process combines robust technical analysis with comprehensive stakeholder engagement to create a routemap for delivering decarbonisation as effectively as possible, identifying actions required by groups including local and national government, energy providers, regulators, and residents.

The process to develop a LAEP aims to account for the local and national wider conditions to achieve net zero, considering how cooperation with adjacent areas can help to bring success to decarbonising the wider area.

A LAEP also aims to facilitate increased local stakeholder awareness, resulting in more widespread and meaningful consent for the changes required and credible commitments to deliver the plan.

Stakeholder engagement in Dundee

Dundee's LAEP has been developed through active involvement with various stakeholders in the local energy system. These include DNOs, Gas Distributions Networks (GDNs), housing providers and associations, charities and non-profits focused on energy issues, energy providers, NHS Tayside, and local cultural and educational institutions. Engaging with stakeholders is crucial to secure support from diverse perspectives and foster collaboration as we progress towards a more localised and interconnected energy system, where energy generation, storage and distribution happens closer to the end-user and more flexibly matches local supply and demand conditions.

1. Introduction
LHEES and LAEP

A joined-up approach

This LAEP has been produced alongside Dundee's LHEES. As a statutory requirement for all local authorities in Scotland, Dundee's LHEES, published in 2024 sets out a strategy and delivery plan for reducing building emissions and addressing fuel poverty. The LHEES identifies opportunities for energy efficiency improvements, heat decarbonisation and priority areas suited for developing heat networks across Dundee. Data collection and analysis was conducted at building level, providing insights sufficient to support planning for energy interventions at a granular level.

The relationship between the LHEES and LAEP is integral, as shown in Figure 1.1. This LAEP has directly incorporated LHEES outputs into whole systems energy modelling and has captured non-LHEES components like power and transport, energy distribution systems and storage. This supports an understanding of how the granular insights provided though the LHEES impacts the broader energy system and its transition to net zero. The linkage enables optimised, integrated planning and decisions across the system of energy components that must evolve and transition in a coordinated pathway to decarbonisation.

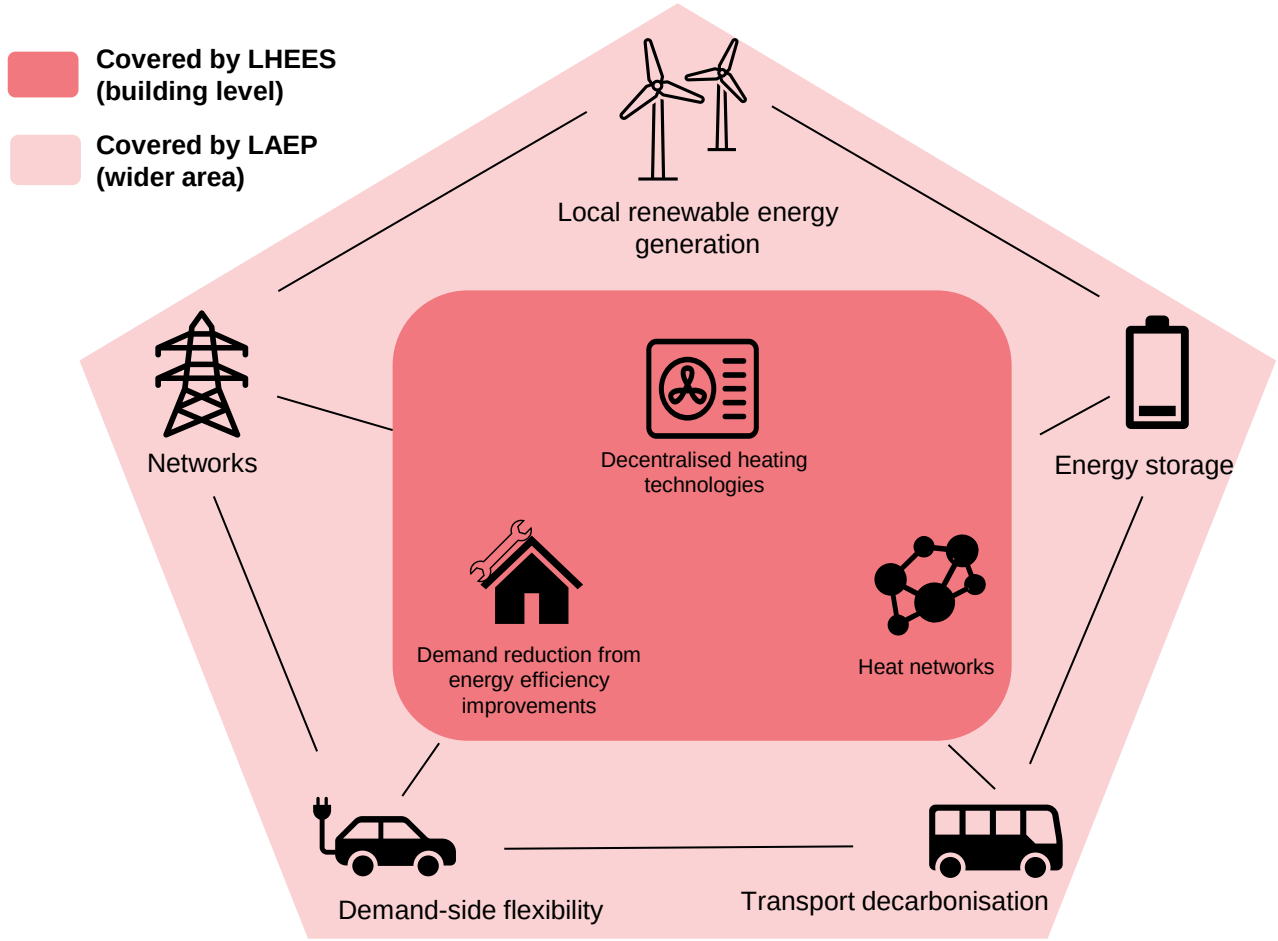


Figure 1.1: Relationship between the LHEES and LAEP

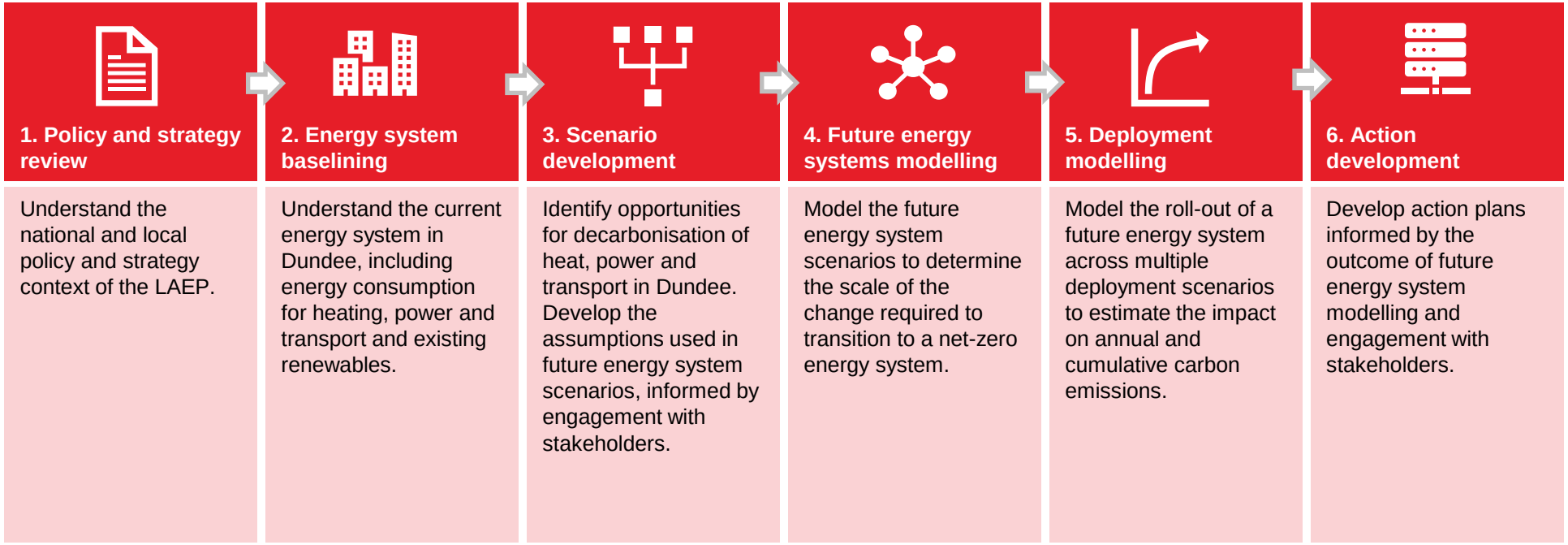
1. Introduction
LAEP Process

LAEP process

This LAEP presents the vision for a net zero local energy system in Dundee, with a routemap to get there, including a set of actions for the Council and the DCLG, whilst also recognising the role of other key actors in government, the energy sector and across the community.

To produce the results presented in this LAEP and inform the vision for a net zero energy system, the process shown in Figure 1.2 was followed.

Figure 1.2: LAEP process flowchart



1. Introduction
Plan contents

Plan contents

The document has been separated into four sections. A description of the content presented in each section and how they relate to each step of the LAEP process (as shown on page 11) is summarised in Table 1.1.

Table 1.1: LAEP section description

Section	Content	LAEP Process step
2. Context and baseline	• Description of Dundee's existing energy system, and a summary of relevant policies and strategies.	1. Energy system baselining 2. Policy and strategy review
3. The future energy system	• Description of technology options for a net zero local energy system. • Presentation of four energy system scenarios tested in this LAEP. • Presentation of modelling results for each scenario, including annual energy flows, heating technologies and the impact on electricity demand requirements. • Presentation of five scenarios for deploying a net zero local energy system. • Presentation of modelling results for each deployment scenario, including the impact on annual and cumulative carbon emissions.	3. Scenario development 4. Optimisation modelling 5. Deployment modelling
4. Priority intervention themes	• Description of five priority intervention themes to deliver a net zero energy system in Dundee. • Presentation of the scale of change required and the area-based priorities identified for each theme. • Description of the wider benefits of transitioning to a net zero energy system.	6. Action development
5. Actions and recommendations	• Presentation of high-level routemap and identified enablers to deliver a net zero local energy system in Dundee. • Presentation of ten overarching actions, including enabling actions and medium-term routemaps.	6. Action development

Chapter 2: Context and baseline

2. Context and baseline
The local area

Socioeconomic context of LAEP area

Dundee is located in central Scotland, covers an area of approximately 60 km^2 and is the fourth largest city in Scotland. Key employment sectors include education, tourism and digital technology and life sciences. Dundee has a significant student population and is home to the University of Dundee, Abertay University and Dundee & Angus College.

Demographics

Population: The estimated population in 2021 was 147,720 which accounts for almost 3% of the population of Scotland.[1] In 2021, Dundee had the 14th highest population out of the 32 council areas in Scotland. The population density is ~2400 people per km^2, significantly higher than Scotland overall, which has a population density of 70 people per km^2.

Ethnicity: At the time of the 2022 census, the largest ethnic group in Dundee was White (89.9%), followed by Asian, Asian Scottish or Asian British (5.9%) and mixed or multiple ethnic group (1.3%). Other ethnic groups make up 2.9% of the population.[2]

Deprivation: Based on the Scottish Index of Multiple Deprivation (SIMD) 2020, a measure of the relative level of deprivation in an area, there is some variation in deprivation levels across Dundee. There is a total of 118 data zones in Dundee, of which 70 are in the 20% most deprived and 29 within the 20% least deprived areas in Scotland.[3] As of 2019, the Scottish House Condition Survey shows the percentage of households in fuel poverty (31%) and extreme fuel poverty (21%) in Dundee is higher than the national average (24.6% and 12.4% respectively).[4]

Domestic Building Stock

Dundee's domestic building stock is made up of 77,485 properties. These properties are a varied mix of ages and property types. The majority of homes in Dundee are flats (53%), followed by semi-detached houses (18%). The percentages of social homes (31%) and privately rented homes (18%) are higher than national average. The highest proportion of properties (39%) were built between 1950–1983, followed by those constructed pre-1919 (20%). Approximately half of the domestic properties in Dundee have Energy Performance Certificate (EPC) ratings of D-G.

Transport

Dundee is a small and compact city, with a comprehensive public transport system that primarily relies on buses to cover most of the urban area. The city boasts one of the highest concentrations of electric vehicles (EVs) in any Council fleet in the UK. With approximately 400 public charge points distributed across Dundee, the Council owns and operates around half of these charging stations.[5]

Figure 2.1: Dundee location in Scotland

Description	Information
Area	60km^2
Population (2021)	147,720
Population density	High
Character	Urban
Fuel poverty (2019)	31% of households

Table 2.1: Dundee key area statistics

2. Context and baseline
Policy and context

Local policy

Key local policies and strategies related to this LAEP include:

- **Dundee Local Heat and Energy Efficiency Strategy**[6] – identifies opportunities for energy efficiency improvement, heat decarbonisation and heat network development.
- **Dundee Climate Action Plan**[7]– sets out actions to reduce emissions and adapt to the changing climate while tackling fuel poverty and maximising economic opportunities. Organised into four themes of energy, transport, waste and resilience to help deliver a just transition to net zero by 2045 at the latest.
- **Dundee Local Development Plan**[8] – sets out the spatial strategy that guides future development in Dundee up to 2029. Includes policy related to the installation of energy generating technologies and identified heat network opportunities. The plan is currently under review prior to adoption of an updated plan in 2028.
- **District Heating Strategy 2018-2028**[9] – identifies short, medium and long-term strategic opportunities and actions for heat network growth in Dundee.
- **City Plan for Dundee 2022-2032**[10] – sets out a common vision for Dundee. This includes tackling climate change and meeting net zero targets as one of Dundee's three strategic priorities.
- **Dundee Council Plan 2022-2027**[11] – sets out the Council's vision, values and priorities in line with the City Plan. Centred around tackling root causes of poverty and delivering fairness in income, education and health, delivering jobs and opportunities (inclusive economic growth), and tackling climate change and net zero.
- **Dundee Sustainable Transport Delivery Plan 2024-2034**[12] – sets out the Council's commitment and plans to deliver sustainable travel infrastructure to encourage sustainable travel and greener transport.
- **Dundee City Council Net Zero Transition Plan 2024-2030**[13] **–** sets out a roadmap for Dundee City Council's transition to become a net zero organisation through actions and implementation of carbon accounting to become a local leader.
- **Dundee Local Housing Strategy 2019-2024**[14] – includes an action plan to retrofit council buildings and decarbonise heat supply.
- **Dundee City Council Housing Energy Efficiency and Net Zero Strategy 2023-2027**[15] – sets out the plan to invest in and retrofit the Council's social housing stock, taking a fabric first approach and reducing fuel poverty for tenants.
- **Tactran Regional Transport Strategy 2024-2034**[16] **–** sets out a vision to reduce emissions from transport in the region, by the Tayside and Central Scotland Transport Partnership (Tactran) including supporting low carbon vehicles and reducing car miles.

2. Context and baseline
Policy and context

National policy

Key national policies and strategies relating to the LAEP include:

- **The Climate Change (Emissions Reduction Targets) (Scotland) Act 2019**[17] – in direct response to the international Paris Agreement, the Climate Change (Scotland) Act 2009 was amended, increasing the ambition of Scotland's emissions reduction targets to net zero by 2045.
- **Update to Climate Change Plan 2018-2032**[18] – sets out the Scottish Government's path to achieve the targets set by the Climate Change Act 2019. The strategy advocates for an electricity system powered by a high penetration of renewables, aided by a range of flexible and responsive technologies. By 2030 at least 50% of Scotland's building stock will be heated using zero emissions systems and the need for new petrol and diesel cars will be phased out.
- **The Scottish Energy Strategy 2017**[19] – sets out the 2050 vision for energy in Scotland. It aims for the equivalent of 50% of the energy for Scotland's heat, transport and electricity consumption to be supplied from renewable sources by 2030.
- **Draft Energy Strategy and Just Transition Plan**[20] – published by Scottish Government in January 2023 and sets out the Scottish Government's plan to transform the way Scotland generates, transports and uses energy. Three overarching aims of the strategy are to scale up renewable energy production; secure continued and increased investment in the Net Zero energy economy; and deliver a fairer, more secure energy system.
- **Heat in Buildings Strategy (HiB)**[21] – sets out the Scottish Government's vision for the future of heat in buildings, and the actions they are taking in the buildings sector to deliver climate change commitments, maximise economic opportunities, and ensure a just transition. The HiB Bill will establish laws for heat decarbonisation and energy efficiency in buildings, specifying timelines for when changes must come into effect. Feedback from the consultation phase, which ended in March 2024, is being used to refine these proposals before the Government present them to the Scottish Parliament.
- **Heat Networks (Scotland) Act 2021**[22] – aims to accelerate the deployment of heat networks in Scotland through the introduction of a regulatory system aimed at boosting consumer confidence and providing greater certainty for investors. Targets include 2.6TWh of heat to be supplied by heat networks by 2027 and 6TWh by 2030.
- **Hydrogen Policy Statement**[23] – sets out a vision for Scotland to become a leading hydrogen nation in the production of reliable, competitive, sustainable hydrogen. Key targets include 5GW of renewable and low carbon hydrogen production by 2030 and 25GW by 2045.
- **Fuel Poverty (Targets, Definition and Strategy) (Scotland) Act 2019**[24] – sets out targets relating to the eradication of fuel poverty. By 2040, no more than 5% of households in Scotland should be in fuel poverty and no more than 1% of households in Scotland should be in extreme fuel poverty.
- **National Transport Strategy**[25] – sets out the vision for Scotland's transport system for the next 20 years. Aims to provide a sustainable transport system that contributes to net zero and creates better connectivity with sustainable, smart, cleaner transport options. Includes commitments to reduce car kilometres by 20% by 2030, decarbonise passenger rail services by 2035, and fully decarbonise scheduled flights in Scotland by 2040. Also includes phasing out the need for new petrol and diesel cars and light vans as well as vehicles of all types in public sector fleets by 2030.

2. Context and baseline
The current energy system

The current energy system in Dundee consists of three largely isolated energy systems: power, heating, and transportation.

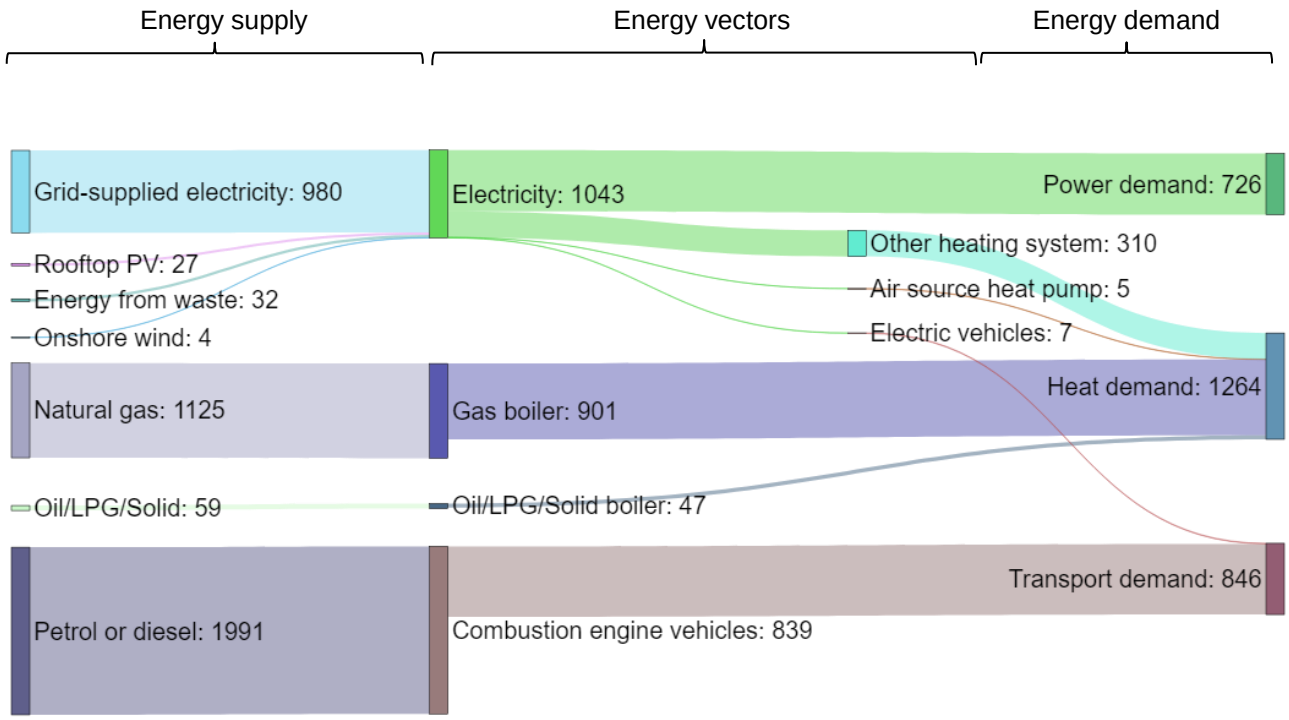
Figure 2.2 presents a Sankey diagram showing how different energy sources flow through energy vectors or converting technologies to meet various end-use demands in the energy system. The baseline Sankey diagram represents the energy system in 2021.

Most electricity in the system is imported from outside of the local area via the National Electricity Transmission System and Scottish and Southern Electricity Network's (SSEN's) distribution network. The remaining electricity is generated locally by the Baldovie energy from waste (EfW) plant, rooftop photovoltaics (PV), and onshore wind.

Heating demand is primarily met by natural gas through individual boilers, with a proportion met by electric heating systems, such as direct electric systems and air source heat pumps. A very small proportion is from oil, liquefied petroleum gas (LPG), and solid fuel boilers.

Currently, almost all road transport demand is met by petrol and diesel, with only a small demand from EVs.

Understanding the energy system now



Note: *Sankey diagrams are a way of visualising energy transfer from energy sources to energy demands via energy vectors or conversion technologies. They are read from left to right and show a snapshot of a scenario in time.*

Figure 2.2: 2021 Baseline Sankey diagram for Dundee (GWh/year)

2. Context and baseline
The current energy system

Historic greenhouse gas emissions

Carbon dioxide equivalent (CO_2e) emissions in Dundee have been decreasing across most sectors over the past 15 years, following the trend of the wider UK emissions.

Figure 2.3 shows Dundee's historic greenhouse gas emissions from 2005, based on sub-national territorial emissions estimate published by the United Kingdom (UK) Government. Note that the figure excludes large industrial sites, railways, motorways, land-use, livestock and agriculture, as these are not considered within the Council's scope of influence.

The domestic sector contributes to the largest proportion of carbon emissions and can be attributed to Dundee's urban environment.

All sectors have seen a decrease in emissions since 2005, which can primarily be attributed to the decarbonisation of the electricity grid.

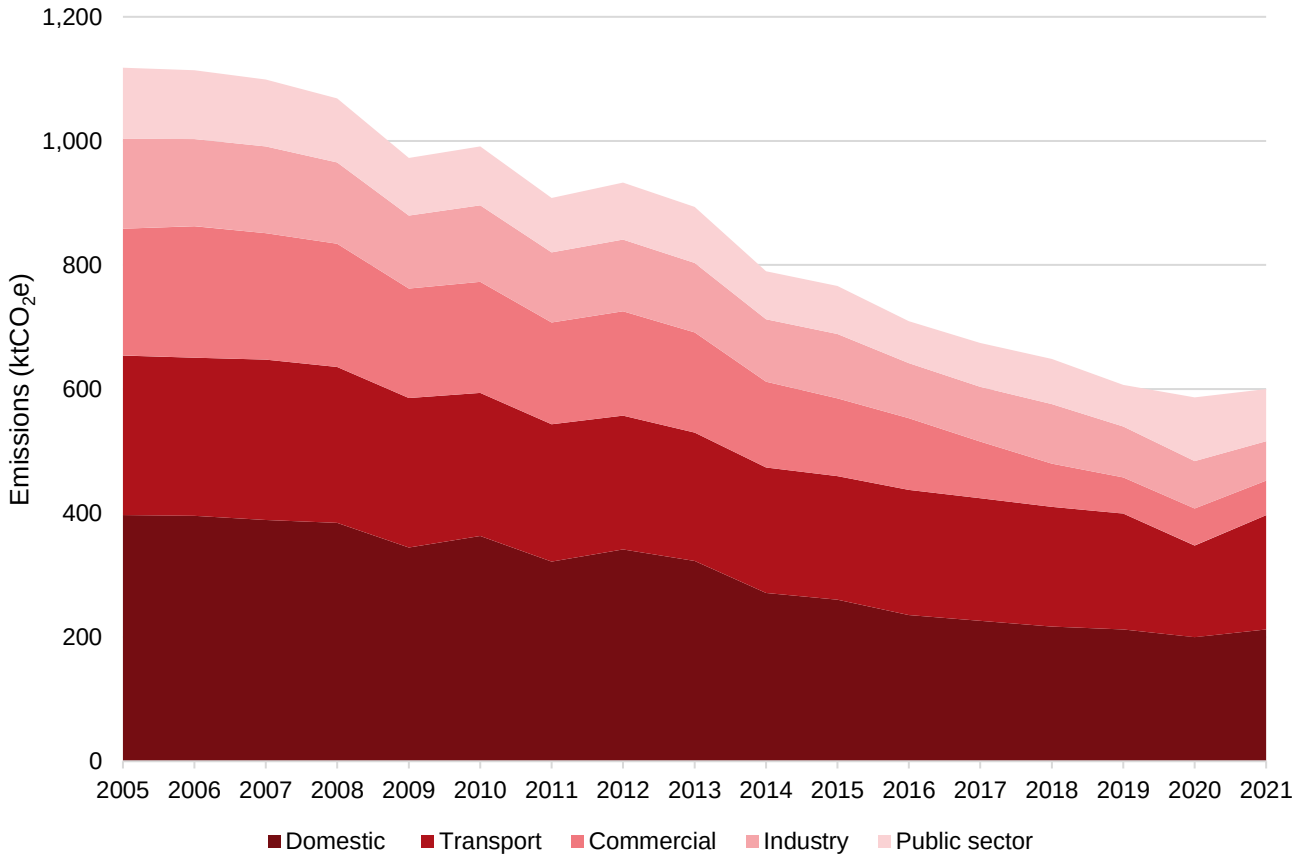


Figure 2.3: Dundee's greenhouse gas emissions 2005-2021 by sector (DESNZ UK local authority and regional carbon dioxide emissions national statistics 2005-2021 [26])

2. Context and baseline
The current energy system

Dundee's current energy infrastructure

Electricity network

Electricity is supplied to homes and businesses in Dundee by a distribution network operated and maintained by SSEN. The network takes electricity from the National Electricity Transmission System at 5 Grid Supply Points (GSPs) and lowers the voltage at 21 primary substations before feeding into the low voltage network supplying energy to customers.

Primary substation have associated 'firm capacities' which represents the maximum load that the substation can handle. Figure 2.4 indicates how constrained each substation is, showing the areas supplied by each primary substation and the proportion of firm capacity currently being used. Areas with a higher proportion are more constrained. Note that some primary substations supply only small areas within Dundee.

Gas network and hydrogen

Scotland Gas Networks (SGN) is the GDN in Dundee. The gas network in the area currently supplies 87% of homes in Dundee. This proportion of gas heated homes is above the Scottish average, due to the urban nature of Dundee. Currently, there are no major hydrogen projects in the area.

Existing heat networks

There are currently two existing heat networks within Dundee – the Low Carbon District Energy Hub at Caird Park and the University of Dundee Heat Network. There are six communal heating schemes that serve ~1,190 Council-owned domestic properties.[6]

A feasibility study was recently carried out to investigate the potential to expand the existing heat network across the Caird Park Golf Course. A study has also been undertaken to explore the opportunity to recovering heat from the energy from waste plant in Baldovie Industrial Estate to supply a district heat network.

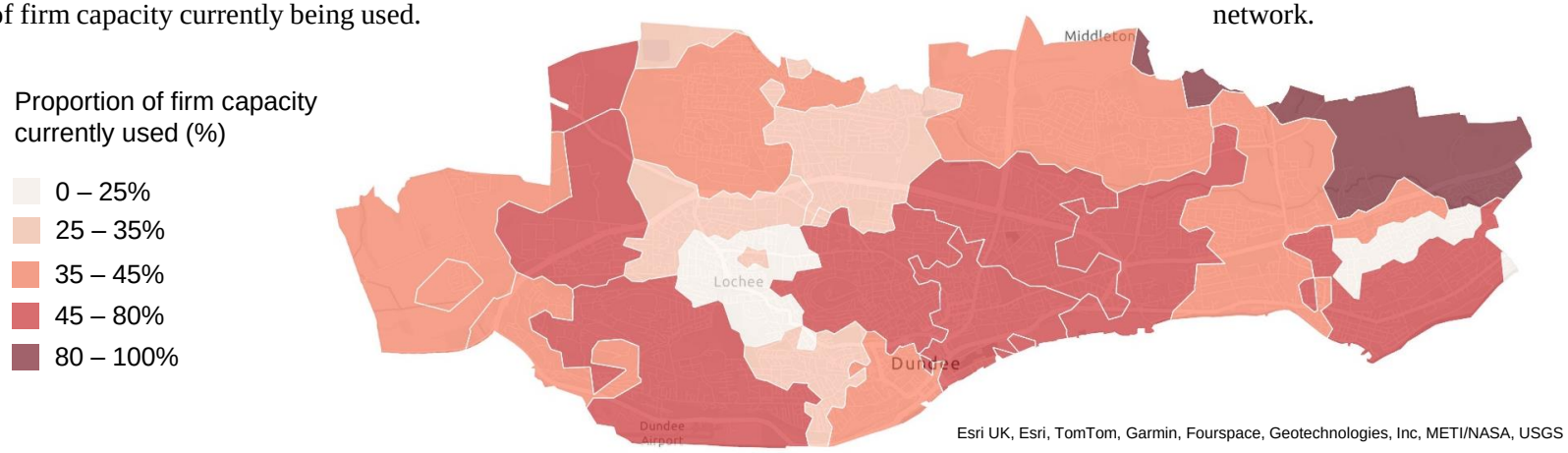


Figure 2.4: Map of primary substation distribution areas in Dundee and capacity constraints (SSEN Network data[27])

2. Context and baseline
The current energy system

Current power consumption

The total baseline annual power consumption for buildings in Dundee is estimated to be 730 GWh. This captures all end-use electricity use, such as powering lighting and appliances, and excludes heat and transport use as, given they can be met by multiple different energy carriers (e.g. gas, electricity and hydrogen), these demands are reported on separately.

Figure 2.5 shows that the domestic sector exhibits the highest power consumption in Dundee, with homes contributing to approximately 60% of the total, amounting to 430 GWh annually.

Hospitality and retail constitutes the highest power consumption within the non-domestic sector, as shown in Figure 2.6. This suggests that businesses in the hospitality and retail industries, such as hotels, restaurants, shops, and shopping centres, are significant consumers of electricity in the city. Consumption can be attributed to factors such as extended operating hours, energy-intensive lighting and ventilation systems.

The remaining non-domestic sectors, including offices, education, healthcare, and other commercial and industrial activities, also contribute to the total power consumption in Dundee. These sectors have varying electricity consumption patterns based on their specific operational requirements, building characteristics, and the nature of their activities.

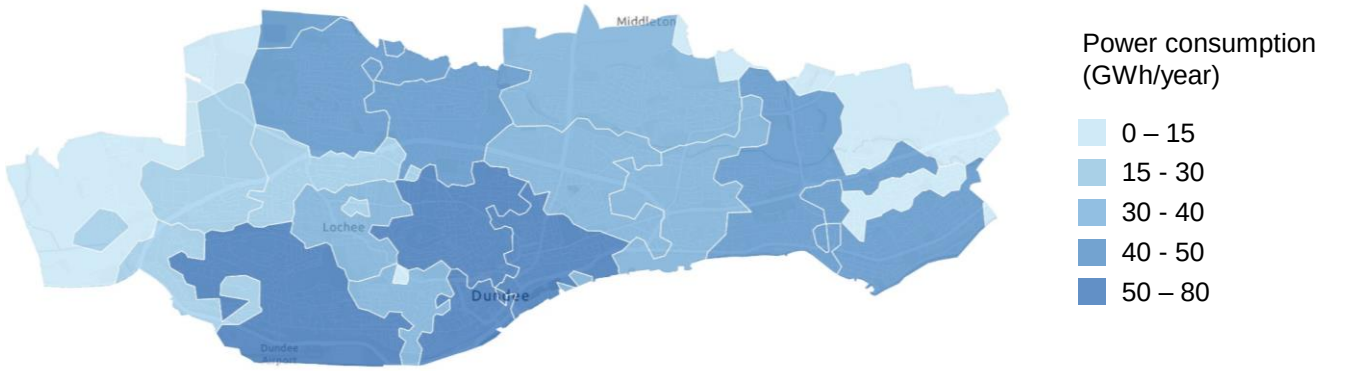


Figure 2.5: Power consumption (GWh/year) by primary substation distribution area

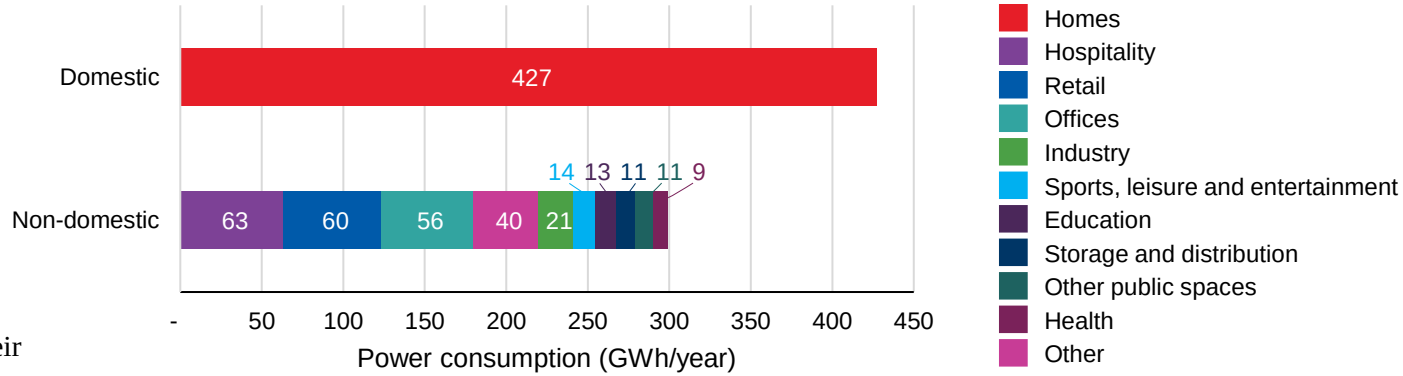


Figure 2.6: Power consumption (GWh/year) by sector

2. Context and baseline
The current energy system

Current heat consumption

The annual baseline heat consumption for Dundee is approximately 1,270 GWh. This refers to both domestic and non-domestic consumption for space heating and hot water.

Heat consumption density is concentrated around the city centre, areas of high residential density and non-domestic buildings with high energy demands, such as Ninewells Hospital as shown in Figure 2.7.

Figure 2.8 shows the proportion of total heat demand (for both domestic and non-domestic properties) met by different fuel types. Heat demand in Dundee is primarily met by mains gas and electricity with a small contribution from electricity, oil, LPG and solid fuel. In particular, a high proportion of homes (~87%) are heated by mains gas.

Figure 2.9 shows that domestic properties (homes) exhibits the highest heating consumption in Dundee, amounting to 786 GWh annually, or 62% of the heating demand. Just as with power demand, this is primarily due to the predominant residential nature of the building stock in Dundee.

Heating consumption within the non-domestic sector is split between a range of sectors, predominantly offices, industry and retail.

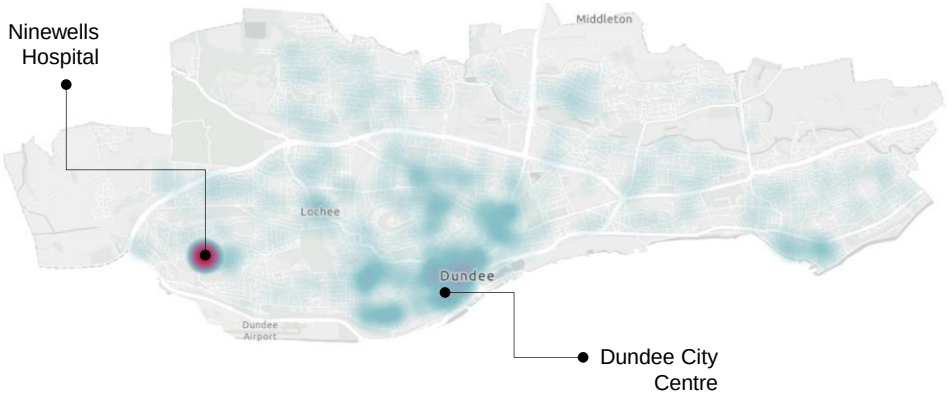


Figure 2.7: Heat map of annual baseline heat consumption

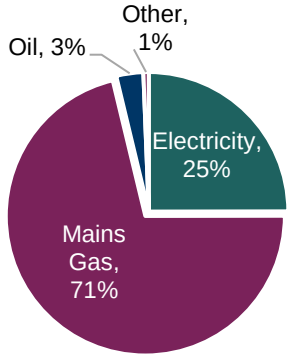


Figure 2.8: Proportion of heat met by fuel type

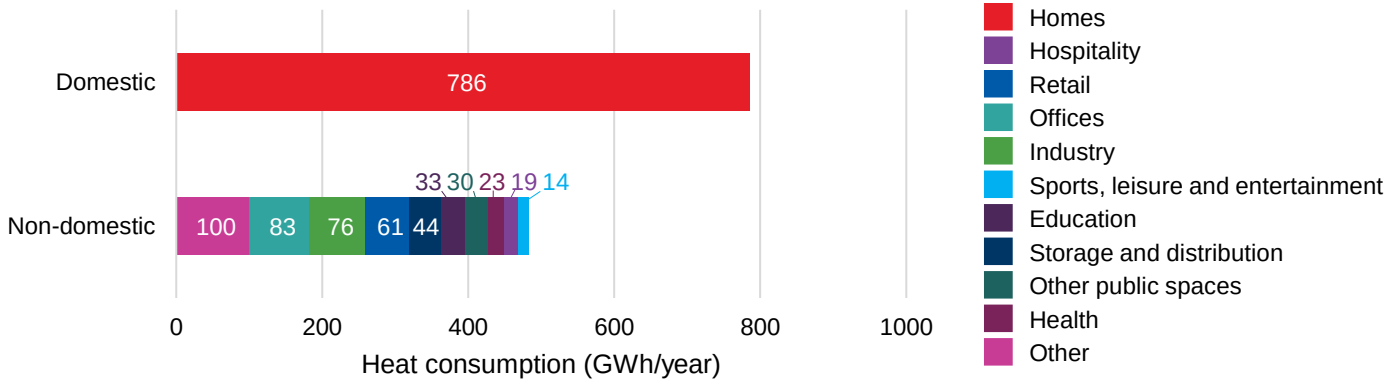


Figure 2.9: Heat consumption (GWh/year) by sector

2. Context and baseline
The current energy system

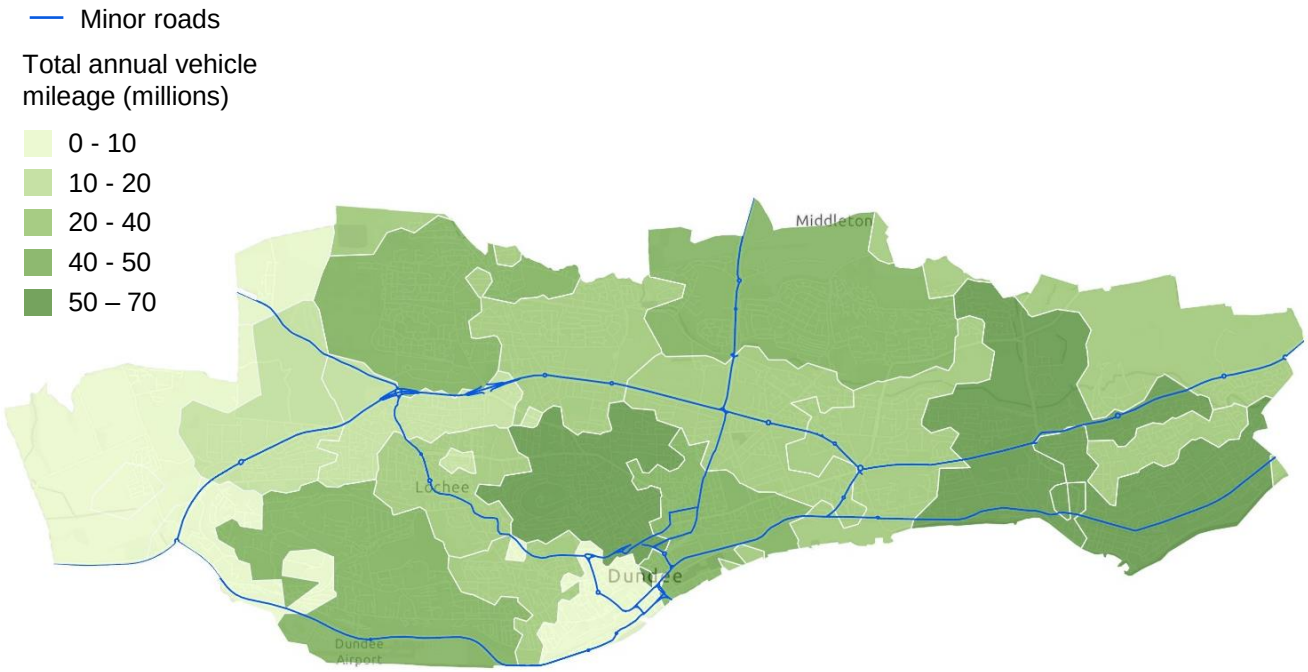
Current transport demand

In 2021, approximately 555 million miles were driven by vehicles in Dundee, with trips by cars comprising the majority of this mileage (73% of miles). There are several primary roads that run through Dundee, including the A90 to Aberdeen and A92 to Arbroath. The Tay Road Bridge forms part of the A92 and connects Dundee with Fife across the River Tay.

Currently transport demand is met almost entirely by petrol and diesel. At the end of December 2021, there were 531 electric private vehicles in the city, which made up 1% of total private vehicle ownership.[30] There are 400 public EV charging points across Dundee.[5]

Figure 2.10 shows an estimate of the vehicle miles driven starting in each primary substation distribution area. This was calculated by allocating total miles to an area based on car ownership rates. Darker green regions indicate higher car ownership and mileage, suggesting that these areas may have high demand for EV chargers in the future.

Despite a large contribution of private vehicles to total transport demand, approximately 40% of households in Dundee do not have access to a car.[12] Public transport services in Dundee includes an expansive bus route network run by private operators which serves neighbourhoods across the city. Dundee's railway station is in the city centre and provides services to cities across Scotland and England.



Esri UK, Esri, TomTom, Garmin, Fourspace, Geotechnologies, Inc, METI/NASA, USGS

Figure 2.10: Annual transport mileage and road network in Dundee by primary substation distribution area [28, 29, 31]

2. Context and baseline
The current energy system

Existing renewable generation assets

Due to the urban nature and limited land area availability in Dundee, there are limited existing and proposed renewable generation assets to supply the local energy system. As shown in Figure 2.11, Dundee currently has an installed generation capacity of ~50 MWe and a battery storage capacity of 100 MWe.

Figure 2.12 shows the location of Dundee's current major renewable energy generation assets, all of which are operational according to the Renewable Energy Planning Database.[32] In addition to these major assets, the total energy generation from rooftop solar PV generation within the LAEP is estimated to be 30 MW. This was calculated based on the estimated number of domestic properties with rooftop PV currently installed.[33]

The energy from waste plant in Baldovie, operated by MVV Environment Ltd, is estimated to have a capacity of 20 MWe, with the completion of an additional line expected to be operational by 2030. In addition to electricity generation from the plant, a feasibility study to understand the potential for heat recovery from the plant has recently been completed. If taken forward, this could provide up to 20 MW_{th} of heat supply to a heat network, with a reduced electricity generation capacity of 16 MWe. MVV are also exploring the opportunities for capturing and transporting carbon away from the site, with initial targets to install carbon capture plant by 2032.[34]

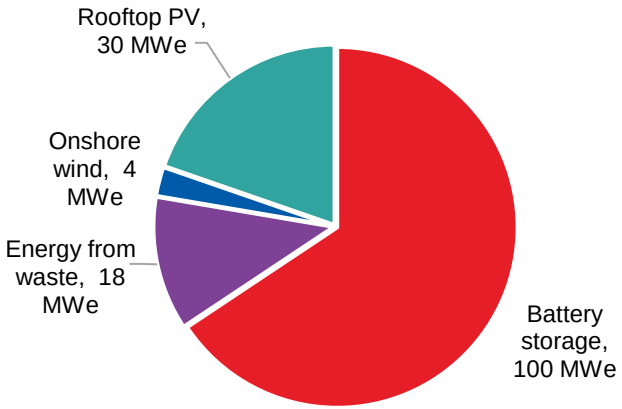


Figure 2.11: Estimated installed capacity of energy assets in Dundee (MWe)

Figure 2.12: Renewable energy assets in Dundee (Renewable Energy Planning Database[32])

Chapter 3: The future energy system

3. Future energy system
Objectives and approach

Future energy system vision

Dundee will be Scotland's pioneering net zero city, establishing an energy system that drives innovation while ensuring accessible and affordable clean energy for all.

Objectives of the LAEP:

1. Chart a clear roadmap to establish a resilient local energy system that achieves net zero emissions across all sectors.
2. Foster local participation, green job creation and economic opportunities through Dundee's energy transition.
3. Establish accessible and affordable clean energy for all of Dundee's residents, with targeted strategies to alleviate fuel poverty.
4. Produce an evidence base to strategically plan network investments, smart technologies, energy storage and other measures necessary to accommodate rising demand from electrified heating and transport while ensuring reliable and resilient energy delivery.
5. Closely align and integrate the implementation of the LAEP with the LHEES to create a cohesive energy transition framework across the city.

Developing the vision and objectives

This vision and plan objectives have been developed through active engagement and collaboration with a range of stakeholders in Dundee's energy system.

Developing options for Dundee's future energy system

Dundee's energy system needs to transition to net zero by 2045, while also ensuring that the system is equitable and resilient to future shifts in demand. However, there are a significant number of uncertainties about how Dundee, as well as the wider energy systems of Scotland and the UK, will transition to enable to a net zero future. These uncertainties include how the cost of technologies might change over time, wider future policy decisions that will be made by the Scottish and UK Governments, how the transition will be funded, and the level of engagement and ambition from the public and private sectors to enable the transition.

Two types of energy system modelling approaches were undertaken consecutively to inform the LAEP:

2045 Optimisation modelling: examining options for the area's energy system in the target year 2045 based on uncertainties on future changes in energy demand; hourly modelling was performed over the year to optimise each scenario against cost and carbon. Two future energy system scenarios were taken forward to be analysed further through deployment modelling.

Deployment modelling: examining how to reach the 2045 preferred energy system and exploring the rate and scale of change required between now and 2045. This was compared against a number of alternative pathway scenarios that the local energy system could take out to 2045.

The details and results of these modelling approaches are presented across the following pages.

Through analysis and comparison of modelling scenarios with stakeholders, a preferred pathway for Dundee's whole systems energy transition can be identified that best aligns with the plan's objectives. Key actions have been identified across Dundee's energy system to support and enable this pathway, while mitigating the risk of uncertainty to certain aspects of the future.

These actions can be taken now to set Dundee on track to deliver a net zero carbon energy system and to ensure the plan's objectives and vision are met.

3. Future energy system
Opportunities for low carbon technologies in Dundee

Developing the optimisation scenarios

Achieving a net zero energy system in Dundee will require the widespread deployment of various low-carbon technologies and measures. Based on Dundee's current energy landscape and context, the following options have been identified as key opportunities in supporting Dundee's energy transition:

- Energy efficiency retrofits
- Heat networks
- Heat pumps
- Hydrogen

These opportunities have been incorporated into the optimisation modelling. While these technologies present promising pathways, their successful implementation is subject to their own unique challenges, as well as significant uncertainties, such as unknowns about future costs and the enabling policy environment necessary to drive their adoption. The following three pages will delve into each of these opportunities, highlighting their potential benefits for Dundee's net zero transition, as well as the challenges and barriers that need to be addressed to leverage the potential they deliver successfully.

It is these opportunities and uncertainties that have informed the development of the future energy system scenarios modelled as part of this LAEP.

Energy efficiency retrofit

Energy efficiency retrofits involve upgrading existing buildings to improve their energy performance, reducing energy consumptions and associated carbon emissions. These retrofits can encompass thermal efficiency improvements to the building fabric through insulation and air-tightness measures, as well as the installation of efficient lighting, appliances, and building systems.

Benefits:

Retrofit offers several benefits. It can enhance occupant comfort, reduce fuel bills, and alleviate fuel poverty. Additionally, it can extend the lifespan of buildings, reducing the need for new construction and associated whole-life carbon emissions. Retrofit also complements other low carbon solutions such as heat pumps by reducing heating loads. Additionally, a well-retrofitted building with improved energy efficiency, comfort, and durability is likely to have an increased market value.

Challenges:

The upfront cost of retrofit can be significant, especially for deeper retrofits involving multiple fabric and system interventions. Achieving sufficient uptake and securing financing can be a challenge, especially in rented and fuel-poor sectors. Installation can also be disruptive for occupants. Furthermore, it is important to ensure quality installations and avoid potential unintended consequences such as overheating, damp, and structural damage through interstitial condensation. Securing a skilled workforce to undertake retrofits at the necessary scale can also be a challenge.

Opportunities and challenges for retrofit in Dundee:

Energy efficiency retrofit presents a significant opportunity for Dundee. A large portion of Dundee's building stock is older and inefficient, with 56% of private homes, and 92% of social housing properties needing some form of intervention in order to meet regulatory standards.[6] There is also an opportunity to address LHEES Category 2 homes, requiring moderate fabric upgrades in order to facilitate heat pump installations. Retrofit interventions are a crucial first step in addressing building energy use in Dundee while also creating local jobs, economic growth, and alleviating fuel poverty.

3. Future energy system
Opportunities for low carbon technologies in Dundee

Heat network opportunities

Heat networks

Heat networks deliver heat to multiple buildings from a centralised source through insulated pipes carrying hot water. While the centralised heat source is typically gas-fired, low carbon sources like heat pumps or recovered waste heat can be utilised.

Benefits:

Heat networks can be supplied by low carbon heating technologies, increasing overall system efficiency and reducing operational costs compared to decentralised heating. Heat networks can leverage large thermal stores, taking advantage of flexibility to further minimise costs and impacts on energy infrastructure. By centralising the equipment, they can also be less expensive to maintain and repair over their lifespan compared to individual heating systems. Heat networks provide a potential decarbonisation pathway for buildings hard to retrofit for other low carbon heating options, such as older tenement properties. The Heat Networks (Scotland) Act 2021 creates a supportive regulatory framework, ensuring heat networks operate efficiently and effectively within Scotland, tailored to local needs.[22]

Challenges:

Heat networks offer significant benefits but can be complex and expensive to deliver, requiring substantial initial capital investment. Consumer perception is a challenge, as uncertainty about pricing and regulation affects public trust. The evolving policy environment will require a robust regulatory framework to protect consumers. Ofgem, appointed as the Heat Networks regulator from 2024, will ensure operators maintain service standards and protect consumers from price volatility. Adhering to new regulatory requirements may pose additional challenges for developers and operators.

Relevance to Dundee:

Dundee is well-suited to heat networks due to its high demand density, particularly in the city centre. There are currently two heat networks in the city, the Low Carbon District Energy Hub in Caird Park and the University of Dundee Heat Network. Gas-served communal heating systems in Council-owned tower blocks also supply heat to ~1190 homes.[6]

As part of Dundee's LHEES, five priority heat network zones were identified. Figure 3.1 shows the location of these zones alongside potential heat sources, including greenspaces for ground source heat pumps, waste heat from the sewer system, and waste heat from the Baldovie EfW plant. These zones represent the priority areas for heat network development; however, other parts of the city may also be suitable for a city-wide heat network.

Figure 3.1: Priority heat network zones and potential sources of heat supply

3. Future energy system
Opportunities for low carbon technologies in Dundee

Future heat decarbonisation opportunities

Heat pumps

Heat pumps use electricity to draw heat from the air, ground, water or another heat source to heat water in a building's heating system.

Benefits:

Heat pumps are a proven technology, ready to deploy at scale. They are highly efficient, providing multiple units of heat for each unit of electricity consumed. Decarbonisation of the electricity grid will also decarbonise future heat pump heating. Air source heat pumps (ASHPs) are 'location agnostic' and can be deployed in almost any area, depending on available space.

Challenges:

For higher efficiencies, reducing running costs and loads on the grid, heat pumps need their output temperatures to be as low as possible. This requires well insulated buildings and means that some buildings may require significant changes to their heating systems to switch to a heat pump. These challenges are less acute for higher temperature sources than air (such as ground or waste heat), but these may not be available or suitable in all locations.

Opportunities and challenges for heat pumps in Dundee:

Given their technological readiness and location agnostic nature, decentralised ASHPs (including systems supplying multiple units within the same building) are the most 'ready-to-go' option for decarbonising the area's heating by 2045. However, a significant proportion (33%) of Dundee's homes fall under LHEES Category 3, indicating they may be unsuitable for heat pump installation without substantial upgrades.[6] Future development of heat networks present opportunities for using heat pumps with other heat sources in the area.

Hydrogen

Hydrogen is a low carbon alternative to natural gas, emitting no CO_2 when burned. Within heating systems, it could replace conventional gas boilers. In transport, hydrogen could power vehicle fuel cells.

Benefits:

Hydrogen heating systems would be familiar to consumers and could potentially use the existing natural gas network, avoiding extra load on electricity distribution networks. In transportation, hydrogen is a potential alternative to electrification of heavy vehicles where battery range limitations pose a challenge. Additionally, hydrogen can offer flexibility for integrating intermittent renewable energy sources, acting as a storage medium for energy to be used when needed.

Challenges:

Hydrogen technologies for both heat and transport are still developing, with uncertainties in production costs, carbon intensity, availability, and network conversion costs. Delays in scaling production and converting the gas network could also hinder decarbonisation and increase costs and emissions.

Opportunities and challenges for hydrogen in Dundee:

Dundee has an existing gas network that could potentially be repurposed for hydrogen, providing a foundation for future integration. However, the city lacks significant industrial sites, limiting large-scale industrial adoption, which is a likely foundation for a widespread hydrogen economy in an area. However, it could be an alternative for hard to decarbonise non-domestic loads, peaking plant for heating systems, and transport fuel. A strong UK government decision in 2026 to support hydrogen for heating could impact usage in Dundee, and this should be monitored.

3. Future energy system
Opportunities for low carbon technologies in Dundee

Other opportunities and challenges

Reducing transport demand

By providing sustainable transport alternatives to private vehicles, including active travel networks and enhanced public transport infrastructure, emissions associated with transport demand in Dundee can be reduced. These measures can also contribute to wider benefits such as improved air quality, reduced traffic and increased well-being. However, changing long-standing travel behaviours and convincing residents to adopt alternative modes of transport can be challenging, requiring sustained public awareness campaigns and incentives.

Although Dundee's compact size means travel distances are small and well-suited for both active and public transport modes, several barriers to the uptake of sustainable travel exist. These include the significant shift in behaviour change required, legacy urban planning that prioritises car journeys, availability of funding for sustainable travel infrastructure, concerns about personal safety, and security of equipment.

Strategies for improving Dundee's sustainable transport offering are set out in Dundee's Sustainable Transport Delivery Plan.[12] The reduction in transport demand is aligned with the National Transport Strategy for Scotland, which highlights the need for significant demand changes across all transport modes in order to decarbonise the sector by 2045.[25]

Electrification of transport

The widespread adoption of EVs can significantly reduce emissions associated with transport demand in Dundee. Coupling EV adoption with the wider decarbonisation of the grid and investment in local renewables can further increase carbon emission reductions. However, EV charging will add significant demand to the electricity network, which must be managed. Additional challenges include higher upfront costs of EVs, charge range anxiety concerns, the need for a accessible charging infrastructure and the availability of funding for EVs and charging infrastructure. Dundee is well poised to support the widespread uptake of EVs in the city. It is often regarded as Scotland's leading city in the adoption, promotion, and operation of EVs with existing efforts focused on transitioning existing council vehicle fleets and rolling out charging infrastructure in key transport hubs.[36]

Local renewable generation

While Dundee's urban landscape presents limitations for large-scale renewable projects, maximising local generation can still contribute to the city's decarbonisation efforts. Rooftop PV installations on residential, commercial, and municipal buildings can harness the city's available solar resources, reducing reliance on imported electricity and associated emissions. Additionally, integrating solar PV with energy storage systems can further enhance the reliability and resilience of the local electricity distribution system. Challenges include the high upfront costs of solar PV installations, limited roof space in densely populated areas, and the intermittency of solar power, which necessitates effective grid integration and storage solutions.

Energy system flexibility

Increasing the flexibility of Dundee's energy system is crucial for accommodating a higher penetration of intermittent renewable sources like solar, as well as supporting the electrification of heating and transport. Demand-side management programs that incentivise consumers to shift their energy consumption to periods of high renewable generation can help manage peak demands and their associated impacts on energy networks. Deploying energy storage solutions, such as battery systems or thermal storage, can store energy for later use, further enhancing grid reliability and resilience. Additionally, innovative EV charging solutions such as vehicle-to-grid and smart charging could reduce peaks in transport electricity demand. However, implementing these measures requires significant consumer buy-in and changes in behaviour, potential regulatory changes, and investments in smart technologies, which can be capital-intensive and face resistance from stakeholders.

3. Future energy system
Optimisation scenarios

2045 system scenarios

Developing the optimisation scenarios

To explore the potential pathways for Dundee's future energy system, the LAEP has developed four system scenarios in collaboration with stakeholders. These scenarios are aimed to assess the impact of various energy system opportunities by considering key uncertainties:

- The level of retrofit delivered to existing buildings (deep or shallow)
- The level of heat network uptake
- The extent of local renewable generation
- The extent of the role hydrogen will play in the energy system
- Flexibility uptake, such as demand-side management

An overview summarising the aims and distinctions between these four scenarios is provided here. For a more comprehensive understanding, a detailed breakdown of each scenario's underlying assumptions and projections is set out on the following page.

Note: the 2045 system scenarios should not be considered as exact predictions for the future of the area but are rather designed to test the impact of different strategic decisions and technologies on the whole energy system of the area.

Local Resilience

This scenario explores an optimised energy system where energy consumption is minimised and local solutions, such as energy generation and heat networks, are maximised.

Retrofit level: High
Renewables uptake: High
Demand-side management: Yes
Heat network uptake: High
Hydrogen applications: None

Hydrogen Integration

This scenario explores an energy system where hydrogen supplies transport, heating in selected non-domestic buildings, and heat network flexibility.

Retrofit level: Low
Renewables uptake: Moderate
Demand-side management: No
Heat network uptake: High
Hydrogen applications: HGVs and buses, heat network flexibility and selected large non-domestic buildings

High Electrification

This scenario explores an electrified, decarbonised energy system that meets the current regulations.

Retrofit level: Low
Renewables uptake: Moderate
Demand-side management: No
Heat network uptake: Low
Hydrogen applications: None

Widespread Hydrogen

This scenario explores an energy system where hydrogen from a transmission pipeline supplies transport, heating in selected homes and non-domestic buildings, and heat networks.

Retrofit level: Low
Renewables uptake: Moderate
Demand-side management: No
Heat network uptake: High
Hydrogen applications: HGVs and buses, hard-to-decarbonise domestic buildings, heat networks, large industrial non-domestic buildings

3. Future energy system
Optimisation scenarios

2045 system scenarios

Developing the optimisation scenarios

Based on hourly optimisation modelling, the Sankey diagrams on the following pages (Figures 3.2-3.5) show the mix of energy sources and vectors that most optimally meet projected demands over 2045, given the conditions set in each 2045 system scenario.

Comparison of all scenarios with the baseline highlights a fundamental change in the energy system: moving from three semi-isolated systems for heat, electricity and transport to a single integrated energy system which depends on the interconnections between energy vectors, as large parts of heat and transport energy demand electrify. This will require reinforcements to the area's electricity network. Flexibility services and technologies will become key to ensure network resilience and to guarantee reliable and affordable supply to consumers. The future system will rely heavily on the decarbonisation of grid electricity. Building retrofit will be crucial to enable switching to low-temperature heating systems like heat pumps. Together with transport mode shift, it will also be key for minimising overall energy requirements and costs.

Table 3.1: Comparison of key energy system components between modelled optimisation scenarios

	Local Resilience	High Electrification	Hydrogen Integration	Widespread Hydrogen
Transport demand	Demand reduction from modal shift and active transport (15% reduction in total demand)	Transport demand increase as projected by Transport For Scotland (14% total increase)		
Transport fuel	Transition from fossil fuel vehicles to EVs		Transition from fossil fuel vehicles to EVs and hydrogen buses and HGVs	
Heating demand	High reduction from retrofit	Lower reduction from retrofit. Domestic properties meet regulatory standards. Non-domestic sector has building management system and service interventions only.		
Power demand	Medium demand reduction. Peak demand load shifting as a result of Time-of-use tariffs (TOUTs).	Limited demand reduction.		
Heat network uptake	High heat network uptake	Low heat network uptake	High heat network uptake	
Local renewables	High rooftop PV uptake	Moderate rooftop PV uptake		
Hydrogen for heating	None		Heat network flexibility and selected large non-domestic buildings	Hard to decarbonise domestic buildings, heat networks, large industrial non-domestic buildings

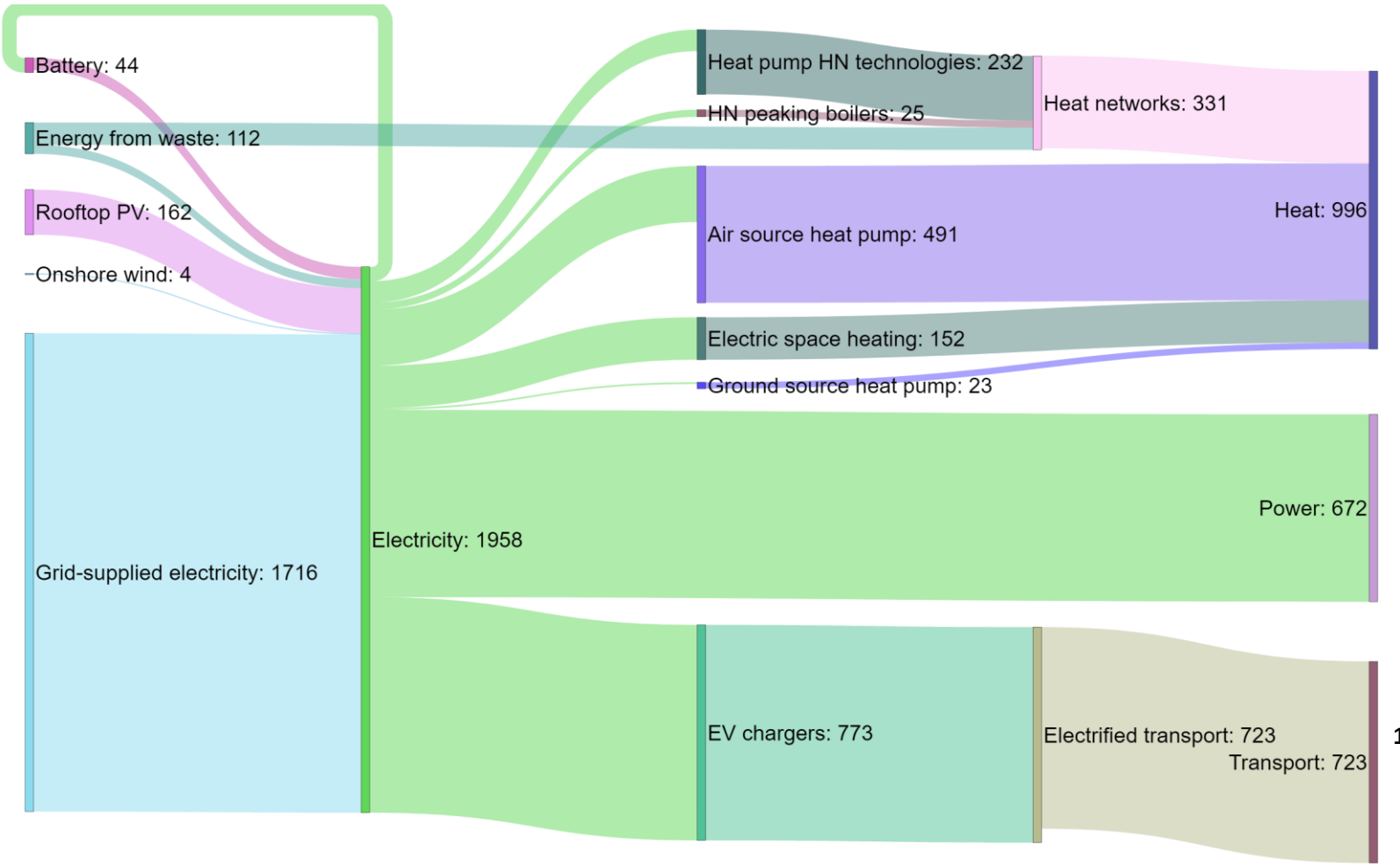
3. Future energy system
"Local Resilience" scenario

Waste heat from EfW utilised in Baldovie HNZ, with significant public sector buildings and anchor loads

6-fold increase in **rooftop PV** generation

Electricity use is **86% larger than baseline**

Transport fully electrified



Around half of all heat met by **decentralised heat pumps** and a third is met by **heat networks**

20% reduction in heat demand

7% reduction in power demand

15% reduction in transport demand

Figure 3.2: Energy flows (GWh/year) in Dundee's Local Resilience scenario

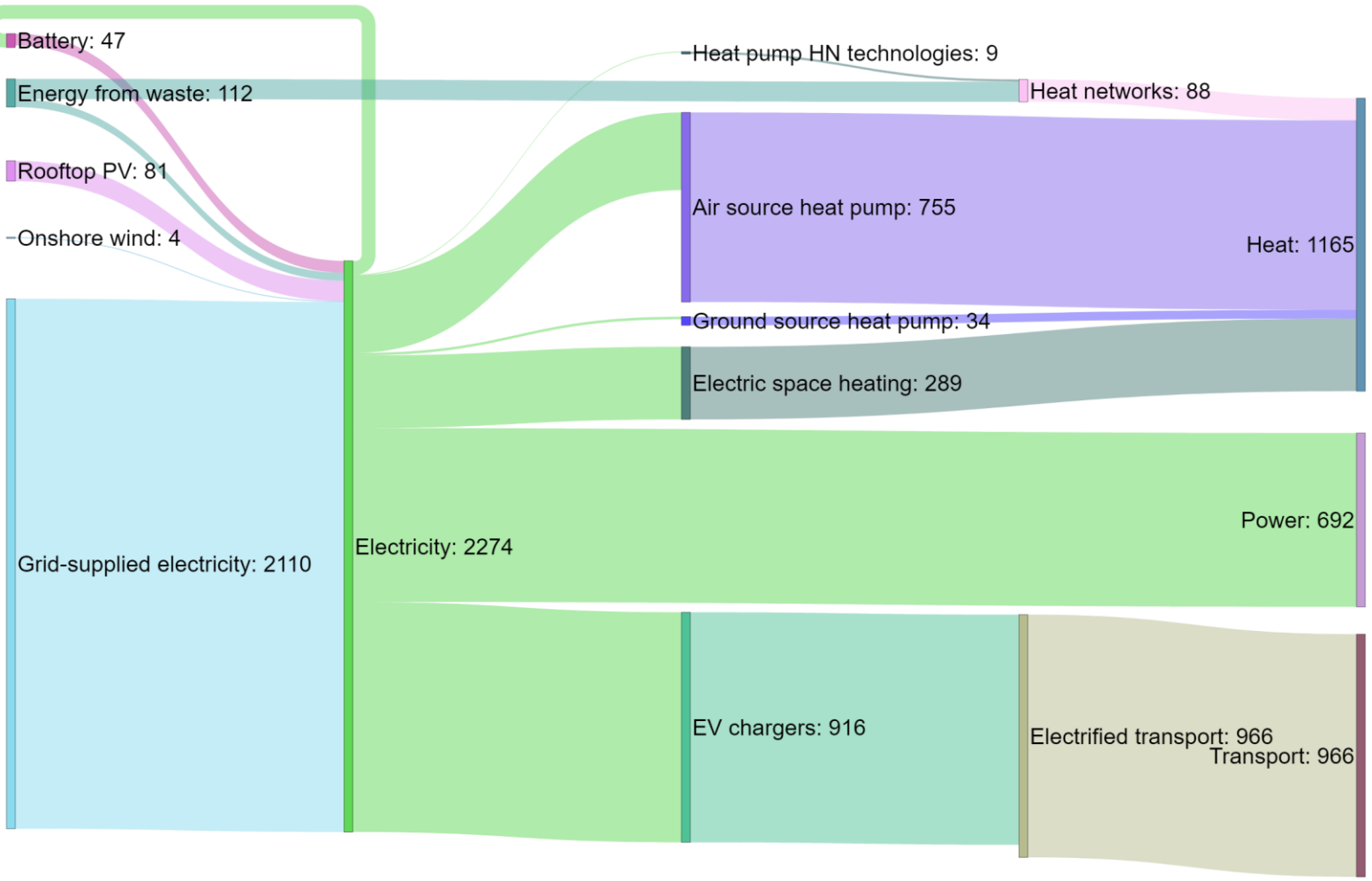
3. Future energy system
"High Electrification" scenario

Electricity use is **116% larger than baseline**

Waste heat from EfW utilised in heat network

Difficult to retrofit properties rely on **direct electric heating** instead of heat networks (25% of demand)

Transport fully electrified



65% of heat demand met by decentralised heat pumps

8% reduction in heat demand

5% reduction in power demand

14% increase in transport demand

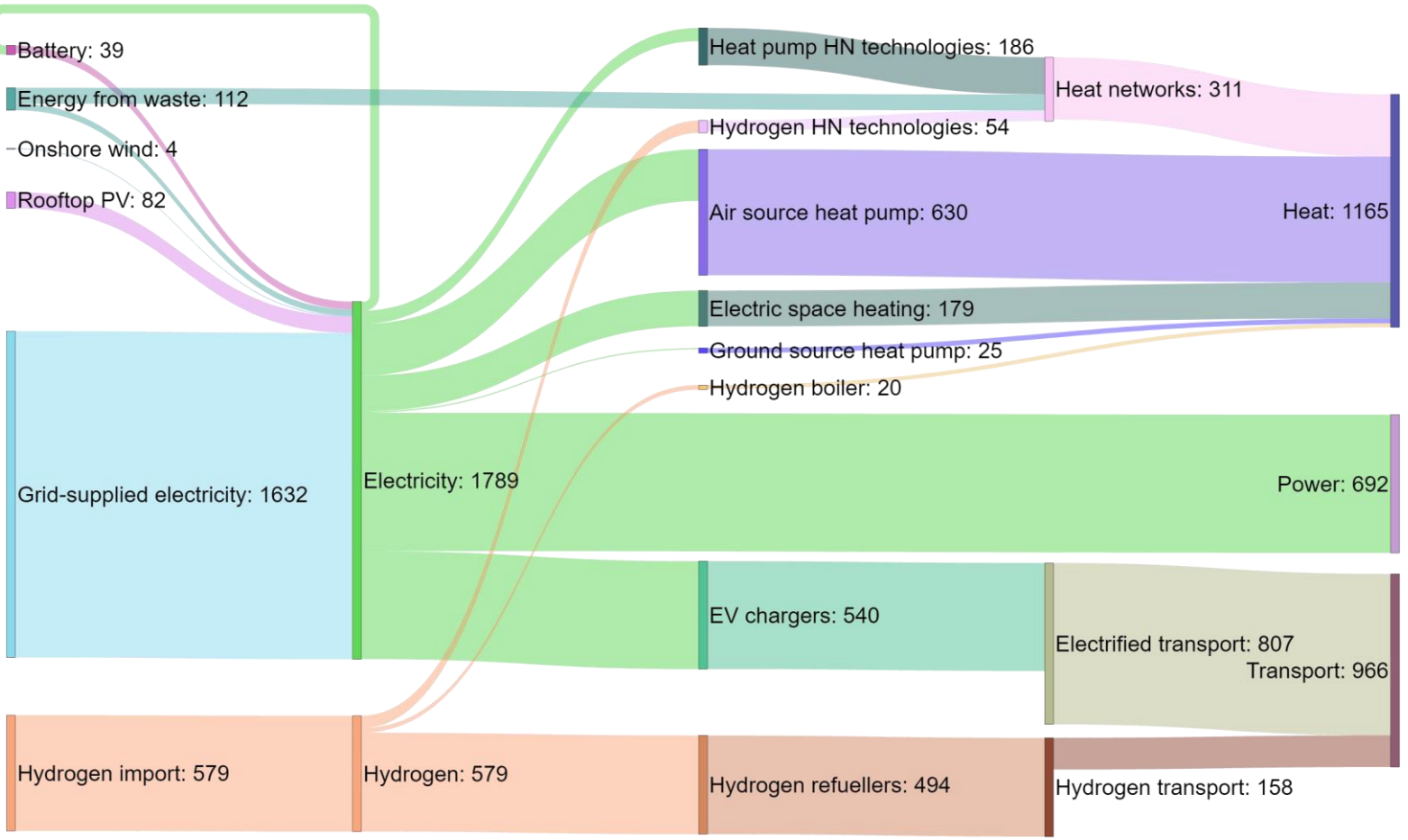
Figure 3.3: Energy flows (GWh/year) in Dundee's High Electrification scenario

3. Future energy system
"Hydrogen Integration" scenario

Hydrogen boiler supplying heat to some heat networks

Electricity use is **70% larger than baseline**

16% of transport demand met by **hydrogen**, used in HGVs and buses



Around a half of all heat demand met by **decentralised heat pumps** and a third is met by **heat networks**

8% reduction in heat demand

5% reduction in power demand

14% increase in transport demand

Figure 3.4: Energy flows (GWh/year) in Dundee's Hydrogen Integration scenario

3. Future energy system
"Widespread Hydrogen" scenario

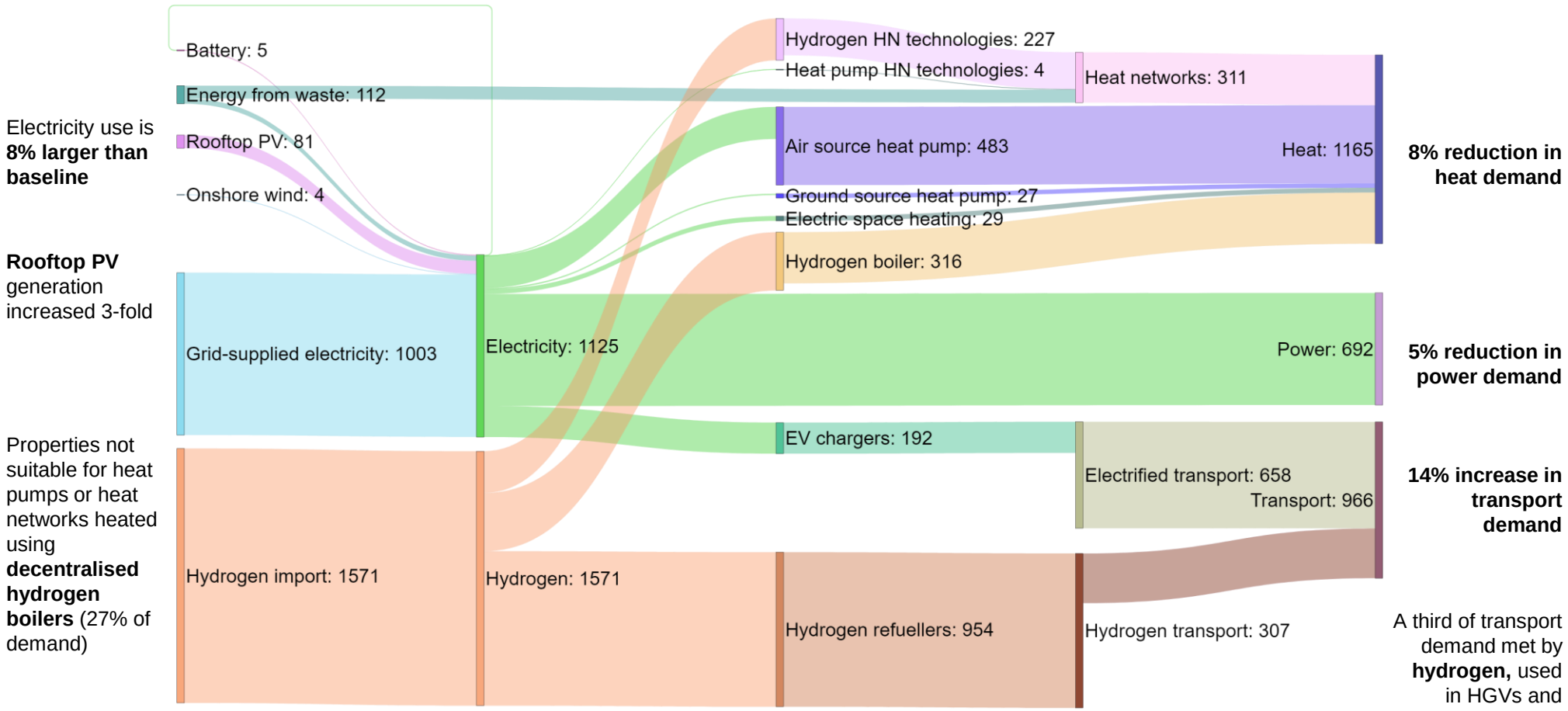


Figure 3.5: Energy flows (GWh/year) in Dundee's Widespread Hydrogen scenario

3. Future energy system
Scenario comparison

Energy system components

Table 3.2 shows the comparison of energy technology uses in each optimisation scenario.

Grid supplied electricity is highest in the High Electrification scenario due to the higher heat demand and limited reduction in transport demand. The two hydrogen scenarios have the lowest requirement for grid supplied electricity as hydrogen partially replaces electricity and is used to meet transport and selected building demands.

In all scenarios electricity consumption required for electric space heating is reduced compared to the baseline. This is due to reduced heating demand in buildings with electric heating and the replacement of direct electric heating systems with heat pumps or connection to heat networks.

The Local Resilience scenario requires less individual air source heat pumps than the electrification scenario as more properties are connected to a heat network.

Table 3.2: Comparison of annual generation and consumption for each energy component (shown in GWh per year)

Key: **Increase** in use of technology | **Decrease** in use of technology

Energy components	Baseline	Local Resilience	High Electrification	Hydrogen Integration	Widespread Hydrogen
Rooftop PV	27	162	81	82	81
Grid supplied electricity	980	1716	2110	1632	1003
EV chargers	7	773	916	540	192
Hydrogen transport	0	0	0	494	954
Air source heat pump	5	491	755	630	483
Ground source heat pump	0	23	34	25	27
Electric space heating	310	152	289	179	29
Hydrogen boiler	0	0	0	20	316
Heat network - EfW	0	80	80	80	80
Heat network - Heat pump	0	232	9	186	4
Heat network - Hydrogen	0	0	0	54	227

3. Future energy system
Scenario comparison

Heat decarbonisation

The decarbonisation of heat is crucial for Dundee's net zero ambitions. Each scenario tested employs a different approach to meeting future heat demand, but all scenarios include a diversified mix of heat sources and make use of local opportunities, as shown in Figure 3.6.

Across all scenarios, a significant portion of heat demand is met by individual air source heat pumps ASHPs, which provide efficient and low carbon heating for residents and businesses. Heat networks also play a vital role, particularly in high density demand zones, as explored on page 27.

The heat sources for these networks vary based on location and scenario. In scenarios with lower heat network uptake, the Baldovie EfW facility supplies clusters of public sector buildings in the Baldovie HNZ. This, along with electric boiler peaking plant, makes up the total heat demand met by heat networks in the High Electrification scenario. In scenarios with higher heat network uptake, the networks expand to clusters supplied by ground source heat pumps, sewer source heat pumps, ASHPs, or hydrogen boilers. Peaking plants, such as electric or hydrogen boilers, are used to meet peak heat demand. In these scenarios, for the Baldovie heat network zone, additional sources such as ground and air source heat pumps may be required to meet demand beyond the Baldovie EfW plant's capacity.

The Local Resilience scenario involves the most ambitious rollout of building retrofits across Dundee, resulting in significantly lower heat demand compared to other scenarios. In contrast, the High Electrification scenario shows the changes needed if retrofits only meet regulatory standards, requiring higher capacities of ASHPs and direct electric heating, and less reliance on heat networks. Both scenarios rely heavily on electricity as a fuel source, leading to increased electrical demand, as discussed on the following page.

Within Hydrogen Integration, hydrogen boilers supply selected non-domestic properties identified as potential pilots for hydrogen heating. Widespread Hydrogen then takes this further to install hydrogen boilers in all LHEES ‘Category 3’, difficult to retrofit properties, that are currently on the gas network. It is worth noting that hydrogen for heating is not widely tested and there is significant and uncertainty in readiness in the short to medium term.

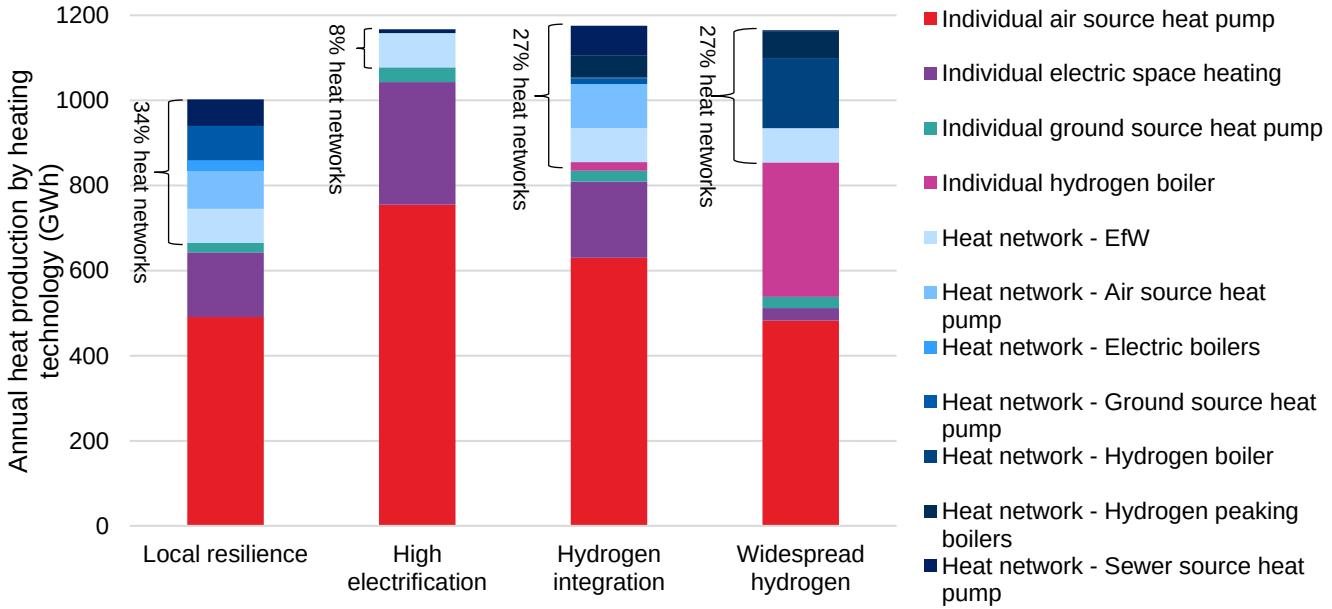


Figure 3.6: Split of heating technologies across Dundee’s four 2045 energy system scenarios

3. Future energy system
Scenario comparison

Electricity networks

Figure 3.7. shows the variation in peak electrical demand in each scenario. Despite High Electrification, Hydrogen Integration, and Widespread Hydrogen having a similar annual heating demand, the resulting peak electrical demand varies greatly. Largely this is due to role of hydrogen displacing electricity used for heat and transport in the hydrogen scenarios. The dashed line on Figure 3.7. shows current substation firm capacity, meaning in all four scenarios additional capacity will need to be delivered to enable a future transition.

In Local Resilience, the increased rollout of retrofit reduces overall heat demand, and results in a higher proportion of buildings being suitable for ASHP installation. This leads to a lower electricity demand due to the better efficiency of heat pumps (>250%) in comparison to electric boilers (100%). The greater rollout of heat networks further enables this, with low carbon and waste heat sources available and being capitalised on to increase efficiency.

Figure 3.7 also demonstrates how hydrogen can relieve stress on the grid by reducing peak electrical demand. Note that this figure shows grid electrical demand only, higher levels of local renewable generation in the Local Resilience scenario also contributes to the reduced peak.

It is important to note that the modelling undertaken optimises the local system to minimise peak electrical demand through measures such as storage and demand-side management. In reality the peak demand across all scenarios may be higher, and any future network should be designed with redundancies to ensure the resilience of the energy system.

While the hydrogen scenarios show a lower overall peak in Dundee, it must be noted that if low carbon hydrogen is produced by electrolysis, this will incur a high electrical demand at the point of production. It is unlikely however that hydrogen production will occur within the boundaries of Dundee City Council. Green hydrogen production should ideally be coupled with large-scale intermittent renewable generation sources, such as wind farms. By producing hydrogen during off-peak times and using it as a store of excess renewable electricity that would be wasted, the grid can be balanced, and the overall system can become more resilient.

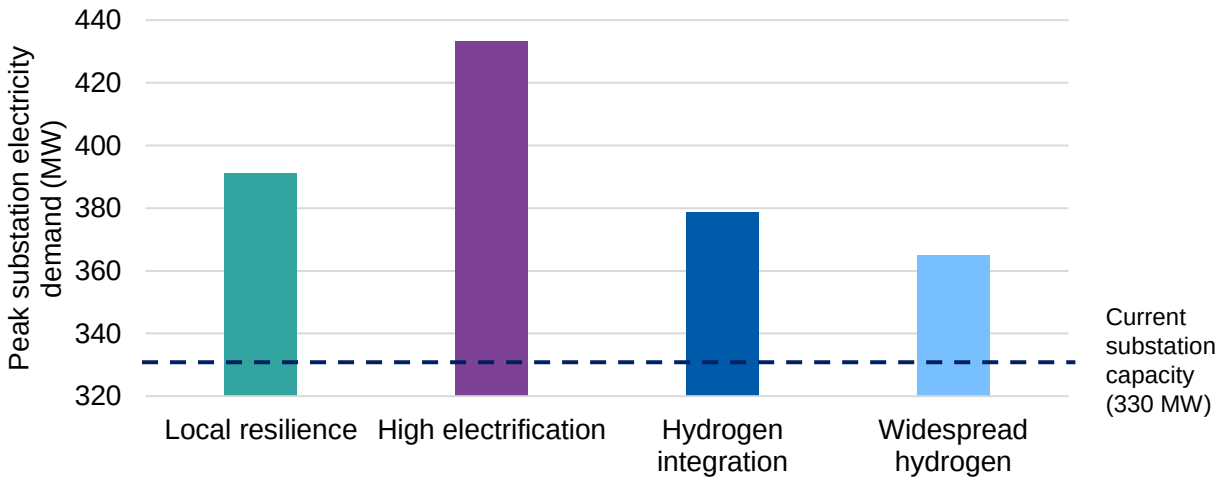


Figure 3.7: Peak primary substation demand (MW) across Dundee's four 2045 energy system scenarios

3. Future energy system
Future energy system vision

A preferred system for 2045

There is a large range of uncertainties which will influence the future of Dundee's energy system. These uncertainties have been examined through the energy system scenarios tested through the optimisation modelling presented in the preceding pages. These system scenarios present both opportunities and challenges for meeting the LAEP objectives. These were considered in-depth, and following discussions with wider energy system stakeholders, two energy system scenarios were taken forward for further analysis for Dundee's future energy transitions.

Less suitable future systems

The High Electrification scenario examines an energy system with lower efforts in reducing building and transport energy demand, moderate renewable build-out, and low heat network penetration. This scenario does not align with Dundee's vision as it results in an energy system heavily reliant on energy imports, straining the electricity distribution infrastructure and leading to a less resilient system overall. This scenario also contradicts ambitions set out in Dundee's LHEES to leverage the city's opportunities for widespread heat network adoption and a fabric-first approach to maximise potential demand reductions before switching heating fuels. It represents a worst-case scenario in which the energy system is decarbonised but not resilient.

The Widespread Hydrogen system presents opportunities in decarbonising hard-to-electrify loads in buildings and transport, increasing system resilience, and easing pressure on the electricity network. However, a lack of industrial sites in the vicinity, which are crucial anchor loads for cost-effective hydrogen rollout, makes this scenario less suited for Dundee. Moreover, the lack of clear plans for green hydrogen supply, uncertainty around future production levels, challenges in sourcing the required volumes, and the absence of immediate funding for hydrogen projects in the area further diminish the viability of this scenario. Even in the event of a strong UK Government decision favouring hydrogen for heating in 2026, Dundee would likely not be prioritised for early gas network conversion, potentially delaying decarbonisation and increasing costs.

A preferred system:

From the modelling carried out for this LAEP and engaging with stakeholders, two preferred systems have emerged to be taken forward for further commentary:

1. Local Resilience
2. Hydrogen Integration

This analysis is centred around the *Local Resilience* scenario, which maximises local renewable energy production, reduces demands in both building and transport sectors, and leverages the city's potential for heat networks with local heat sources. The following pages provide more detailed insights into the Local Resilience scenario and how energy use is optimised across the year.

While prioritising the energy system components of the Local Resilience scenario, Dundee will also monitor progress and potential future hydrogen applications aligned with the Hydrogen Integration scenario. Both scenarios were explored further through deployment modelling, to show how these scenarios may be delivered over time within the context of current policies and plans, and their cumulative impact on energy system emissions. The results of this modelling are discussed in further detail from page 45.

It is likely that Dundee's final future energy scenario may incorporate elements from both the Local Resilience and Hydrogen Integration scenarios considered, and the actions identified in this LAEP are aligned to reflect this, ensuring a balanced and tailored approach which addresses the city's energy transition challenges.

3. Future energy system
Future energy system vision

Energy dispatch – entire year

The optimised generation and supply of electricity to meet the energy demand in Dundee over the year 2045 for the Local Resilience scenario is depicted in Figure 3.8. Electricity use for transport, lighting, appliances, and cooling remains fairly steady throughout the year, while electricity for heating spikes during the winter months when heating needs are higher. During the winter, more electricity is consumed by individual and heat network heat pump technologies and direct electric heating systems to supply heat to buildings.

Rooftop PV systems emerge from the modelling as a low carbon, local generation option that is especially productive in meeting summer electricity and EV charging demands when solar output is high. The electricity production from the energy from waste plant remains constant throughout the year. However, due to the limited availability of large-scale renewable development in Dundee, the optimised energy system does maintain a level of dependence on non-local electricity supply out to 2045.

The technology mix is optimised to balance seasonal variations in demand and supply, ensuring system resilience across the year. The interplay of local renewable generation and grid electricity aims to provide consistent, sustainable energy to meet Dundee's needs in 2045.

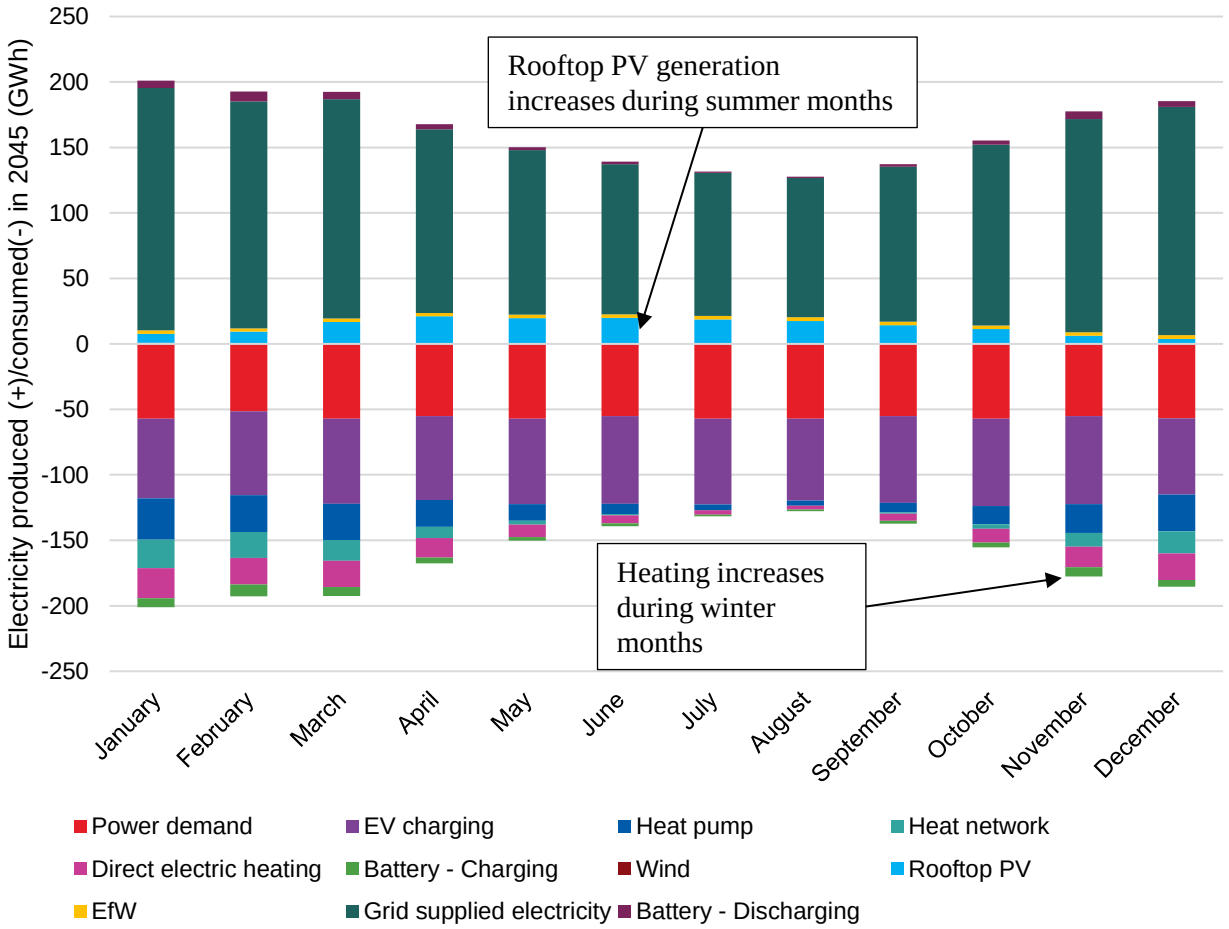


Figure 3.8: Electricity supply and utilisation

3. Future energy system
Future energy system vision

Energy dispatch – peak electricity day

To gain a comprehensive understanding of the technology capacity required to meet peak demands, hourly modelling of the energy system was performed over the course of an entire year. Figure 3.9 illustrates the optimised generation and supply of electricity necessary to satisfy the energy demand during the day of the year with the highest electricity demand.

During daylight hours rooftop PV generates electricity contributing to the overall energy supply. However, the majority of electricity demand is met through grid-supplied electricity. The batteries in the system are charged during the day when rooftop PV generation is high, and then discharged in the evening to help meet the peak demand period.

Notably, EV charging, as well as power consumption for lighting and appliances, contribute significantly to the overall peak demand on the system, which occurs between 6 and 7 pm on the day shown in the figure. Currently, this peak demand is managed through the strategic discharge of stored energy generated during the day.

As technology continues to advance and energy markets evolve, there is potential for further management of this peak demand through measures such as dynamic energy pricing and smart, flexible EV charging strategies for residential overnight car charging.

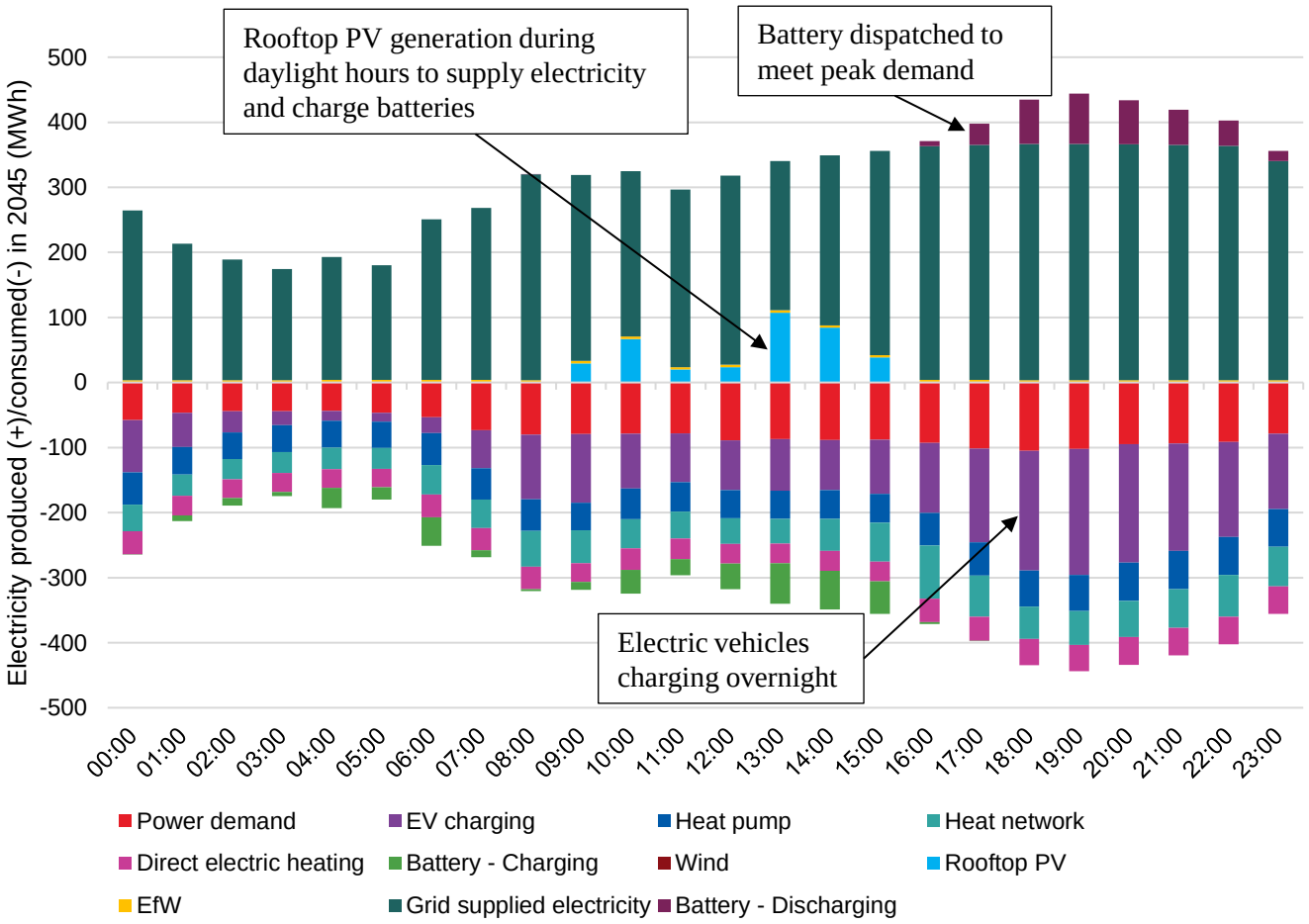


Figure 3.9: Electricity supply and utilisation for a peak electricity demand day in January

3. Future energy system
Future energy system vision

Network reinforcements required

To support the electrification of the energy system, upgrades to the electricity network will be required. Figure 3.10 shows the likelihood that each primary substation will need reinforcements. This likelihood was calculated by comparing the current substation capacity with the modelled capacity required to meet future demand. The labels indicate the reasons that significant upgrades may be more likely within each areas. The results of this analysis inform the key actions that need to be taken in each area:

- Macalpine Road, Menzieshill, Rosebank Street, Constable Road and Broughty Ferry need **essential infrastructure upgrades** to support heat and transport decarbonisation.
- Heat network development in Lochee, Caird Park and Baldovie is less likely to be dependent on **significant upgrades to support development.**
- The energy centre(s) for a City Centre heat network **will need to be carefully sited**. For example, adding demand to the Constable Street substation will require significant upgrades however siting in Overgate may require less infrastructure upgrades.
- Individual air source heat pump installation can be accelerated in Charleston, Ninewells, Gourdie and Edzell Street as **infrastructure upgrades are less likely.**

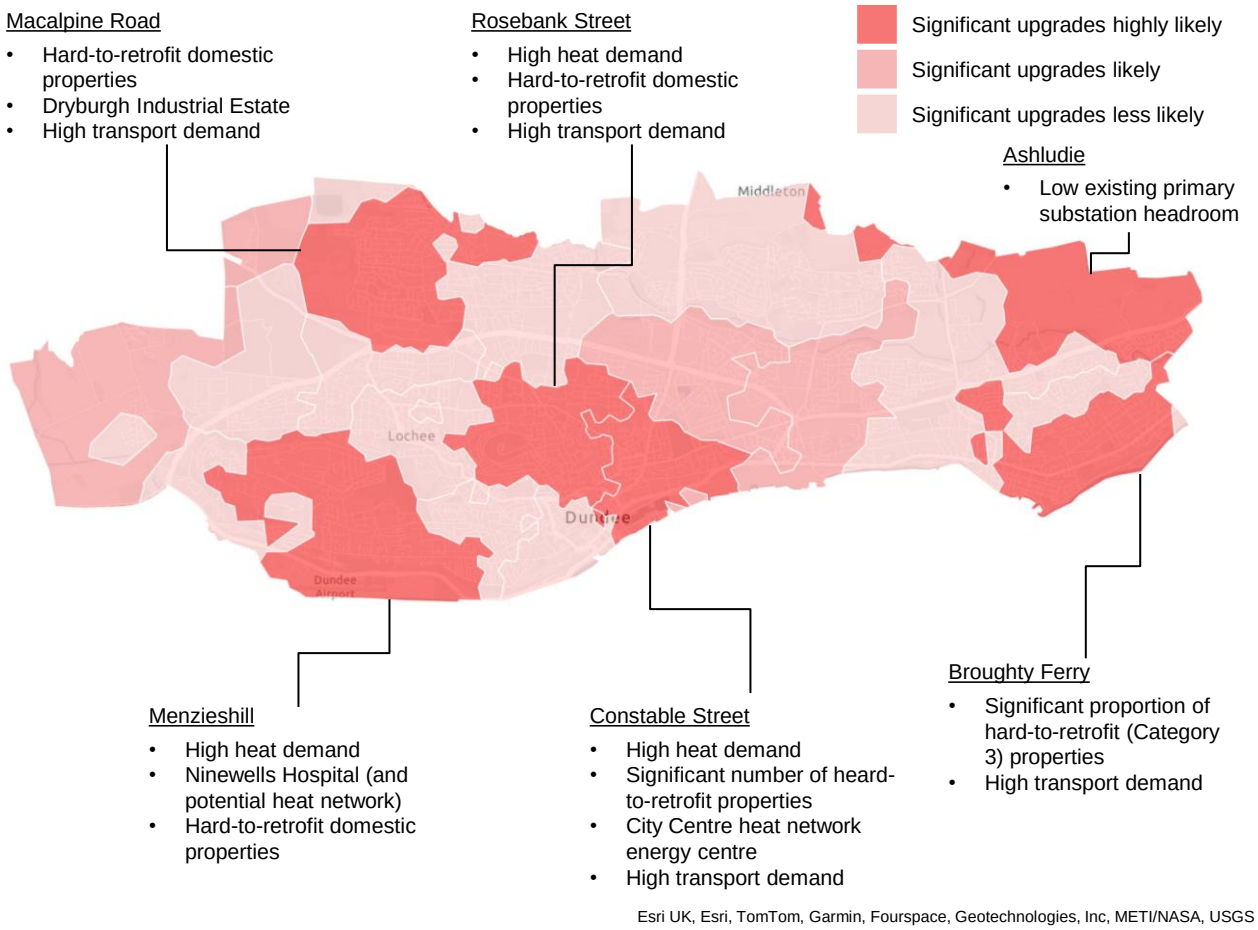


Figure 3.10: Likelihood of network reinforcements required by primary substation

3. Future energy system
Transition pathways

Pathways overview

Deployment modelling has been carried out to identify the impact the rate of change of the energy system has on emissions and energy consumption. The pathways have been developed with input from the Council to explore where current forecasts put Dundee in 2045 and whether it is on track to meet net zero targets.

The **Business as Usual** (BaU) pathway has been used to indicate what the energy system in Dundee would look like if there was no out-of-the-ordinary action taken by residents, local businesses, or the Council. As a result, this pathway assumes that all existing technologies uptake remains at current rates. Heating and cooling demand are assumed to remain constant, however transport demand is forecast to increase based on current trends. This tests the worst-case scenario for 2045.

Regulatory Standards (RS) goes one step further than BaU and assumes that all existing or planned legislation and policies are implemented. National, regional and local plans have all been incorporated, prioritising the most local level of legislation available. However, this only considers actions rather than targets. For example, Scotland's national net zero target for 2045 is not assumed to be met within this scenario, but any existing policies related to achieving this target have been implemented. This scenario therefore shows the gap between national targets and projections based on existing legislation.

The **Public Sector Led** (PSL) scenario tests how far action from the Council and other public sector organisations can contribute to net zero targets. In this pathway, it is assumed that all public sector assets and activities are decarbonised and reach their optimised capacities by 2045. The residual emissions in the local energy system are those that must be addressed by the private sector.

Local Resilience (LR) and **Hydrogen Integration** (HI) are based entirely on the optimisation modelling carried out as part of this LAEP. These pathways reach the respective optimised energy systems in 2045 with deployment based on current trends and forecasts, while also meeting regulatory standards.

The assumptions for each scenario are explored in more detailed overleaf in Table 3.3.

The following pages present and discuss the results of the deployment modelling, starting with the associated energy consumption of each pathway followed by the associated carbon emissions, and a breakdown of residual emissions in 2045.

Local Resilience (LR):
Involving the build out to the modelled optimised Local Resilience energy system.

Hydrogen Integration (HI):
Involving the build out to the modelled optimised Hydrogen Integration energy system.

Public Sector Led (PSL):
Only publicly owned energy system components achieve optimised targets (e.g., publicly owned buildings, Council vehicle fleet).

Regulatory Standards (RS):
All energy system components meet statutory requirements (e.g., Heat in Buildings Strategy).

Business as Usual (BaU):
Assuming a BAU build out rate and demand change

Figure 3.11: Overview of deployment pathways

3. Future energy system
Transition pathways

Pathways assumptions

Table 3.3: Deployment assumptions for pathways tested.

Technology	Sector	Assumed increase from baseline					Explanation				
		Business as Usual	Regulatory Standards	Public Sector Led	Hydrogen Integration	Local Resilience	Business as Usual	Regulatory Standards	Public Sector Led	Hydrogen Integration	Local Resilience
Onshore wind capacity	Generation	No change	No change	No change	No change	No change	No new generation capacity installed	No new generation capacity installed	No new generation capacity installed	No new generation capacity installed	No new generation capacity installed
Energy from waste capacity*	Generation	No change	No change	No change	No change	No change	Generation unchanged as Line 4 replaces Line 2	Generation unchanged as Line 4 replaces Line 2	Generation unchanged as Line 4 replaces Line 2	Generation unchanged as Line 4 replaces Line 2	Generation unchanged as Line 4 replaces Line 2
Rooftop PV capacity	Generation	Low	Low	Medium	Medium	High	Assumed to follow existing installation rates in Scotland	Assumed to follow existing installation rates in Scotland	Maximised build out on council-owned buildings	Maximised build out on all buildings	Maximised build out on all buildings
Domestic retrofit rollout	Heat	No change	Low	Medium	Medium	High	No retrofit	Meets EPC target dates[21]	Public sector buildings retrofitted to optimised demand savings	Meets EPC target dates and remaining moderate retrofit by 2045	Meets EPC target dates and remaining ambitious retrofit by 2045
Non-domestic retrofit rollout	Heat	No change	No change	Low	Low	Medium	No retrofit	No regulation on non-domestic retrofit	Public sector buildings retrofitted	Low levels of retrofit	Optimised retrofit to maximise demand savings
Domestic heat pump installation	Heat	Low	Low	Medium	Medium	High	Assumed to follow existing installation rates in Scotland	Assumed to follow existing installation rates in Scotland	Heat decarbonised in public sector buildings by 2038	Remaining heat electrified by 2045, rollout in line with retrofit	All heat electrified by 2045, rollout in line with retrofit
Non-domestic heat pump installation	Heat	No change	No change	Low	Medium	High	No new heat technologies installed	No regulation on non-domestic properties	Heat decarbonised in public buildings by 2038[37]	Remaining heat electrified by 2045, rollout in line with retrofit	All heat electrified by 2045, rollout in line with retrofit
Heat network installation	Heat	No change	No change	Low	Medium	High	No new heat technologies installed	In line to meet Scotland Targets set out in the Heat Networks Act (2027 and 2030)[21]	Heat networks connections in public sector buildings where suitable	Connections in line with optimised capacity	Connections in line with optimised capacity, and meeting HNA targets
Hydrogen boilers	Heat	No change	No change	No change	Medium	No change	No hydrogen boilers	No hydrogen boilers	No hydrogen boilers	Hydrogen blend in gas network from 2026 and hydrogen in heat network by 2030	No hydrogen boilers demand
EV uptake	Transport	Low	Low	Low	Medium	High	No EV uptake	No new ICEs by 2035	Public sector owned transport electrified	HGV and bus transport demand met by hydrogen with remaining met by EVs, rollout inline with FES leading the way[39]	100% of transport demand met by EVs, rollout inline with FES leading the way[39]
Hydrogen HGV uptake	Transport	No change	No change	No change	High	No change	No future hydrogen demand	No future hydrogen demand	No future hydrogen demand		
Transport demand*	Transport	Increase	Increase	Increase	Increase	Decrease	Growth in transport demand projected by Transport Scotland[38]	Growth in transport demand projected by Transport Scotland[38]	Growth as BAU, offset by small reduction in public sector fleet demands	Growth in transport demand projected by Transport Scotland[38]	Demand reduction necessary to meet Transport Scotland net zero target[38]

* The EfW plant has been assumed to be decarbonised by 2032 using carbon capture and storage technology. This will reduce the electricity and heat generation of the plant.
** An increase in transport demand is forecast for the BaU, RS and PSL pathways which has a negative impact in overall emissions, hence it is highlighted in red here. The rest of the table measures the increase in technologies.

3. Future energy system
Transition pathways

Energy consumption pathways

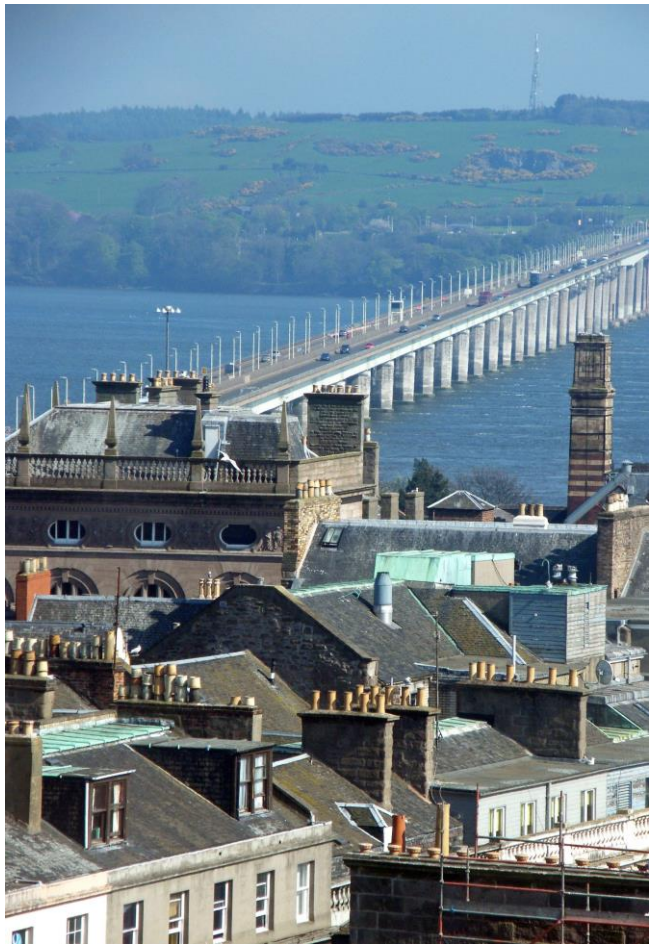
Figures 3.12 to 3.15 overleaf show the split of energy consumption within Dundee from 2024 to 2045 across four deployment pathways, excluding the Business as Usual (BaU) pathway. These energy consumption pathways show the direct impact of actions on consumption within Dundee. The carbon emission pathways (see Figure 3.17) are then created by applying the respective emission factors to show the impact these changes have in meeting Dundee's net zero target, and the influence of the emissions factor of the fuels used. The consumption pathways only show imported energy, excluding local electricity generation via renewables and EfW.

Figure 3.12 and 3.13 show that petrol and diesel consumption decrease in both the Regulatory Standards and Public Sector Led pathway. Although an increase in transport demand is forecast, the continued uptake of electric vehicles will reduce reliance of petrol and diesel for transport. As fossil fuel boilers and heating is being switched out for electric alternatives, there is a decrease in fossil fuel heating fuels. As all public buildings are switched to electric alternatives in the Public Sector Led pathway, consumptions of fossil fuel heating fuels by 2045 is significantly reduced.

The increase in electric heating systems, and the uptake of EVs, does however lead to an increase in grid imported electricity.

Within the Local Resilience pathway, the optimised system eliminates the consumption of petrol and diesel and fossil fuel heating fuels as transport and heating demand is electrified. This leads to a significant increase in grid electricity imported. This increase is minimised by improvements in building energy efficiency, which, combined with the higher efficiency of heat pumps compared to fossil fuel heating technologies, results in a 50% reduction in overall energy consumption. In the Local Resilience scenario in 2045, 90% of total energy demand is met by grid electricity, with the remaining electricity generated from EfW, rooftop PV and onshore wind.

The Hydrogen Integration pathway, shown in Figure 3.15, considers a transition to an optimised energy system utilising hydrogen. Electricity and hydrogen consumption increase significantly to replace the use of petrol and diesel and fossil fuels. Hydrogen heating technologies tend to have lower efficiencies than heat pump solutions, leading to a reduction in overall energy consumption of 10% compared to the baseline. The energy consumption remaining in 2045 is predominantly imported electricity (61%), imported hydrogen (35%) and local renewable generation.



3. Future energy system
Transition pathways

Energy consumption pathways

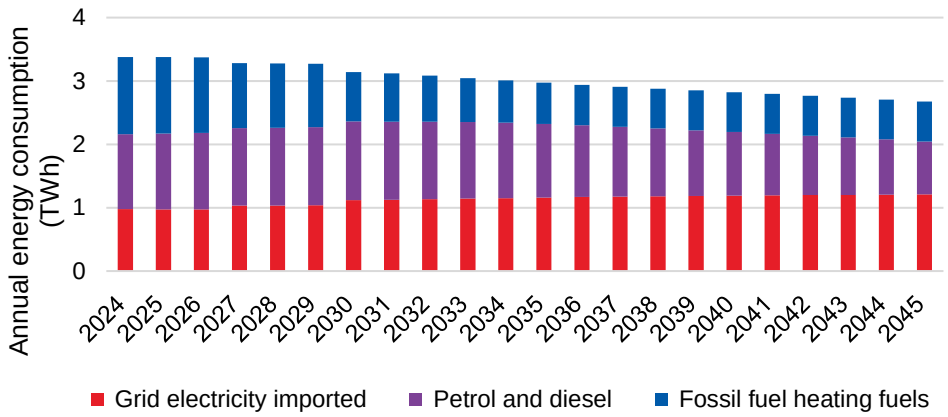


Figure 3.12: Energy consumption by fuel type for Regulatory Standards

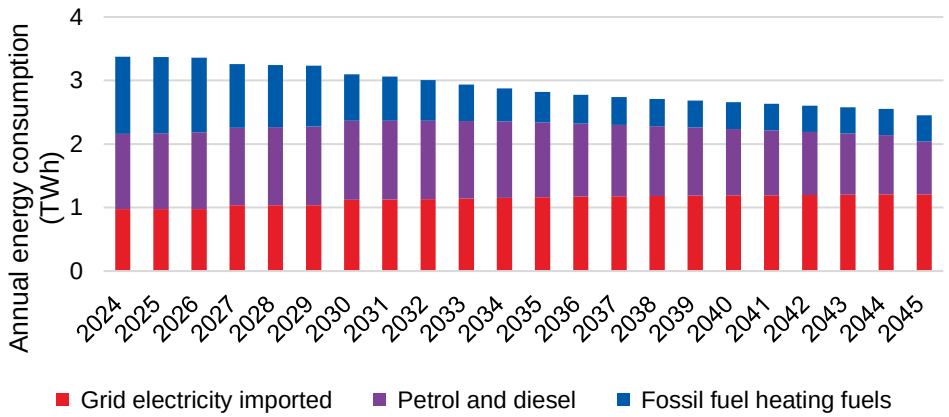


Figure 3.13: Energy consumption by fuel type for Public Sector Led

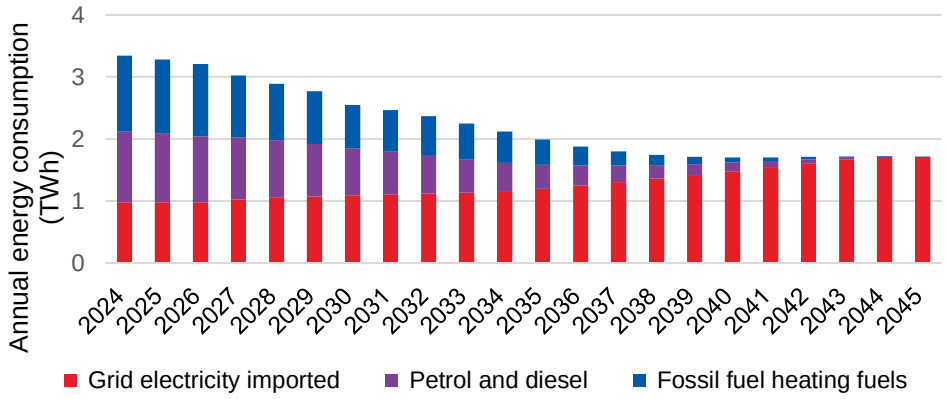


Figure 3.14: Energy consumption by fuel type for Local Resilience

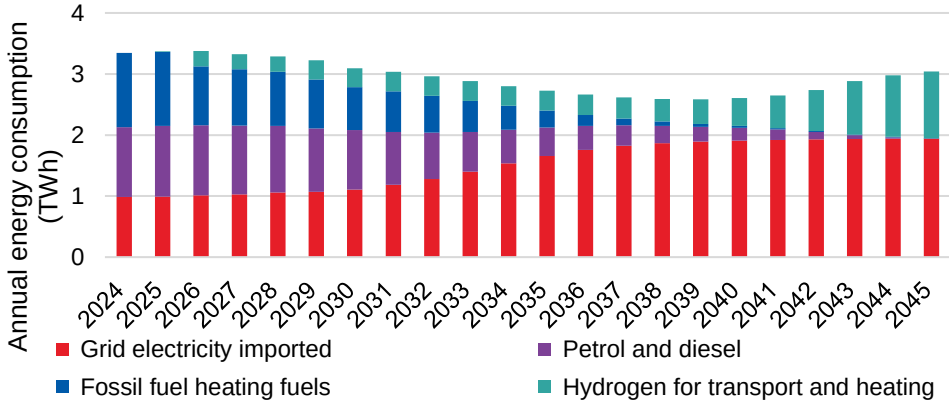


Figure 3.15: Energy consumption by fuel type for Hydrogen Integration

3. Future energy system
Transition pathways

Carbon emissions pathways

Carbon emission pathways have been developed to show how energy emissions could change between 2024 and 2045 within Dundee for each of the five pathways. These are shown on the next page in Figure 3.17 with key targets annotated on the figure.

Across all pathways, the same grid emissions factors were assumed using the Future Energy Scenario 2023: Leading the way electricity CO_2 intensity (excluding negative emissions from bioenergy with carbon capture and storage (BECCS) by National Grid.[39]

The baseline emissions were estimated to be around 623 $ktCO_2e$. Within the Business as Usual (BaU) scenario, this is forecast to decrease by 29% to 445 ktCO2e, however is dependent on the current uptake rate of low carbon technologies and decarbonisation of the electricity grid.

Regulatory Standards (RS) presents the potential annual carbon emissions reduction to 2045 if all current local and national policy and legislation is met. Within this pathway, transport demand is expected to grow but the switch to EVs and heating decarbonisation and efficiency measures lead to an overall decrease by 2045 of 49% when compared to the baseline.

The Public Sector Led (PSL) pathway then tests how far action from the Council can contribute to meeting net zero. Both the PSL and RS pathways rely heavily on the decarbonisation of the grid to reduce emissions without many interventions to reduce heating demand and no action to reduce transport and power demand in the private sector. This leads to higher cumulative emissions and higher fuel costs for consumers.

Figure 3.17 shows that both LR and HI pathway achieves a 97% reduction from baseline levels. The LR pathway and the residual emissions in 2045 are explored in more detail on pages 50 and 51. The overarching statutory target for greenhouse gas emissions, as set by Scottish Government, is to reach net zero by 2045. Only the Local Resilience and Hydrogen Integration scenarios will reach the net zero target once residual emissions have been offset.

That no other pathway reaches net zero implies that current legislation and targets will not be enough to reach Dundee's 2045 net zero target, even with additional action from the Council as shown in the PSL pathway.

This highlights the importance of buy-in and action from industry and the private sector to meet the overall 2045 target.

The impact of this is highlighted by the shaded areas of Figure 3.16 below which show the emissions gap and therefore the emission reduction that can be met by public sector action (blue) and private sector action (light grey). The scale to which this gap is closed and potential emissions are avoided, by improving on the current RS trajectory, will be dependent on the implementation of the delivery actions detailed in Chapter 5.

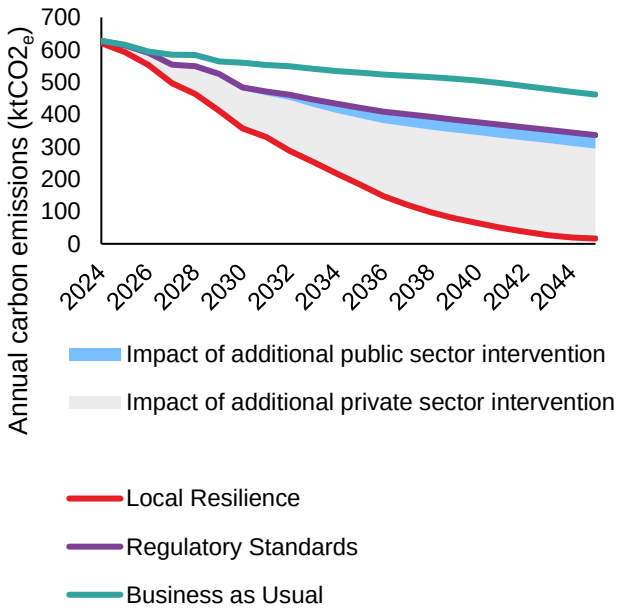


Figure 3.16: Emission reduction opportunity

3. Future energy system
Transition pathways

Annual carbon emissions

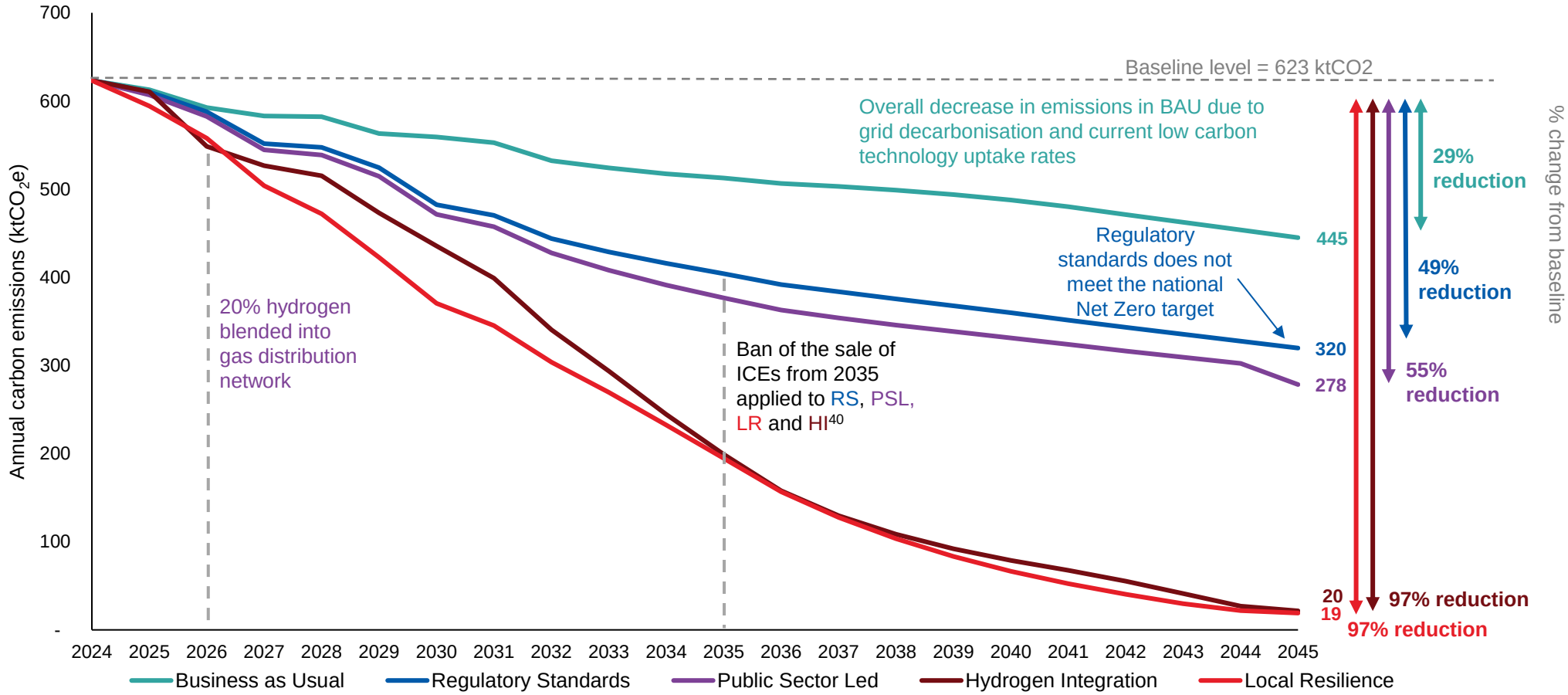


Figure 3.17: Annual carbon emissions of deployment pathways

3. Future energy system
Transition pathways

Cumulative emissions

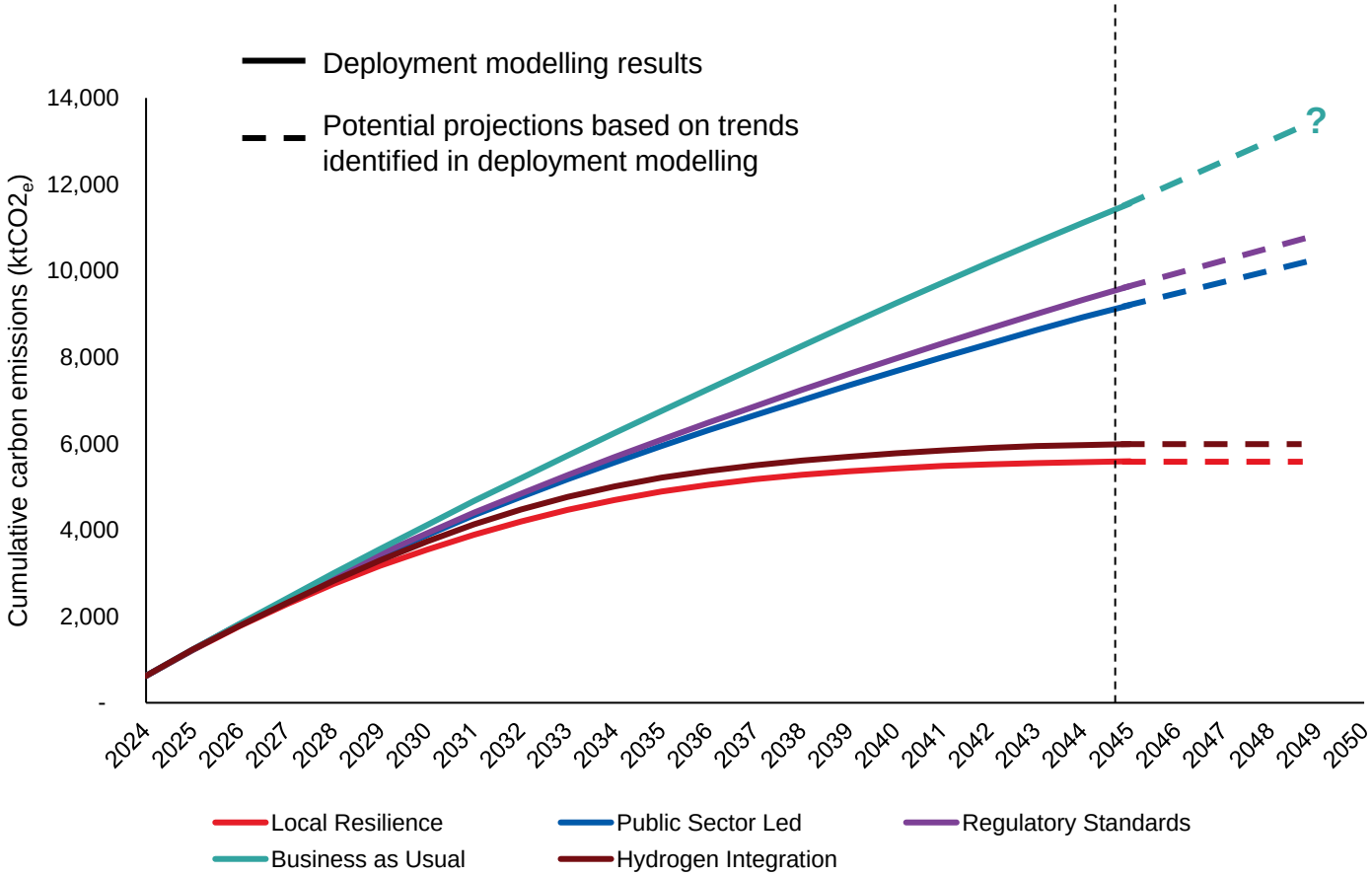


Figure 3.18: Cumulative carbon emissions of deployment pathways

Figure 3.18 shows the difference in cumulative emissions between each pathway. This shows the scale of impact these pathways could have on their overall contribution to climate change.

It is important to note that reaching net zero will not be a fix-all and that any emissions generated up to the point of reaching net zero have a damaging effect. Reducing emissions earlier will have co-benefits such as improved air quality, reduced environmental effects and potentially reduced energy costs from efficiency improvements.

The solid lines in Figure 3.18 show the results from the deployment modelling carried out up to 2045. The dashed lines continue the trends identified within deployment modelling to show an indication of how emissions may change past this point. The wider electricity grid is expected to decarbonise, leading to the Local Resilience and Hydrogen Integration scenario reaching a plateau as the majority of demand is met by electricity or green hydrogen across heating, power and transport in 2045.

The cumulative emissions for the BaU pathway keep growing with no signs of slowing down due to the increase in demand and annual carbon emissions with even grid decarbonisation not enough to cause a decrease in annual emissions.

3. Future energy system
Transition pathways

Residual emissions

Figure 3.19 shows the breakdown of carbon emissions by demand sector in 2045 and the impact of following each pathway compared to the previous one. The pathways are presented in ascending order of intervention from the local area.

Note that this does not include emissions avoided from local generation, and instead assumes all electricity demand is met by grid electricity. Local generation will reduce grid import across all sectors where electricity is used and reduces the residual emissions in 2045 for the Local Resilience scenario from 20.6 $ktCO_2e$ to 19. $ktCO_2e$. This is explored more on the following page.

To achieve net zero, these residual emissions must be offset or balanced. This will require input and action from the local authority, developers and large emitters who all have a responsibility to meet net zero within their own emissions. The funding required to offset these residual emissions and where the responsibility for these payments lie should be considered by local and central government. This should involve engaging stakeholders throughout the delivery of the LAEP to reach a consensus on the approach to compensate residual emissions. This is essential to ensure a successful transition to a net zero future.

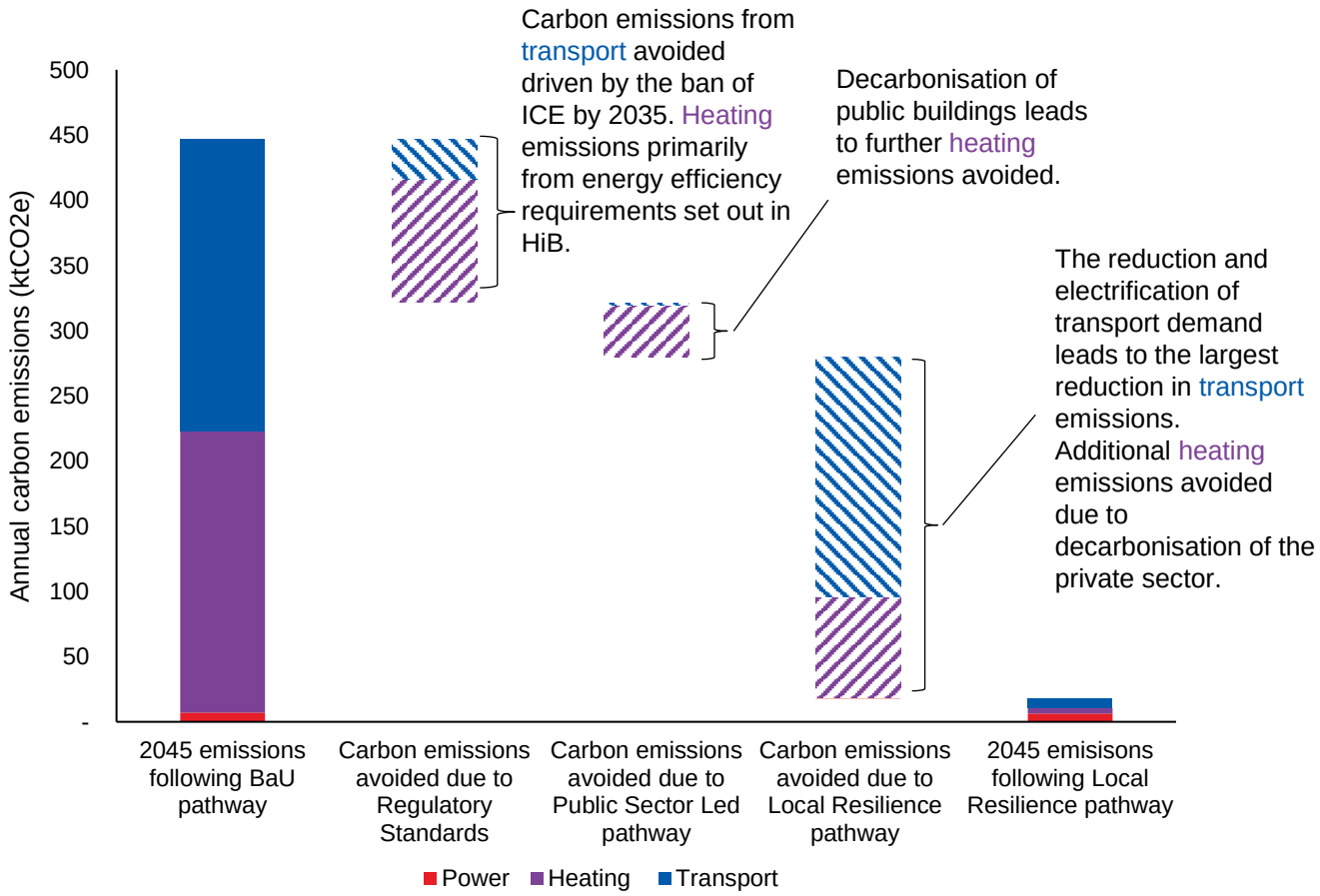


Figure 3.19: Waterfall chart showing residual emissions in 2045 and carbon emissions that can be avoided through alternative pathway implementation

3. Future energy system
Transition pathways

Local Resilience pathway

To meet net zero targets, Dundee should aim to closely follow the Local Resilience scenario, while monitoring potential for future green Hydrogen Integration. Figure 3.20 highlights the reductions in emissions that need to be made across different demand sectors.

Although local generation capacity grows over time, avoided emissions reduce over time due to declining grid emission factors. However, local generation remains vital for reducing grid constraints, cumulative emissions, and fuel costs, particularly in earlier years with higher grid carbon intensity. By strategically siting renewable energy sources near areas with high heat demand, the generated electricity can be efficiently utilised for local heat networks or heat pumps, minimising transmission losses and maximising the overall system efficiency.

The analysis carried out as part of the deployment modelling highlights the importance of the transport and heating sectors in reaching net zero targets. Decarbonising these sectors through measures such as electrification of transport, widespread deployment of heat pumps, and the integration of low carbon heat networks will be essential in achieving Dundee's ambitious climate goals.

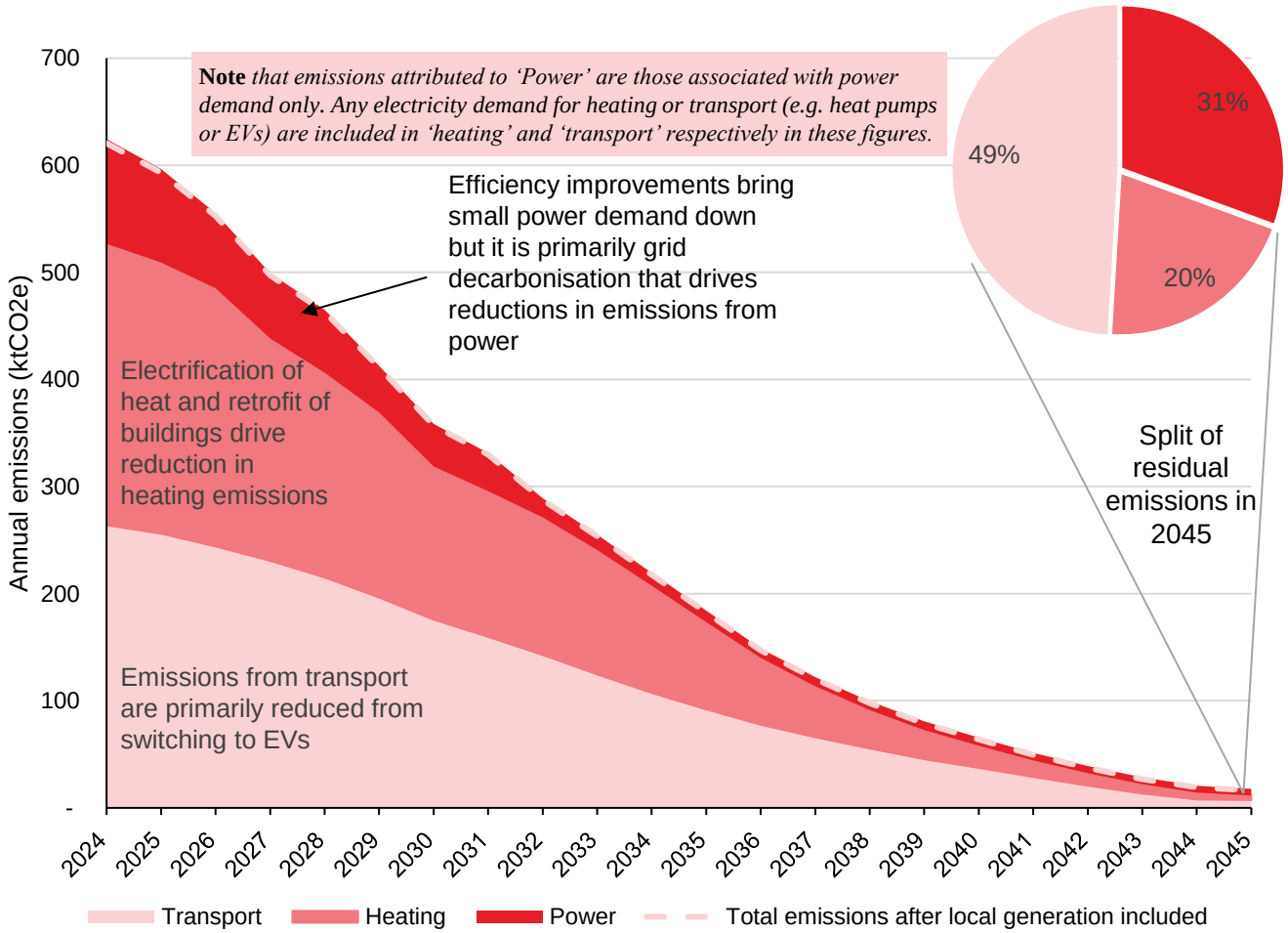


Figure 3.20: Projected annual carbon emissions for the Local Resilience scenario split by demand

Chapter 4: Priority intervention themes

4. Priority intervention themes
Introduction

Priority intervention themes

The modelling presented in previous pages illustrates the radical transformation necessary to create a net zero local energy system for Dundee. Through the optimisation and deployment modelling carried out for this LAEP, it can be concluded that a least-cost, lowest-carbon pathway to net zero will involve significant reductions in demand for heating, electricity, and transport, along with profound changes in energy use.

Figure 4.1 outlines the priority intervention themes to achieve the LAEP's objectives of the proposed future energy system and recommended pathway. These span all aspects of the area's energy system, with numerous interdependencies across them. This highlights the importance of a coordinated, whole system approach to delivery in order to meet the 2045 net zero carbon target.

Achieving the LAEP's broader objectives will require appropriate governance, engagement, policies, and financing solutions. The radical changes modelled will involve interventions across heating, transport, electricity, and overall energy use. A coordinated effort across all facets of the energy system is vital for the net zero transition.

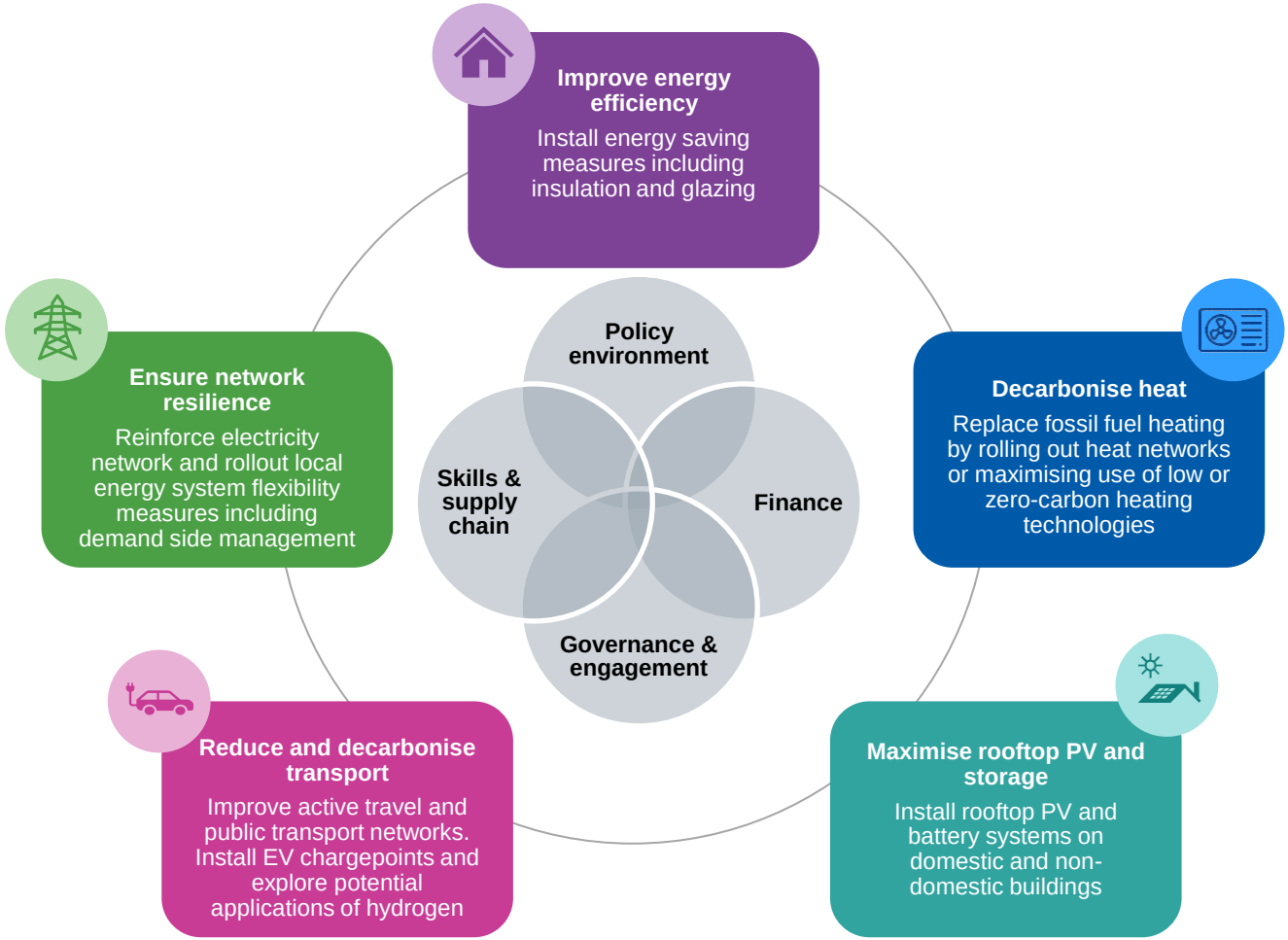


Figure 4.1: Priority intervention themes in Dundee

4. Priority intervention themes
Focus areas for the delivery of the LAEP

Priority intervention themes

The Council and the DCLG should aim to work collaboratively with stakeholders across the local energy system to support delivery of the net zero system as follows:

Decarbonise heat

Dundee is an urban area with a high density of heat demand, making it a suitable location for the development of heat networks. Dundee's LHEES has five priority zones for heat network development as set out on page 27. Heat networks can be an efficient and low carbon heat source when paired with local renewable heat opportunities. The modelling carried out for this LAEP illustrates that up to 34% of heat demand can be met through a range of efficient heating technologies supplying heat networks. The feasibility of developing heat networks in these prioritised zones should be further investigated.

Currently, it is estimated that 87% of domestic buildings in Dundee are connected to the gas network. Transitioning these on-gas domestic properties to low carbon heating systems requires careful planning to ensure fuel poverty is not exacerbated from increased fuel bills. Characteristic of an urban city, a high proportion (53%) of Dundee's homes are flats. Not all flats in Dundee will be able to connect to a district heat network. Installation of individual heat pumps can be challenging in flats due to several constraints, including limited space for the necessary heat pump components. Communal heating systems could be considered as an alternative decarbonisation solution for flats. Existing communal heating systems currently heated by gas should be decarbonised.

Improve the energy efficiency of the existing building stock

The installation of energy efficiency measures will minimise the overall demand from the building sector, reducing the need for new generation assets and energy network reinforcement.

Adopting a fabric-first approach for buildings with poor thermal performance is important when considering the rollout of low-temperature heating systems, such as heat pumps. Prioritising the installation of fabric improvements offers a range of benefits for occupants, including lower energy costs, warmer homes and a better indoor environment. Decisions should be made on a case-by-case basis regarding how best to sequence the deployment of fabric improvements alongside low carbon heating systems.

In Scotland, the HiB Strategy sets targets to improve the energy efficiency of buildings, with all Scottish private homes required to reach an EPC Band C by 2033. A significant proportion of private domestic properties in Dundee do not meet this target, as 56% currently fall below a Band C. Similarly, 92% of social housing properties will need some form of intervention to meet the target of an EPC Band B by 2032.

Both Dundee's LHEES and LAEP have identified locally-specific challenges to the installation of energy efficiency measures, which will need to be addressed to ensure the 2033 HiB target can be met. For example, the higher proportion of flats and tenement buildings in Dundee presents a challenge for the planning and execution of retrofit projects due to the multiple stakeholders involved and the more complex building modifications required. Actions set out in this LAEP will provide the foundations to address these challenges, accelerating the rate of retrofit in Dundee.

Public-owned buildings, such as schools and offices, should be initially targeted for energy efficiency improvement. The Council, the DCLG, and other public bodies have greater control over the installation of measures across their building stock, enabling quicker and more streamlined implementation of retrofit projects. Through community engagement, government incentives, and planning measures, homeowners and private businesses should also be encouraged and supported to implement efficiency upgrades. Success stories from projects in public-owned buildings should be shared to encourage uptake among the private sector.

4. Priority intervention themes
Focus areas for the delivery of the LAEP

Priority intervention themes

Maximise rooftop PV and storage

In an urban context, there are limited opportunities for large-scale renewable energy projects. However, rooftop PV systems can contribute to Dundee's local energy system by providing low-cost, low carbon energy to residential and commercial users.

The Council should aim to deploy rooftop PV and battery systems across its own assets, accessing available funding schemes. Additionally, the Council and the DCLG should encourage 'able-to-pay' consumers to install rooftop solar PV, developing strong communication and engagement plans to drive uptake. It is important to provide information about the supply chain, available funding schemes and tariffs to ensure consumers have the necessary information to make informed decisions.

Ensure network resilience

Electricity network reinforcement will be required to meet increased electricity demand from the shift to electrified heating and transport technologies. This LAEP has been developed in collaboration with SSEN through the RESOP project, with outputs feeding into the LENZA tool intended to assist with the DNO's future energy planning.

As renewable generation capacity continues to increase, there will be greater variability in generation outputs. Flexibility will therefore become increasingly important to manage the difference between generation and demand. The Council and the DCLG could raise awareness of demand-side flexibility mechanisms, like time-of-use tariffs which incentivise consumers to shift energy use away from peak times.

Reduce and decarbonise transport

The National Transport Strategy for Scotland has set a target to reduce car kilometres travelled by 20% by 2030, and further demand changes across all travel modes will be necessary to achieve a fully decarbonised transportation system by 2045.[25] Achieving this shift requires a coordinated approach focused on shifting toward more sustainable modes like active travel and public transport.

There are rapid ongoing changes in how people and goods travel that impact not just car mileage, but also van and HGV mileage. This includes new transportation technologies, evolving work and commuting behaviours stemming from the COVID-19 pandemic, and an increase in online services and online shopping. These wider shifts should also inform decisions and actions taken in Dundee going forward.

Dundee is leading in transport decarbonisation, with more public EV chargers per capita and the highest proportion of zero emission local authority vehicles in the country. Decarbonising transportation will require a full transition to zero emission vehicles by 2045, enabled by vehicle fleets shifting to low emission vehicles, expanded public charging infrastructure, incentives for EV uptake in the private sector, and monitoring new technologies like hydrogen fuel cell vehicles.

Many residents do not have off-street parking; 53% live in flats or multi-unit dwellings and will rely on on-street public chargers to enable EV uptake. Installing more public EV charging points, including rapid and fast chargers at workplaces, travel hubs, and destinations, will be crucial for a just transition. Homes with off-street parking will require home charging installations, coupled with smart energy use. By 2045, at least 225 MW EV charging capacity will be required across Dundee.

EVs offer immediate emissions reductions potentials for passenger cars, vans and some heavier traffic such as buses and HGVs. The Council can lead by continuing to electrify its own fleets whilst working with the DCLG partners and other key stakeholders to shift away from petrol and diesel vehicles. Monitoring the role of local green hydrogen production and refuelling stations could further explore the potential of hydrogen in decarbonising freight transport.

4. Priority intervention themes
Focus areas for the delivery of the LAEP

Cross-cutting themes across priority intervention themes

Skills

To address the skills shortage in the decarbonisation sector, a dedicated skills and training programme should be developed in collaboration with key supply chain partners. This initiative will help build a resilient workforce capable of meeting the installation rates required to achieve the scale of retrofit necessary to meet energy efficiency targets. Furthermore, the quality of these training programmes will contribute to ensuring that the work delivered meets acceptable standards, thereby building confidence in the local supply chain.

Finance

A significant barrier to deploying energy efficiency measures, heat pumps, and rooftop PV systems is the high upfront cost of installation. To address this, the Council and the DCLG should leverage available government incentives to support the adoption of building decarbonisation technologies.

For privately owned buildings, the Council and the DCLG could clearly promote and signpost any active funding schemes that cover or contribute towards the upfront costs of these technologies. This could involve creating informative resources, hosting workshops, or providing one-on-one consultations to ensure building owners are aware of and can access these financial supports.

Additionally, the Council and the DCLG could collaborate with industry partners to explore innovative funding mechanisms. This might involve developing financing programmes that spread the cost over time, partnering with financial institutions to offer low-interest loans, or creating public-private partnerships to subsidise initial expenses. By investigating and implementing these potential finance solutions, the Council and the DCLG can help make the initial investment in energy efficiency measures, heat pumps, and rooftop PV systems more affordable and manageable for building owners.

Communication and engagement

The transition to a decarbonised energy system will require not only complex technical interventions but also a cultural shift in how the energy system is perceived. Community awareness and engagement in energy projects are critical for ensuring successful delivery.

The Council and the DCLG can foster this necessary buy-in by collaborating with community energy groups. Involving these groups in the decision-making process can ensure that the community's perspectives and concerns are addressed. This collaborative approach helps to build trust and transparency, making community members feel more invested in the outcomes of the projects.

When a community is actively engaged in the development and delivery of energy projects, its members become more familiar with the technologies being implemented. This familiarity can demystify the technology, making its benefits more apparent and understandable. As a result, the community is more likely to support and advocate for these projects.

The rollout of technologies should be accompanied by a clear communication and engagement plan. This plan should explain the benefits of the technology, as well as details about installation, operation, and maintenance.

4. Priority intervention themes
Targets and actions

Overview of the challenge

Scale of the challenge

Table 4.1 sets out the scale of change required for each priority intervention area to reach an optimised future energy system by 2045. The number of heat pumps installed may be higher if the energy efficiency of hard-to-retrofit properties can be improved to a standard suitable for heat pumps.

The change in vehicle mileage presented in Table 4.1 is based on a study undertaken on behalf of Transport Scotland to understand the reduction in mileage required to meet net zero targets[38]. It is acknowledged that achieving this reduction in vehicle kilometers, particularly for freight transport, is challenging and will require additional national interventions beyond those outlined in this plan. If the scale of vehicle mileage reduction set out in Table 4.1 is not achieved, additional EV charging capacity will be needed to support the electrification of transport in Dundee.

Identifying area-based actions

The action plan set out in Chapter 5 details actions that are applicable throughout Dundee. However, detailed modelling was conducted at primary substation level to assess specific challenges and opportunities within different areas of the city. By analysing the results in each substation area, priority actions for each substation area have been identified.

These follow the seven area-based actions set out in Figure 4.2, grouped by priority intervention area.

Figure 4.3 on the following page illustrates the priority actions for each substation area. Although all actions identified in the plan will be relevant to all areas in the long-term, this map highlights the immediate priorities and potential areas for pilot projects.

Table 4.1: Area wide rollout needed by 2045

Action category	Scale required
Homes retrofit	~ 69,600
Buildings with HPs installed	~ 42,900
Properties connected to HNs	~ 21,000
Rooftop PV panels	~ 400,400
Home batteries (with PV)	~ 13,200
Fast chargers installed*	~ 15,500
HGV mileage reduction	15%
Bus use increase	10%
Van mileage increase**	10%
Car mileage decrease	20%

*Assuming the installation of 7-22kW EV chargers
**Van mileage increase limited to 10% in comparison to current projected increase of 43% by 2045

Engage with non-domestic properties
The substation area contains a high proportion of non-domestic properties. Buy-in and action from non-domestic building owners will be required to decarbonise properties in these areas.

Collaborate with neighbouring LAs
The substation area overlaps significantly with a neighbouring local authority. Collaboration will be required to understand if network upgrades will be required in these areas.

Install individual heat pumps
The substation area has a higher proportion of properties suitable for heat pump and sufficient network capacity. Projects to decarbonise heat using heat pumps could be targeted at this area.

Develop heat networks
The substation area contains a high proportion of properties within a prioritised heat network zone. The capacity of the electricity network should be considered when developing feasibility studies for heat networks as discussed on page 42.

Investigate opportunities for hard-to-retrofit homes
The substation area contains a high proportion of hard-to-retrofit homes. Efforts should be made to understand the extent of retrofit possible these and the most appropriate heat decarbonisation option.

Install EV chargers
The substation area is likely to have a high demand for electric vehicles. These areas could be investigated for on-street charging.

Reinforce network to enable decarbonisation
The substation associated with the substation area is highly likely to required network reinforcements to meet the modelled demand and to enable electrification of heating and transport.

Figure 4.2: Area-based actions

4. Priority intervention themes
Area-based actions

Figure 4.3 presents area-based actions for each primary substation distribution area. For a more in-depth description and justification of each action, refer to page 57.

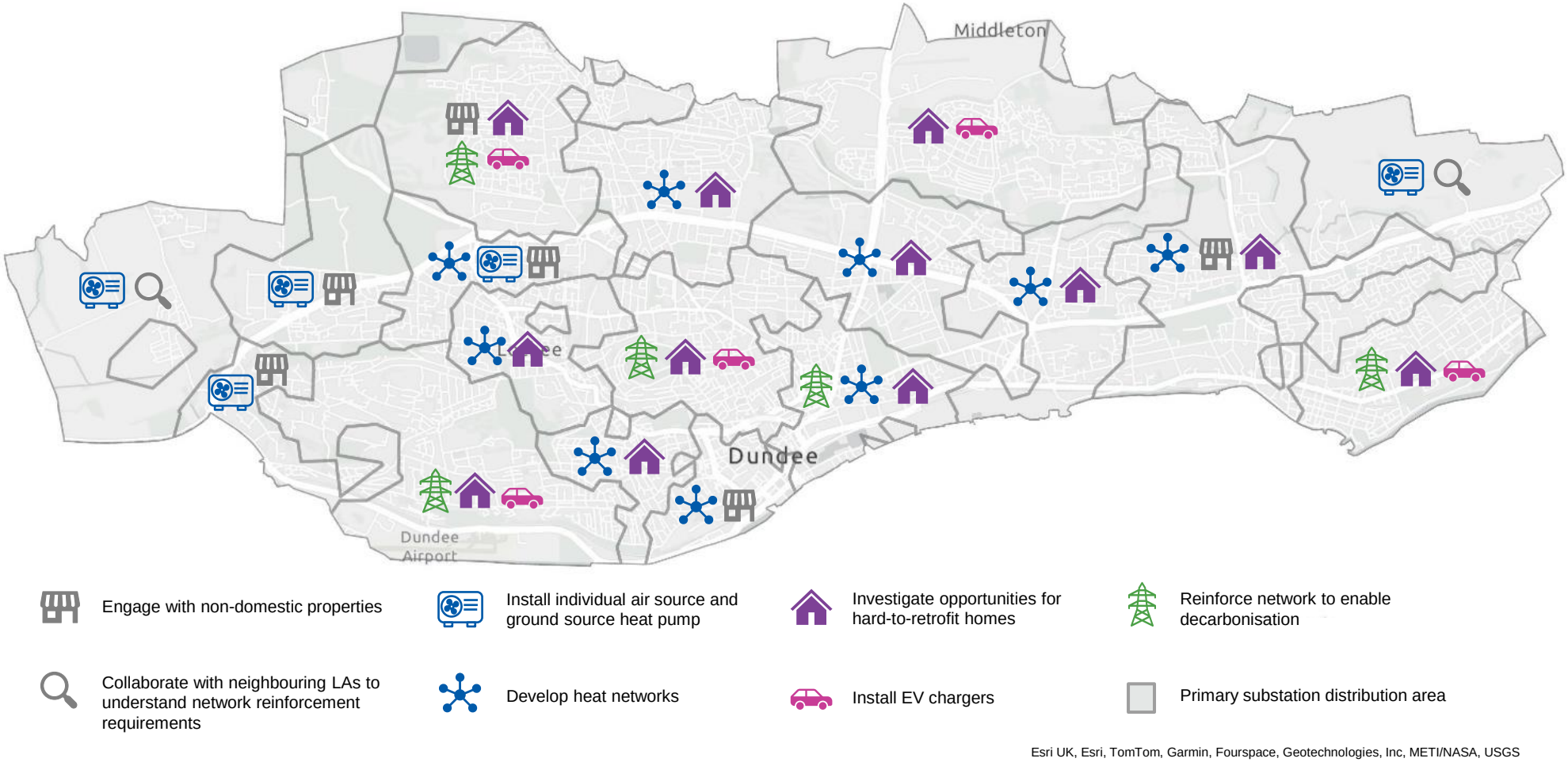


Figure 4.3 Priority area-based actions for each primary substation distribution area

4. Priority intervention themes
Wider benefits

Wider benefits and a just transition

Transitioning to a low carbon, resilient energy system will deliver significant co-benefits for residents and businesses across Dundee beyond emissions reductions alone. The priority interventions identified this LAEP, can create local jobs, reduce energy bills, alleviate fuel poverty, and improve public health.

It is estimated that delivering Dundee's clean energy transition will require a specialised regional workforce of around 25,500 job-years (~1,300 full time jobs) in areas like renewable energy installation, building insulation, EV mechanics, heat pump maintenance, and more between now and 2045. While its likely much technology manufacturing will occur outside the region, local employment opportunities will be generated for on-site installation, operation, and servicing of these local systems. For example, installing and maintaining, heat pumps, heat networks, solar panels, and EV chargers at scale will require specialist knowledge and skills training which can be facilitated through local initiatives such as capacity building, training programmes and trade apprenticeships which can empower local actors to access green jobs and support the local energy system transition.

The extensive building upgrades and fuel switching outlined in this LAEP will ensure affordable warmth for households throughout the city. By improving insulation, replacing inefficient heating systems, and transitioning buildings away from fossil fuel reliance to low-carbon alternatives, Dundee can significantly reduce fuel poverty currently experienced by 31% its residents.[4]

By electrifying all vehicles in Dundee by 2045, the city will eliminate petrol and diesel tailpipe emissions, resulting in cleaner air for its inhabitants. Reduced exposure to harmful pollutants such as particulate matter, nitrogen oxides, and carbon monoxide has been conclusively linked to improved respiratory health and lower risks of cardiovascular disease. These public health co-benefits will be experienced across Dundee.

To ensure a just and inclusive energy transition, Dundee will need to implement policies and investments that maximise these benefits while supporting affected workers and communities. This can be achieved through collaboration with key regional stakeholders across the public, private and third sector, such as local businesses and community groups, and colleges and universities like the University of Dundee and Abertay University. Such partnerships will facilitate reskilling and re-employment programmes, ensuring that no one in Dundee is left behind by the low-carbon shift. By working together, Dundee can create a sustainable future that benefits all its residents while positioning itself as a leader in Scotland's green energy transition.

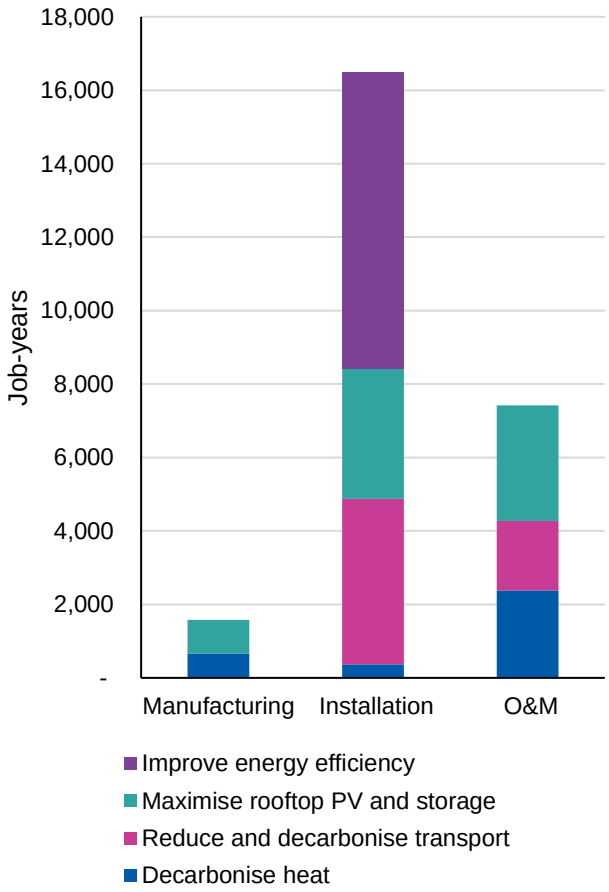


Figure 4.4: Job-years provided by priority intervention area

Chapter 5: Actions and recommendations

5. Actions and recommendations
Introduction to the action plan

Plan outline

The LAEP action plan will set out a high level routemap showing recommended actions to enable the delivery of the LAEP, in the context of wider policy targets and decisions.

Figure 5.1 on page 62 presents a long-term roadmap from now until 2045, with proposed targets mapped according to their associated priority interventions. Additionally, 10 overarching actions have been identified for the medium term, which are to be undertaken between now and 2030. Each overarching action has its own roadmap, detailing a set of sub-actions. Overarching actions are assigned to one or more of the priority intervention themes introduced in Section 4:

1. Improve energy efficiency

2. Decarbonise heat

3. Maximise rooftop PV and storage

4. Reduce and decarbonise transport

5. Ensure network resilience

Before launching the LAEP program, the Council and the DCLG need to mobilise resources, secure necessary funding and establish governance and monitoring processes. A suggested phased approach to implementation is outlined in Figure 5.5 on page 87.

Actions require joined up but differentiated efforts by the stakeholders to deliver the LAEP's objectives. Opportunities and enablers across each intervention area have also been identified to support the delivery of the overarching priority intervention areas. These are shown on page 63.

It is important to note that while this routemap lays out a proposed sequence of actions and timelines, it should be viewed as a set of recommendations rather than definitive requirements. Despite having identified an optimised energy system and a pathway to deliver this system, uncertainty remains over the exact form of the decarbonised energy system in 2045.

The actions identified here are resilient to this uncertainty and can be taken now to create an enabling environment to maintain the ability to meet the 2045 and interim targets. However, future changes will require the plan to adapt, and monitoring of the plan will be crucial. Annual reviews and full updates in line with the local plan refresh cycle are recommended to ensure the actions and timelines remain optimal as the decarbonisation landscape evolves.

The routemap provides a focused view of actions that will be taken in the coming decade while also showing key milestones on the decarbonisation trajectory to 2045. Each intervention requires five key elements to be successful:

1. Mobilising finance
2. Strong and consistent policy framework
3. Delivery owners
4. Local engagement and ownership
5. Supply chain and skills readiness

The role that the Council and the DCLG can play for each intervention will vary. Some actions will call for direct intervention in the material delivery of programmes, while other interventions will require the Council to act as a facilitator for market driven change.

The following section provides further detail on each of the actions within each intervention area, as well as the key asks of others in addition to the Council and the DCLG.

5. Actions and recommendations

Long-term routemap

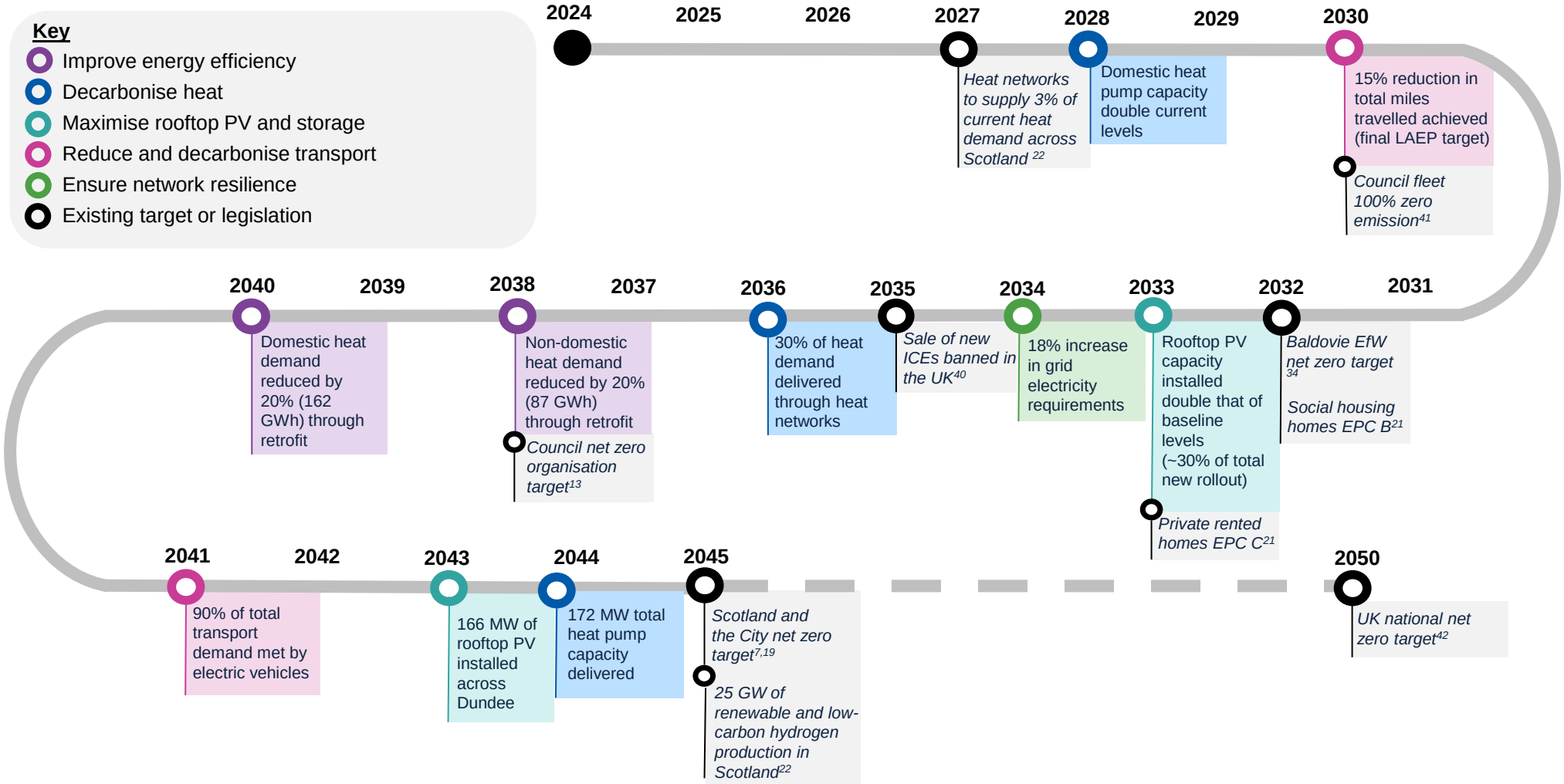


Figure 5.1: Dundee's long-term routemap of targets

5. Actions and recommendations

Opportunities and enablers matrix

This table presents a matrix of opportunities and enablers, including funding mechanisms, relevant tools, resources and studies, and other drivers and enablers for each of the priority intervention themes.

Table 5.1: Action opportunities and enablers

	Funding mechanisms & incentive examples	Tools/resources/studies	Other drivers and enablers
Improve energy efficiency	Private Rented Sector Landlord Loan, Small Medium Enterprise Loan Scheme, Area-based Schemes, Warmer Homes Scotland, Home Energy Scotland Grant and Loan Scheme, Energy Company Obligation Schemes, Dundee Climate Fund	Scarf, Energy Savings Trust (EST), Home Energy Scotland, Dundee Citizens Advice Bureau, Dundee Energy Efficiency Advice Project (DEEAP), Energiesprong, Changeworks, Council Local Housing Strategy	Housing to 2040, Fuel Poverty Act, National Planning Framework 4 (NPF4)
Decarbonise heat	Scotland's Heat Network Fund (SHNF), Green Heat Innovation Support Programme, Home Energy Scotland Grant and Loan Scheme, Council Green Business Grants and Loans, UK Infrastructure Bank, Scottish National Investment Bank, Public Sector Decarbonisation Fund	Heat Network Support Unit, Home Energy Scotland, Scarf, Energy Savings Trust (EST). Scottish Climate Intelligence Service, Baldovie and Caird Park Heat Network Feasibility Studies	Heat Networks (Scotland) Act, Heat in Buildings Bill, Building Assessment Reports (BARs)
Maximise rooftop PV and storage	Community and Renewables Energy Scheme (CARES), Smart Export Guarantee (SEG), Power Purchase Agreements (PPA), Dundee Climate Fund	Scotland's draft Energy Strategy and Just Transition Plan, Energy Statistics for Scotland, Community Energy Scotland, Local Energy Scotland, Transition Dundee	Improved fuel security and resilience Unlocking energy system flexibility
Reduce and decarbonise transport	Cycling Friendly Programme (Cycling Scotland), Places for Everyone (Sustrans), Cycling, Walking and Safer Routes Fund, Active Travel Infrastructure Fund, Bus Partnership Fund. The OZEV EV Domestic Chargepoint Grant, EST Domestic Chargepoint Grant, Used Electric Vehicle Loan, Business chargepoint funding, Scottish Zero Emission Bus challenge fund, Low Emission Zone Support Fund	Dundee Sustainable Transport Development Plan, Transport for Scotland's National Transport Strategy Third Delivery Plan, Network Development Tool, Bus Service Improvement Partnership, Drive Dundee Electric, Mission Zero for transport	Under 22 Free Bus travel, Scotland Car Demand Management Framework (2025), Extent of Commercial Bus Network Access to chargepoints via ChargePlace Scotland, phasing out of fossil fuel vehicles
Ensure network resilience	SSEN flexibility services SSEN RIIO-ED3 price control SGN RIIO-GD3 price control DNO Funded, with Ofgem approval Time-of-use tariffs (TOUTs) and	SSEN LENZA data tool SSEN DSO Acceleration Strategy National Grid ESO and Octopus Energy domestic flexibility trial	Increased capacity on the electricity network Whole system approach with gas network supporting electricity resilience

5. Actions and recommendations
Control and influence in delivering the LAEP

Control and influence

This LAEP outlines a potential zero-carbon energy system for Dundee by 2045, and the actions needed to achieve this.

To deliver the LAEP, the Council and DCLG members will need to decarbonise assets under their direct control, such as public buildings and transport fleets. They must also drive wider area decarbonisation through policy, incentivising, collaboration and community engagement.

The Council and the DCLG's sphere of influence in actions includes:

- Budget and finance
- Defining and helping to achieve project outcomes
- Identifying priorities
- Identifying potential risks and monitoring risks
- Monitoring timelines
- Monitoring the quality of the project as it develops

The following pages detail each of the proposed actions, and Figure 5.2 illustrates the varying levels of influence and control the DCLG can exert for each action. DCLG members will have different levels of control in delivering each action, requiring a coordinated approach where the most appropriate group takes ownership of individual actions to maximise effectiveness.

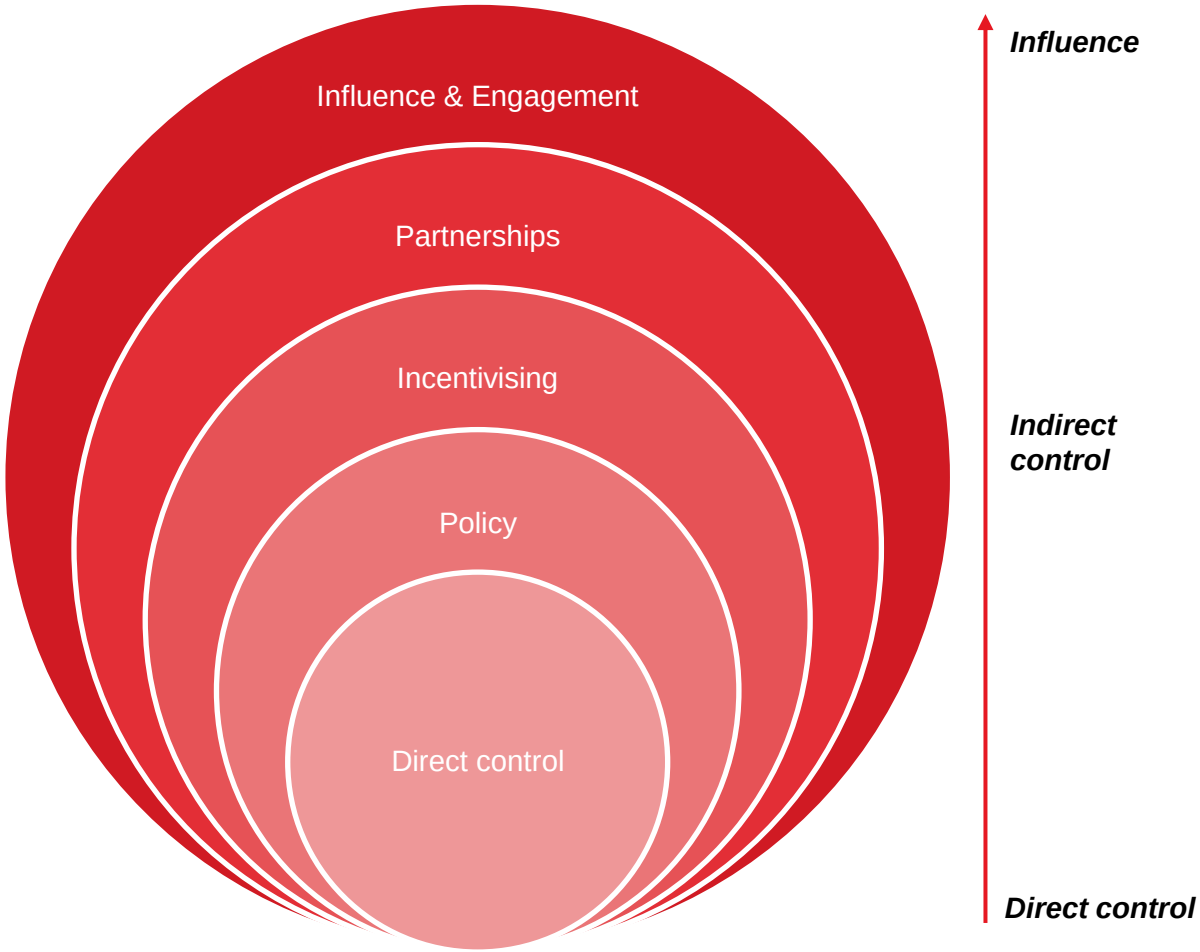


Figure 5.2: Control and influence

5. Actions and recommendations
Short-medium term actions

Overarching actions

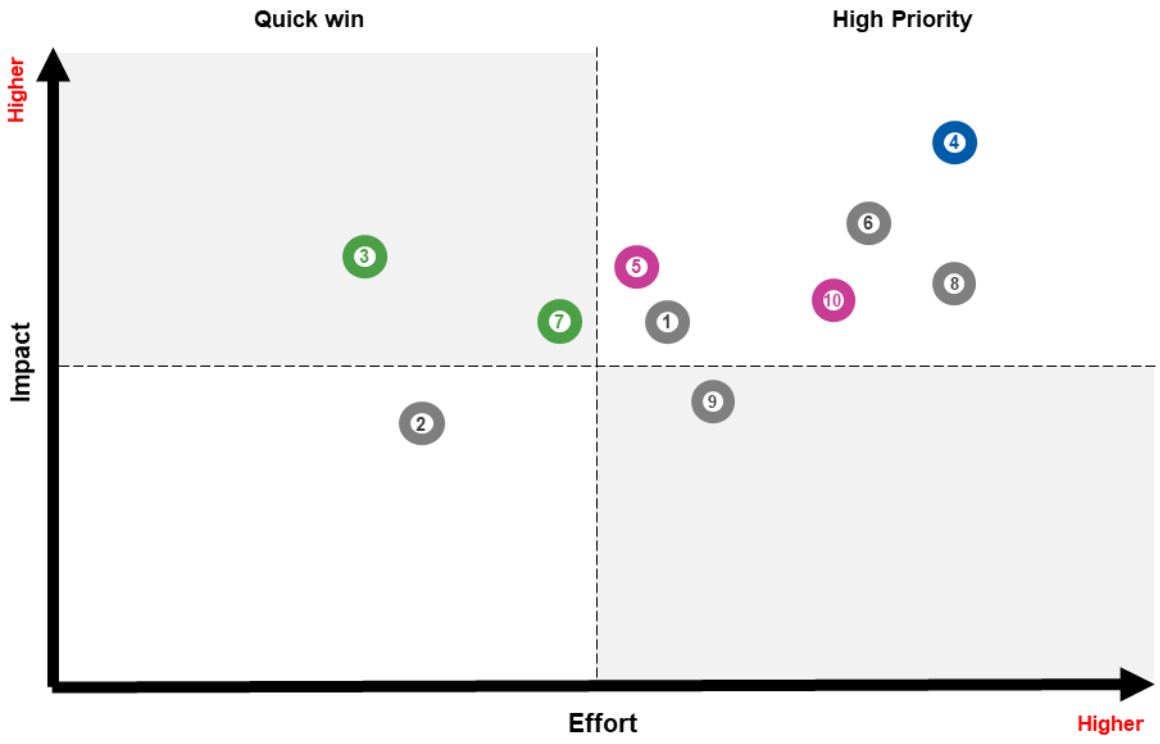
A set of overarching actions has been identified based on evidence gathered from the modelling results and engagement with the Council, the DCLG and other relevant stakeholders. These actions are planned for the short to medium term, extending up to 2030. In Figure 5.3 below, they have been prioritised according to the level of control the Council and the DCLG have in implementation.

Figure 5.3: Dundee's overarching LAEP actions

5. Actions and recommendations

Action priority matrix

The overarching actions in this LAEP were ranked based on how much effort would be required by the action owner and other stakeholders involved to implement the action and how much impact the action would have in reaching net zero in Dundee, relative to other actions presented. The result is the action priority matrix below which identifies high priority and quick win actions.



Overarching Actions Legend

1 - Decarbonise public-owned building stock

2 - Foster coordination and collaboration with other local authorities

3 - Collaborate with network operators to inform energy planning

4 - Develop heat networks

5 - Implement a strategy to reduce transport demand and encourage sustainable travel

6 - Promote the growth of the supply chain and foster confidence in local suppliers

7 – Raise awareness of grid flexibility opportunities to households and businesses

8 - Identify and implement place-based energy initiatives to target outreach and achieve economies of scale

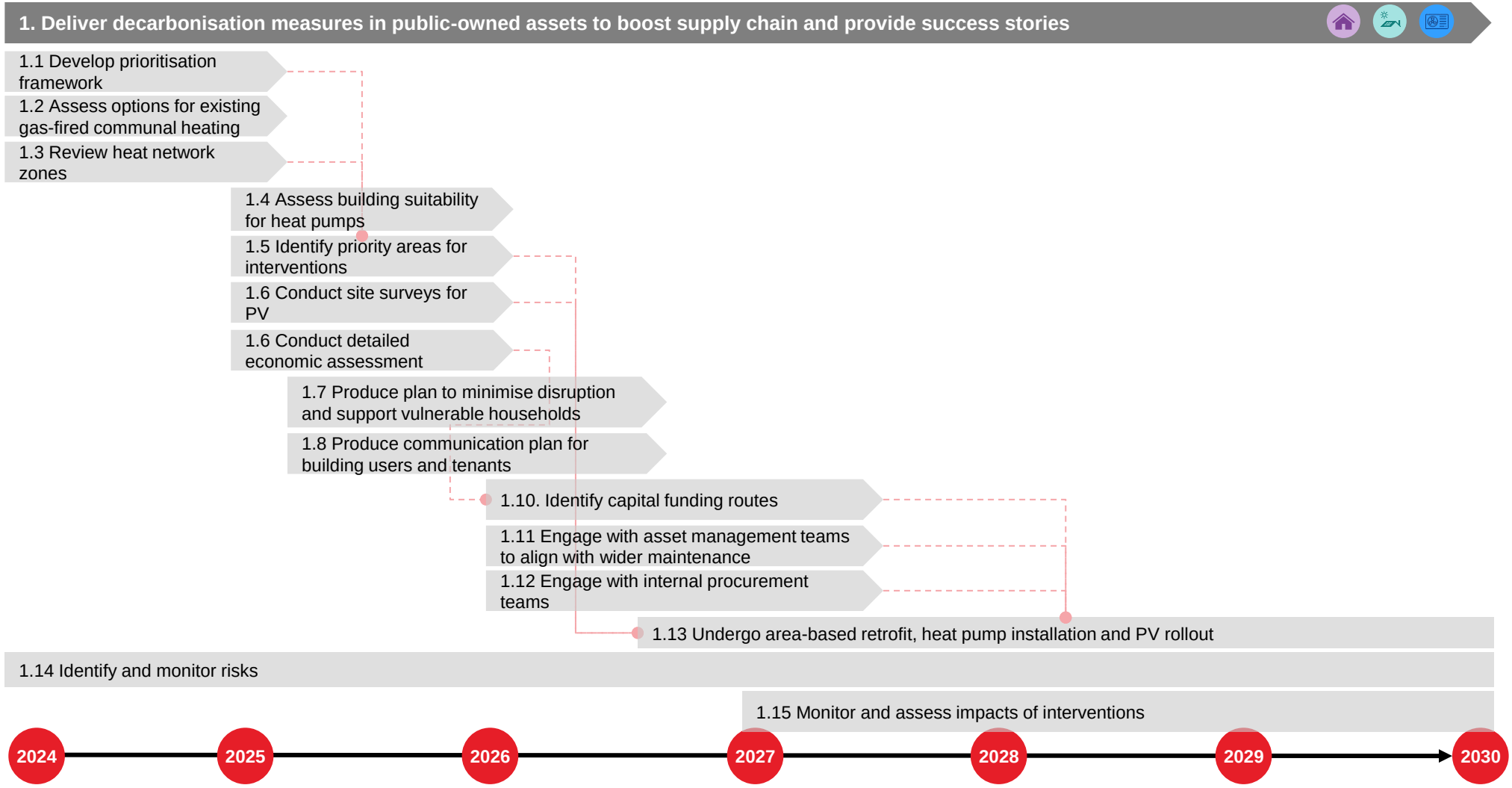
9 - Promote advice service for homeowners and business

10 - Deliver infrastructure to support a decarbonised transport system

Figure 5.4: Prioritisation of overarching LAEP actions

5. Actions and recommendations

Medium term routemap



5. Actions and recommendations
Descriptions of overarching actions

1. Deliver decarbonisation measures in public-owned assets to boost supply chain and provide success stories

Description

Public sector organisations, including the Council and relevant members of the DCLG, should focus on deploying energy efficiency and heat decarbonisation measures across their own properties. This retrofit programme represents a quick win, as the public sector organisations have direct control over these buildings and can efficiently target interventions.

To prepare for the delivery of energy efficiency measures, heat decarbonisation solutions and solar PV, the organisations should develop a prioritisation framework that clearly outlines the criteria and process for prioritising retrofit projects across its property portfolio. Organisations should consider conducting detailed site surveys to assess the scale of measures needed, resources required, and costs involved in retrofitting the building stock. For the Council, these assessments should align with the LHEES delivery plan and the actions set out in the Net Zero Transition Plan 2024-2030.

The tenants currently occupying Council buildings will be a primary consideration in this retrofit programme. A detailed plan will need to be produced to minimise disruption caused by construction work. For all organisations, an engagement plan will be developed to keep tenants and building users informed about the planned work and clearly explain the benefits to them.

Organisations should also develop a robust plan for funding arrangements, identifying available capital funding routes. In addition, collaborating with internal procurement teams early on will be important to share intelligence on the scale of works, investment requirements, and delivery timescales

Throughout the programme, public sector organisations should monitor the impacts of interventions to ensure the intended benefits are being realised by consumers. This monitoring should include regular data collection and analysis on energy usage, cost savings and tenant satisfaction.

Key considerations

Benefits

Public sector organisations will be able to promote success stories from the programme, which will build confidence across the community and hopefully encourage private sector building owners to undertake retrofits themselves. An increased demand for retrofit services and materials can also lead to the growth of local businesses and the development of specialised skills.

Risks

There is currently a lack funding to cover or contribute towards the required capital investment required for such projects. Further, there may be resistance from tenants and building users in agreeing to the required works in their properties. There is also a potential shortage of local installers to complete the rollout across the entire public sector building stock, which could result in delays to programme delivery.

Level of Council control

In reference to Figure 5.2 on page 64, the Council has *direct control* over its assets and can *influence and engage* other public sector organisations.

Stakeholder involvement

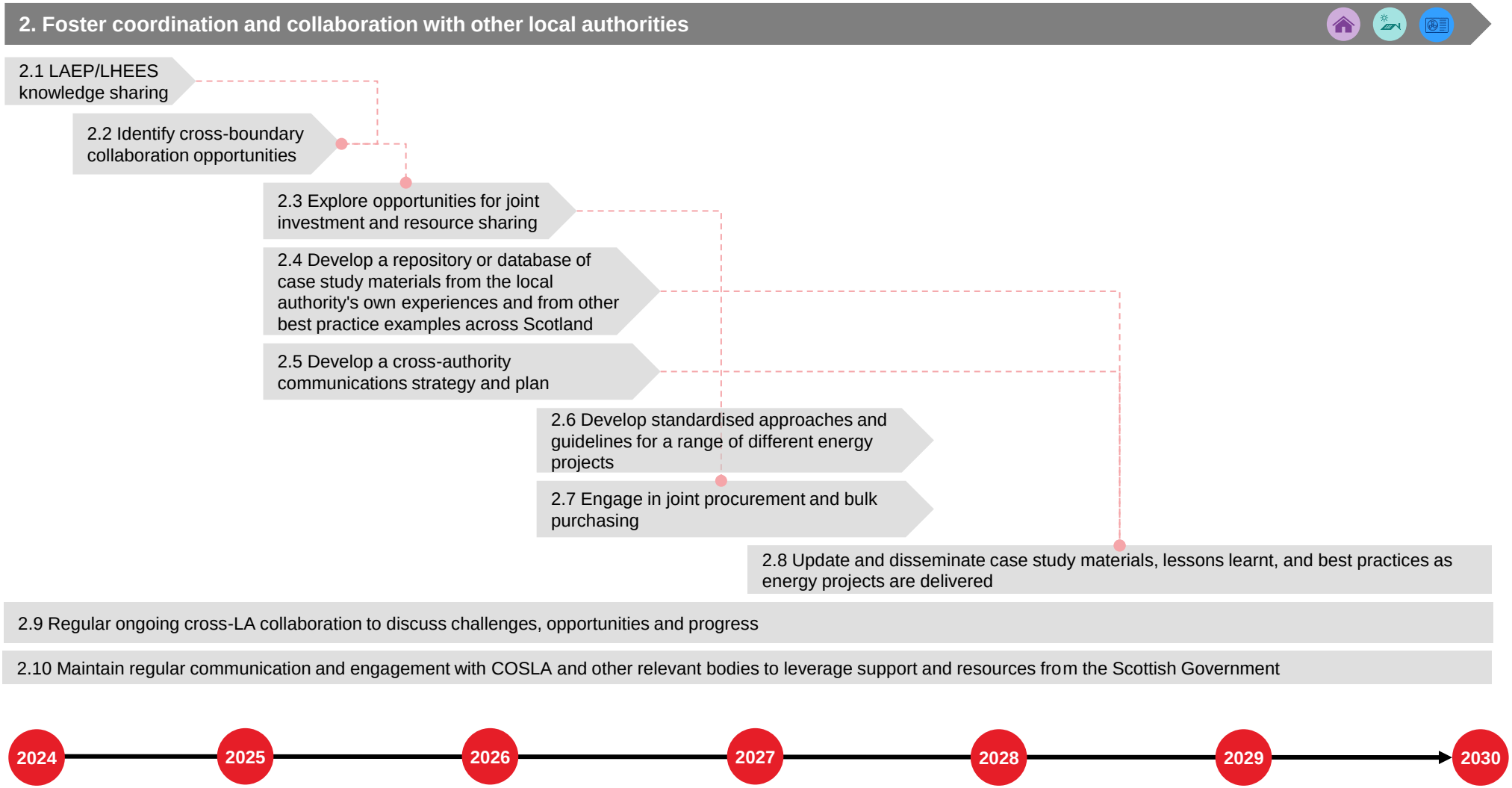
Whilst public sector organisations, including the Council and the DCLG, will lead on delivering the programme, they may wish to seek further support by outsourcing some of the tasks, like site assessments, to an external provider.

Council property management, schools, retrofit construction companies, residents, and housing associations could also be engaged with throughout the delivery of this programme.

Ask from others

To ensure this programme can be delivered successfully, cooperation from the key stakeholders above will be required. Furthermore, support and guidance from Scottish Government will help leverage available financing incentives.

5. Actions and recommendations
Medium term routemap



5. Actions and recommendations
Descriptions of overarching actions

2. Foster cooperation and collaboration with other local authorities

Description

Reaching decarbonisation targets is a challenge faced by all Scottish local authorities. Therefore, it is important for councils to communicate regularly, share lessons learned from decarbonisation projects, and collaborate where project synergies exist to realise the benefits from economies of scale.

The Council should initially aim to promote knowledge sharing across local authorities bordering Dundee by hosting a stakeholder session to provide an overview of key findings and delivery plan actions from the LHEES and LAEP. Furthermore, additional sessions should be held with other neighbouring local authorities, such as Perth and Kinross Council, to identify specific areas for collaboration. By comparing delivery plans, the Council will be able to identify synergies in various projects and uncover potential opportunities for delivering cross-boundary initiatives.

If opportunities for collaboration are identified, councils could undertake joint initiatives that support effective project delivery. One example would be to develop a cross-boundary communication plan aimed at driving engagement around projects across different local authorities. This plan could include coordinated outreach efforts, joint public information campaigns, and shared digital platforms to keep all stakeholders informed.

Leveraging previous experience across the different councils, guidelines for delivering a range of different energy projects could be developed. These guidelines would be based on shared experiences from previous projects, ensuring that learnings are captured and applied.

To maintain momentum and ensure continuous improvement, the Councils should regularly engage on decarbonisation initiatives. Councils should dedicate time to disseminating their findings to ensure that the lessons learned are recorded and shared widely. Hosting a recurring forum would be beneficial for discussing progress, sharing findings, and updating each other on new developments.

Key considerations

Benefits

This action facilitates the sharing of best practices and lessons learned from successful decarbonisation projects, including retrofit schemes, enabling local authorities to replicate plans, reduce costs and avoid common issues. Pooling opportunities across multiple local authorities could make projects more financially attractive to investors due to economies of scale and larger project sizes.

Risks

There may be resource constraints within local authorities to compile study materials.

Decarbonisation projects and retrofit schemes may also vary significantly in scope, technology and outcomes, making it challenging to generalise best practices and replicate success factors for different projects. Finally, the Council may face difficulty in coordinating with other local authorities and community energy groups, due to differing priorities.

Level of Council control

In reference to Figure 5.2 on page 64, this action leverages Council has *direct control* over engagement with other councils in delivering joint programmes. However, the Council is also reliant on *partnerships* to instigate collaboration and identification of opportunities.

Stakeholder involvement

The Council and other Scottish councils that are willing to collaborate could lead on the delivery of cross-boundary projects.

Leveraging support from existing cross-authority groups such as COSLA and community energy groups could also facilitate partnerships across Councils.

Ask from others

For cross-boundary opportunities to be identified, other Scottish Councils must be willing to collaborate on delivering decarbonisation initiatives.

5. Actions and recommendations
Medium term routemap

Key
- Ends at specified date
- Ongoing action
- Dependency

3. Continue to collaborate with network operators to inform energy planning

- 3.1. Leverage the LENZA platform and the output of LAEP to produce an evidence base for network planning
- 3.2. Engage with SGN to gather insights into decarbonisation plans for existing gas infrastructure and communicate relevant Council plans
- 3.3 Support SGN in producing their business plan for the RIIO-GD3 price control period
- 3.4. Engage with SSEN for strategic heat network planning
- 3.5. Support SSEN in producing their business plan for the RIIO-ED3 price control period
- 3.6. Prioritise and direct energy efficiency funding toward areas with identified network constraints
- 3.7. Explore opportunities for joint funding and cost-sharing mechanisms with network operators for energy projects or network upgrades that benefit multiple parties
- 3.8. Continuously update the LENZA platform as new data becomes available and energy projects are delivered
- 3.9. Maintain open and regular communication with SSEN and SGN through the Energy Systems Working Group to share updates, discuss challenges and coordinate efforts
- 3.10. Monitor the development of the UK Hydrogen Industry and engage with SGN to explore potential applications for hydrogen in hard to decarbonise assets in Dundee.

2024 — 2025 — 2026 — 2027 — 2028 — 2029 — 2030

5. Actions and recommendations
Descriptions of overarching actions

3. Continue to collaborate with network operators to inform energy planning

Description

As the energy system decarbonises and the deployment of zero and low-carbon technologies accelerates, network infrastructure must be reinforced to ensure reliable energy supply that meets growing demand. This transition requires close collaboration with SSEN and SGN to inform them of upcoming plans and projects aimed at implementing energy efficiency measures, heat decarbonisation solutions, and renewable energy generation in Dundee.

The dataset gathered from this LAEP, once uploaded to the LENZA platform, will serve as a valuable resource for SSEN's network planning. The Council and the DCLG should ensure that SSEN receives project data even after the LAEP's completion, maintaining an up-to-date evidence base that reflects the latest developments and insights across the local energy system.

By collaborating closely with SSEN and referring to findings in the LAEP and LHEES, heat network energy centres can be strategically identified to minimise the need for grid upgrades.

Engaging with SGN is equally important to understand their development plans and associated impacts on the local energy system. This could include assessing the potential for integrating low carbon technologies such as hydrogen production and storage and ensuring the infrastructure is adaptable to future energy needs. Collaborative efforts with SGN might involve joint feasibility studies and pilot projects to understand the opportunity for hydrogen application in Dundee.

The Council and the DCLG should also support the development of SGN's RIIO-GD3 and SSEN's RIIO-ED3 Business Plans. The RIIO price control framework, governed by Ofgem, determines the regulated revenues and required outputs for DNOs and GDNs. These Business Plans detail the activities DNOs and GDNs intend to undertake and their associated costs, which will be subject to Ofgem's review and approval.

Key considerations

Benefits

Strategic energy planning will reduce project costs and the likelihood of any delays associated with necessary reinforcement. By providing input early in these business planning stages, the Council and the DCLG can also help shape plans and align with local energy goals.

Risks

The success of this action relies heavily on strong communication between the Council, the DCLG and network operators. Resource constraints from either party may limit or restrict the level of engagement. For instance, if the Council has limited resources, they might be unable to fulfil data requests and provide support for delivering projects.

Level of Council control

In reference to Figure 5.2 on page 64, this action drives change by leveraging *partnerships* with network operators to implement sub-actions successfully.

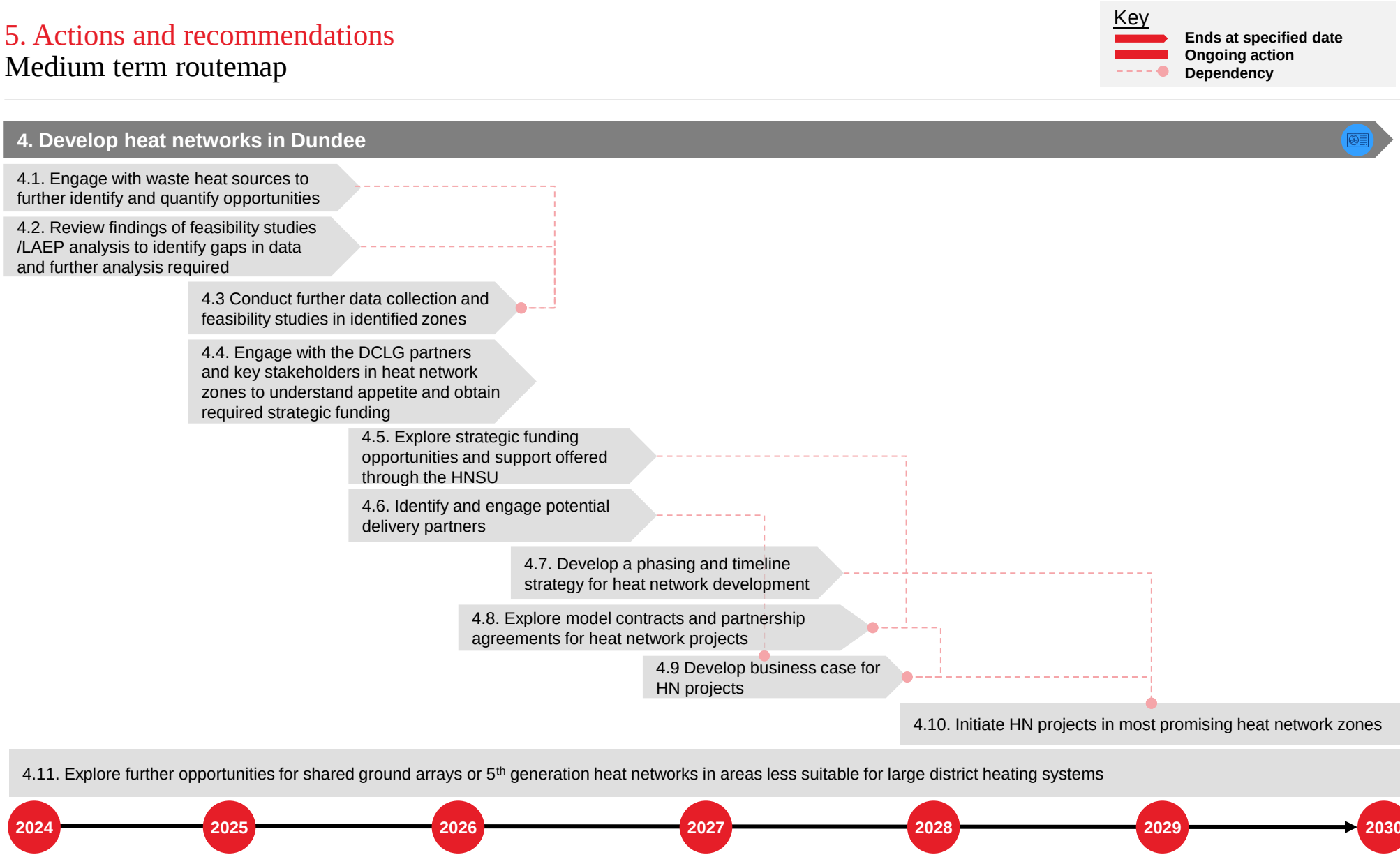
Stakeholder involvement

The Council, the DCLG, SGN and SSEN should aim to sustain strong communication and engagement through the DCLG's Energy Systems Working Group and other relevant local forums.

Ask from others

The Council will need network operators to continue working closely with them across the LHEES and LAEP initiatives. The DCLG and its Energy Systems Working Group are ideal forums for updating on progress and maintaining a strong partnership. The network operators should also provide the Council with a request for information, detailing the data they require to inform their business planning.

5. Actions and recommendations
Medium term routemap



5. Actions and recommendations
Descriptions of overarching actions

4. Develop heat networks in Dundee

Description

The Council's LHEES identifies five priority areas for heat network zones in Dundee. Further investigation is required to determine the feasibility of developing heat networks in these areas.

In the early stages of heat network development, the Council could initially review findings from existing feasibility studies (e.g. Baldovie and Caird Park Heat Network), the LHEES and the LAEP. This would help identify any gaps in knowledge or the data that need further analysis. This process would involve engaging with owners of potential heat sources, such as waste heat from sewers, to assess their capacity and interest, as well as with building owners who have large heat demands. The Council should also work with the DCLG to monitor strategic funding opportunities aimed at supporting heat network projects. In preparation for applying to these funding schemes, the Council and the DCLG could begin engaging with key public and private stakeholders, including those identified in the LHEES. Early engagement can help foster potential partnerships for accessing investment and supporting project delivery. The Council could also work with the DCLG to explore various contracts and partnership agreements to formalise these collaborations. Examples include forming joint ventures, special purpose vehicles or public-private partnerships.

A phased timeline for heat network development should be planned to outline all the necessary tasks and their associated timescales, influenced by available funding and/or the stakeholders willing to act as delivery partners.

By gathering additional information, engaging with stakeholders to form potential partnerships, and producing a detailed delivery programme, the Council will be well-positioned to write a business case for initiating heat network development in the most suitable zones.

The Council could also explore innovative approaches such as shared ground arrays or fifth-generation heat networks to address heating needs in areas where traditional large district heating systems may not be suitable.

Key considerations

Benefits

This action will build on the LHEES heat network zoning work to consider long-term delivery of viable heat networks. The benefits of heat networks utilising low-carbon heat sources include reduced emissions, improved energy efficiency, increased energy security, and potential for lower fuel costs for customers.

Risks

It is economically and logistically difficult to deliver heat networks of significant scale. Further, there is uncertainty over the business and policy environment to facilitate heat network development. Navigating technological challenges, such as adapting infrastructure to varying terrain or building types, will require strategic planning and collaboration among stakeholders.

Level of Council control

In reference to Figure 5.2 on page 64, the Council may have some *direct control* over heat network development but will also be heavily reliant on the willingness of DCLG partners and other key stakeholders to form *partnerships*.

Stakeholder involvement

The Council could identify a potential energy delivery partner to support with planning. Other stakeholders to engage with include MVV Environment Ltd, Scottish Water, external consultants, SSEN, other waste heat process owners/operators, residents and businesses.

Ask from others

Operators of potential waste heat sites to share data and energy efficiency plans so that the opportunity for waste heat offtake can be captured.

Cooperation from DCLG partners and other key stakeholders identified and willingness to input into the planning and delivery of heat networks.

5. Actions and recommendations

Medium term routemap

Key
- Ends at specified date
- Ongoing action
- Dependency

5. Implement a strategy to reduce transport demand and encourage sustainable travel

- 5.1 Review the Sustainable Transport Delivery Plan to identify opportunity areas for a joined-up approach
- 5.2 Establish a joint sustainable transport working group to lead on the delivery of the LAEP and Sustainable Transport plan
- 5.3 Identify projects for piloting mobility hubs and shared transport initiatives
- 5.4. Continue to develop routes identified for active travel network, including ‘Active Freeways’
- 5.5. Identify and secure funding routes
- 5.6. Continue to work with Tayside Bus Alliance to increase passenger numbers
- 5.7. Develop and launch public awareness campaigns highlighting the benefits of sustainable transport and active travel options
- 5.8. Launch a campaign to encourage residents to shop locally by partnering with local businesses
- 5.9. Identify and work with local delivery partners to implement efficient last mile delivery solutions
- 5.10. Advocate for and facilitate the provision of incentives and facilities to promote the adoption of active travel modes

2024 — 2025 — 2026 — 2027 — 2028 — 2029 — 2030

5. Actions and recommendations
Descriptions of overarching actions

5. Implement a strategy to reduce transport demand and encourage sustainable travel

Description

To reduce emissions from the transport sector, the city's transport landscape will need to be reshaped through the development and promotion of sustainable transportation options. Plans for delivering sustainable transport infrastructure are outlined in the Sustainable Transport Delivery Plan[12] and Tactran's Regional Transport Strategy[16]. The delivery of the LAEP should take a joined-up approach with these strategies, recognising that sustainable transport is intrinsically linked to the broader energy and environmental goals set out in this plan.

An initial step for delivery of this overarching action should involve a review of these existing plans to identify opportunities for collaboration across energy and transport. By establishing a dedicated working group, diverse expertise and perspectives can be brought together.

A key focus should be to deliver infrastructure projects such as smart transport hubs, improved destination cycle parking, and safe and accessible 'Active Freeways' in Dundee. Additionally, working with the Tayside Bus Alliance to identify and implement strategies to improve bus journey time reliability and integration of services will be essential to increase bus passenger use. The delivery of sustainable transport initiatives will rely on securing and allocating funding, as well as leveraging both local resources and external funding opportunities from regional and national bodies. Infrastructure projects should be complemented by the implementation of a public awareness campaign that educates residents on the benefits of sustainable transport options. This can also include partnerships with private businesses and employers, promoting shop local campaign and facilitating the provision of cycle parking and Cycle to Work schemes to promote the adoption of sustainable travel. Efforts should also focus on collaborating with local delivery partners to implement efficient last mile delivery solutions to reduce overall transport demand in the city.[36]

Key considerations

Benefits

This action will offer significant benefits, including reduced tailpipe emissions, improved air quality, enhanced public health, and potential economic gains from supporting local businesses. Initiatives could lead to a more liveable urban environment across Dundee.

Risks

Resistance to change from residents and businesses who are accustomed to current transportation patterns. Implementing infrastructure projects could lead to disruptions causing temporary inconvenience for residents. Benefits of initiatives may not be evenly distributed across Dundee, potentially exacerbating existing inequalities.

Level of Council control

In reference to Figure 5.2 on page 64, the Council exercises control directly by developing infrastructure, as well as influencing change through *partnerships*, *incentivising and engagement* to achieve the desired outcomes.

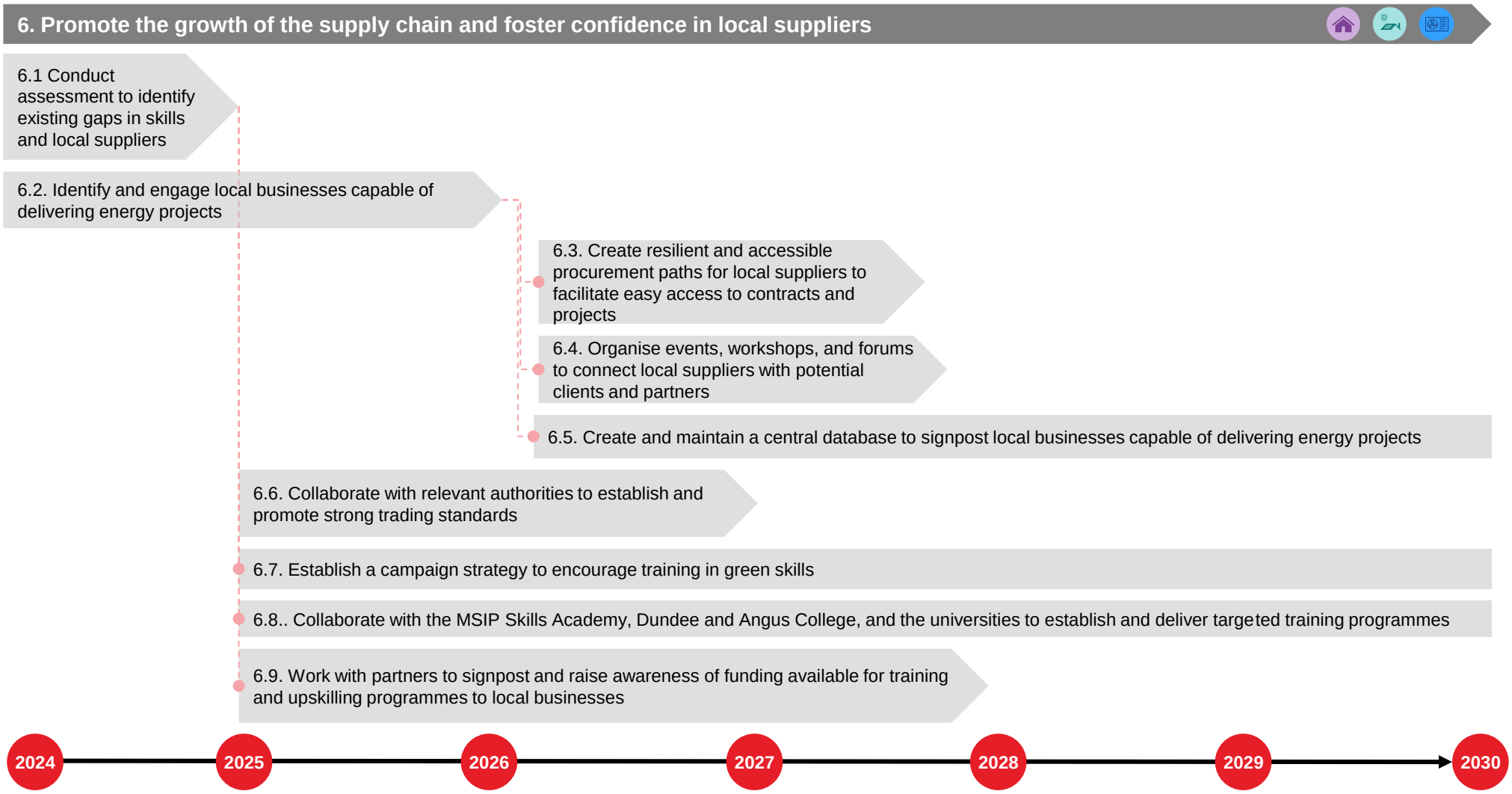
Stakeholder involvement

This action will require involvement from the transport and energy teams in the Council, as well as engagement with the DCLG, other local businesses and employers, transport providers, and infrastructure delivery partners. Residents will need to actively participate in and provide feedback on new initiatives.

Ask from others

The Council will need support from all stakeholders and leadership from the DCLG partners, as well as cooperation from the city's key stakeholders, to actively support the city's sustainable transport initiatives. This relies on businesses to adopt efficient travel systems, residents to embrace and provide feedback on new measures, government bodies to offer funding and policy support, transport providers to adapt their services and employers to promote sustainable commuting.

5. Actions and recommendations
Medium term routemap



5. Actions and recommendations
Descriptions of overarching actions

6. Promote the growth of the supply chain and foster confidence in local suppliers

Description

To achieve the rate of delivery required to reach Net Zero by 2045, Dundee will need a resilient local supply chain, capable of delivering retrofit at scale, developing heat networks and installing renewable energy and zero emission transport technologies.

The Council and the DCLG should focus their efforts on supporting the growth of the local supply chain. An initial step could involve conducting a preliminary assessment to identify any sectors where there is a deficit in skills or trained personnel. The findings from this study could then be used to develop training programmes. Working closely with Dundee and Angus College and the MSIP Skills Academy, the Council and the DCLG could support the design of new courses or tailor existing ones to address these identified skill gaps. Working with educational partners, the Council and the DCLG could support the development of a campaign strategy aimed at driving enrolment in these courses. This might involve marketing initiatives, informational sessions, open days, and partnerships with local media to raise awareness about the new opportunities in the green economy.

The Council and the DCLG should also look to build a trusted pool of existing installers, creating a central list of credible local businesses. This should be a regularly updated and maintained database, which could eventually be shared more widely with the public to signpost to trusted installers.

The Council and the DCLG could connect developers, RSLs and other building owners with relevant contacts by hosting workshops and forums that allow local businesses to showcase their services and offerings. For example, the Council and the DCLG could facilitate match-making networking sessions where businesses can directly engage with potential clients and partners.

To build confidence in the supply chain, it is important that work is delivered to an acceptable standard. The Council could work with relevant authorities to establish and promote strong trading standards across the local supply chain, ensuring quality and reliability in all projects.

Key considerations

Benefits

This action will both increase the size of the skilled labour force in Dundee, but also implement measures to ensure high quality work is being delivered. This should build up trust in the local supply chain, helping drive the deployment of heat decarbonisation, rooftop PV and energy efficiency measures.

Risks

Maintaining high standards across the supply chain could be challenging, particularly for those new market entrants who might lack experience.

The implementation of new training programmes will require significant investment which is currently not available.

If the public does not perceive the green economy jobs as desirable, there may be difficulties in attracting individuals to the training programmes. There might also be resistance to change from traditional industries or sectors that feel threatened by the shift to a green economy.

Level of Council control

In reference to Figure 5.2 on page 64, the Council will need to leverage *partnerships and engagement* to achieve the desired outcome of this actions.

Stakeholder involvement

This action will require involvement from procurement, housing and energy teams in the Council, as well as engagement with local businesses and colleges.

Ask from others

To support this action, the Council and the DCLG will need support and leadership from Dundee and Angus College and the MSIP Skills Academy.

5. Actions and recommendations

Medium term routemap

Key
- Ends at specified date
- Ongoing action
- Dependency

7. Raise awareness of grid flexibility opportunities to households and businesses

- 7.1. Work with SSEN and energy suppliers to identify local opportunities and current initiatives for domestic and non-domestic flexibility mechanisms
- 7.2. Collect and collate case studies of successful flexibility initiatives across the UK to support engagement
- 7.3. Engage with DCC asset management to explore switching council assets to smart electricity tariffs
- 7.4. Engage with public sector estates management to switch to smart meters and tariffs at public sector sites across Dundee
- 7.5. Develop communication and engagement campaign for households and businesses demonstrating benefits of smart energy tariffs
- 7.6. Develop communication and engagement campaign demonstrating benefits of smart energy monitoring, micro storage and in property controls
- 7.7. Work with local households, businesses and energy companies to develop and share local case studies and success stories to illustrate cost-saving benefit of adopting flexibility mechanisms

2024 — 2025 — 2026 — 2027 — 2028 — 2029 — 2030

5. Actions and recommendations
Descriptions of overarching actions

7. Raise awareness of grid flexibility opportunities to households and businesses

Description

To raise awareness of grid flexibility opportunities amongst households and businesses in Dundee, a multi-faceted approach will be needed. The first step should be to work closely with SSEN and energy suppliers to identify local opportunities and current initiatives for both domestic and non-domestic flexibility mechanisms. This collaboration will help establish a baseline understanding of the existing landscape and potential avenues for engagement.

Concurrently, efforts should be made to collate case studies of successful flexibility initiatives from across the UK. These case studies can support engagement efforts by demonstrating the tangible benefits of adopting flexibility measures.

Internally, the Council should engage with its asset management team to explore the feasibility of switching council assets to smart electricity tariffs. This initiative can serve as a leading example for other public sector entities in Dundee. Collaboration with public sector estates management should also be pursued to encourage the adoption of smart meters and tariffs at public sector sites across the city.

To effectively communicate the benefits of smart energy solutions, targeted communication and engagement campaigns should be developed to focus on the benefits of smart energy solutions, including tariffs, smart monitoring, micro storage, and in-property controls.

To illustrate the cost-saving potential of adopting flexibility mechanisms, the Council and the DCLG should continually work with local households, businesses, and energy companies to develop and share local case studies and success stories. These real-life examples will help build trust and encourage wider adoption of smart energy solutions across Dundee.

Key considerations

Benefits

Raising awareness of grid flexibility opportunities can lead to increased adoption of smart energy solutions, resulting in reduced energy costs for households and businesses. It will also contribute to a more stable and efficient local energy system, supporting Dundee's broader sustainability goals.

Risks

Some households and businesses may be resistant to change or sceptical about the benefits of smart energy solutions, with a fear that costs may increase. There may also be technical challenges in implementing smart meters and tariffs across different types of properties.

Level of Council control

In reference to Figure 5.2 on page 64, the Council will need to work closely with the DCLG and other external *partners* such as SSEN and energy suppliers to identify opportunities and develop *engagement* strategies. However, the Council can *directly* influence the adoption of smart energy solutions in its own assets and across the public sector.

Stakeholder involvement

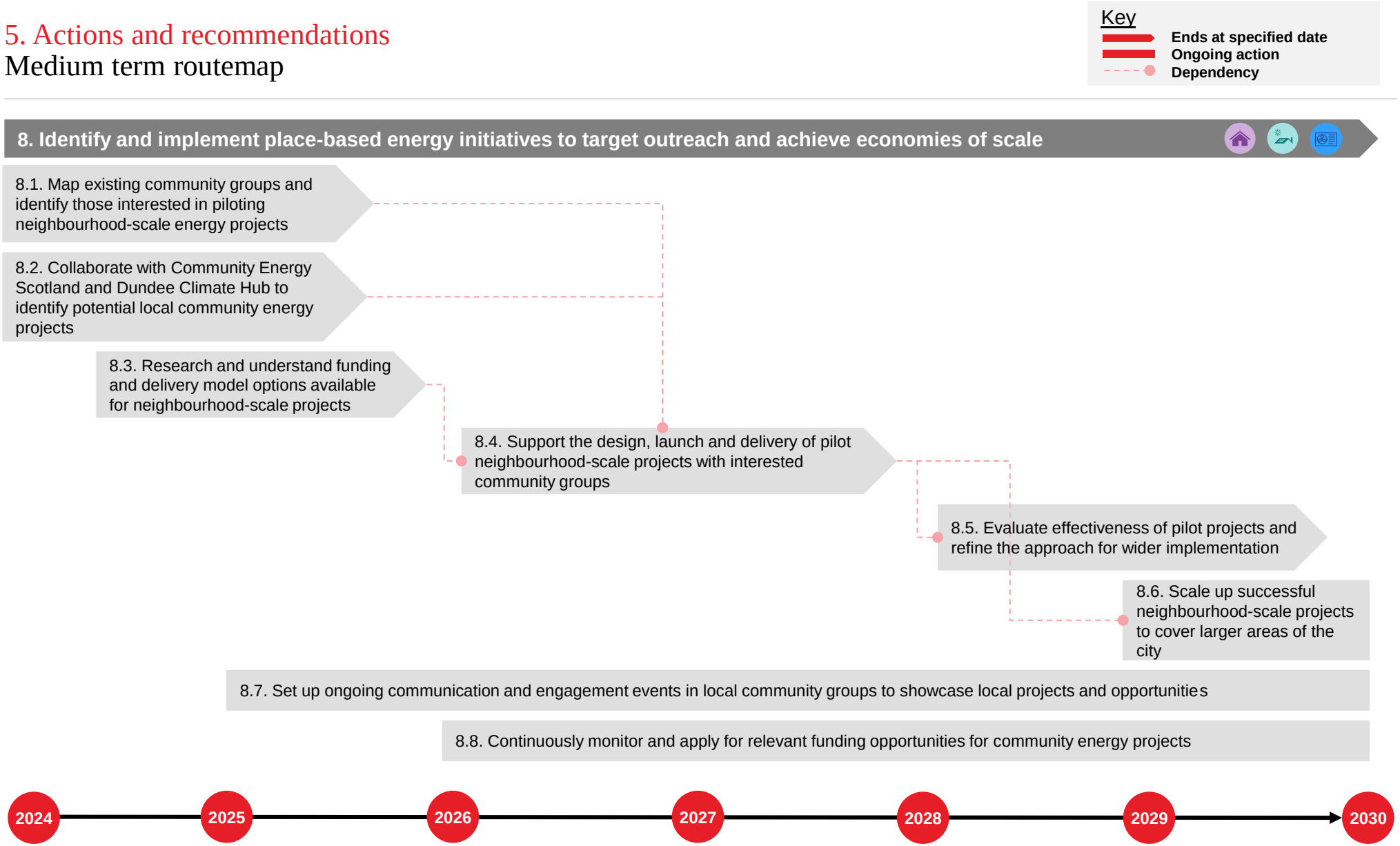
This action will require close collaboration between the Council, the DCLG and with a wide range of other key, including SSEN, energy suppliers, households, businesses and public sector organisations. The Council and the DCLG will need to engage with these stakeholders to gather information, develop case studies and deliver targeted communication campaigns.

Ask from others

To support this action, the Council and the DCLG will need SSEN and energy suppliers to be proactive in sharing information about local opportunities and initiatives. Households, businesses, and public sector organisations will need to be open to adopting smart energy solutions and sharing their experiences.

5. Actions and recommendations

Medium term routemap



5. Actions and recommendations
Descriptions of overarching actions

8. Identify and implement place-based energy initiatives to target outreach and achieve economies of scale

Description

Implementing place-based energy initiatives can result in economies of scale. The first step should involve reviewing existing community groups and identifying interested parties in piloting neighbourhood-scale energy projects. This will help establish a foundation for community engagement and participation. In parallel, the Council and the DCLG should collaborate with Community Energy Scotland and the Dundee Climate Hub to identify potential projects.

To support the identified projects, it will be necessary research and understand the available funding and delivery model options. This will involve exploring various financing mechanisms and partnerships that can help bring neighbourhood-scale projects to fruition.

Once potential projects have been identified and funding options explored, pilot neighbourhood-scale projects should be designed, launched, and delivered with interested community groups. These pilot projects can serve as a proof-of-concept and help demonstrate the viability and benefits of community energy initiatives. Pilots can be used to identify best practices, lessons learned, and opportunities for improvement.

Building on the success and insights gained from the pilot projects, the Council and the DCLG could then develop a strategic scale-up of successful neighbourhood-scale projects to cover larger areas of the city. This expansion will help maximise the impact and benefits of community energy initiatives.

Ongoing communication and engagement events with local community groups can be used to maintain momentum and to showcase local projects and opportunities. These events will help raise awareness, foster community ownership and encourage continued participation in energy initiatives.

Finally, the Council and the DCLG should continuously monitor and apply for, and signpost relevant funding opportunities to support community energy projects (e.g., the Dundee Climate Fund). This will ensure a sustainable pipeline of resources to scale and replicate successful initiatives across Dundee.

Key considerations

Benefits

Place-based energy initiatives can help achieve economies of scale, reduce energy costs for residents, and foster community engagement and ownership. These projects can also contribute to Dundee's broader sustainability goals and improve the resilience of local energy systems.

Risks

Community energy projects may face challenges in securing adequate funding and buy-in from residents. There may also be technical and logistical hurdles in implementing neighbourhood-scale projects.

Level of Council control

In reference to Figure 5.2 on page 64, the Council has a moderate level of control over this action, by supporting and *incentivising* community energy projects. However, the success of these initiatives will depend on the *engagement* and participation of local community groups.

Stakeholder involvement

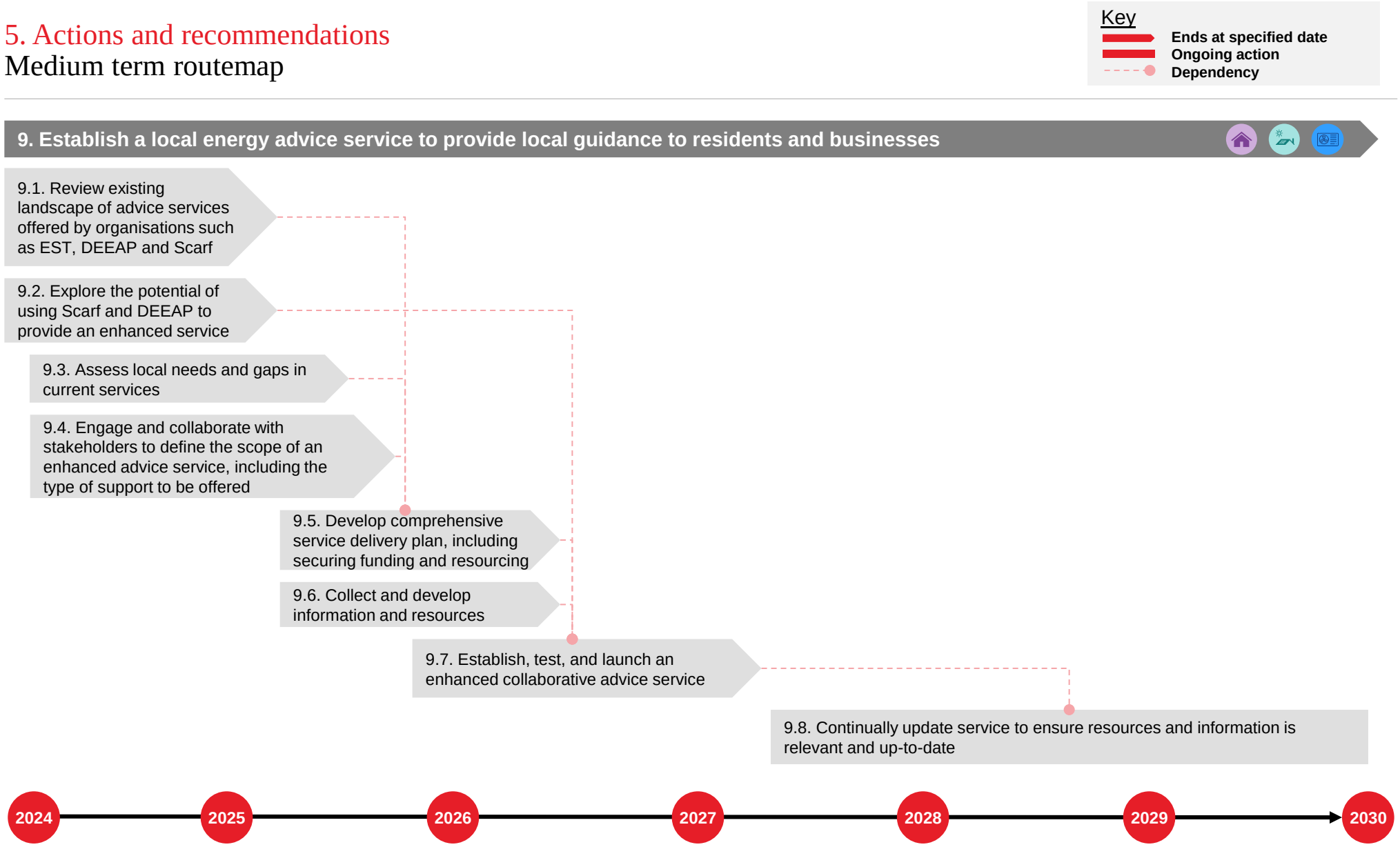
This action will require close collaboration with the Dundee Climate Hub, other local community groups, Community Energy Scotland, and potential funding partners. The Council and the DCLG will need to engage with these stakeholders to identify opportunities, secure resources, and implement projects.

Ask from others

To support this action, local community groups will need to be willing to participate in pilot projects and help champion energy initiatives in their neighbourhoods. Community Energy Scotland will need to provide technical expertise and guidance in developing and implementing projects. Funding partners will need to offer resources and support to help scale and replicate successful initiatives.

5. Actions and recommendations

Medium term routemap



5. Actions and recommendations
Descriptions of overarching actions

9. Establish a local energy advice service to provide local guidance to residents and businesses

Description

The establishment of an enhanced local energy advice service can provide a first point of contact for residents and businesses wanting to undergo local energy projects. This action is linked to building trust in a local supply chain, as the advice service would play a role in connecting residents and businesses with energy solutions.

Initially, a review of the existing landscape of advice services offered by organisations such as Energy Saving Trust (EST), Dundee Energy Efficiency Advice Project (DEEAP) and Scarf should be conducted. The potential of using Scarf and DEEAP to host an enhanced advice service should also be explored. Existing resources and infrastructure could be leveraged to provide a centralised location for energy advice and support.

To ensure the advice service meets the needs of the local community, an assessment of local needs and gaps in current services should be carried out. This can involve engaging with residents and businesses to understand their specific energy-related challenges and requirements. If the gap analysis identifies an opportunity for a potential enhanced advice service, the scope should be defined and a service delivery plan, including securing funding and resourcing, should be developed.

Relevant information and resources should be collected and developed as part of the service. This includes energy advice materials, case studies, and tools that are accessible and useful for residents and businesses.

The enhanced advice service should be established, tested, and launched, with an initial pilot of the service with a small group of users, gathering feedback, and making improvements before a full-scale launch. To ensure the ongoing relevance and effectiveness of the enhanced advice service, resources and information should be updated by monitoring changes in the energy landscape, incorporating new best practices, and adapting the service to meet evolving needs of residents and businesses.

Key considerations

Benefits

An enhanced local energy advice service would provide residents and businesses with customised guidance on energy efficiency, renewable energy and cost savings. This could lead to lower energy bills and increased adoption of sustainable energy practices in Dundee. By connecting users with trusted local suppliers and installers, the advice service would also contribute to building a robust and reliable local supply chain.

Risks

Establishing and operating an advice service may require significant resources, expertise and close partnership working. There is a risk that the service may not be utilised to its full potential if it is not effectively promoted or if it does not meet the specific needs of the local community. Additionally, the advice service would need to ensure that it maintains impartiality and provides reliable recommendations to maintain trust among users.

Level of Council control

This action involves *influencing* change by providing access to information and services to facilitate the uptake of energy projects across Dundee.

Stakeholder involvement

The advice service would require collaboration with a range of stakeholders, including existing energy advice organisations (e.g., EST, DEEAP and Scarf), community groups, businesses, and residents.

Ask from others

To support this action, there will need to be close partnership working between DEEAP, Scarf and EST to ensure expertise and resources are provided and referrals are maximised. Local businesses and community groups will need to promote the service and encourage their members to use it. Local suppliers and installers should engage with the advice service, providing information on their offerings and delivering high-quality services to referred customers.

5. Actions and recommendations

Medium term routemap

Key
- Ends at specified date
- Ongoing action
- Dependency

10. Deliver infrastructure to support a decarbonised transport system

10.1 Review the Sustainable Transport Delivery Plan and identify synergies with the LAEP and opportunity areas for a joined-up approach

10.2 Explore options for financing public charging infrastructure, including attracting private investment

10.3 Continue to identify areas and key destinations that require public charging facilities

10.4 Work with SSEN to assess electricity network impacts of public charger provision

10.5 Explore support and incentives for businesses to switch to electric fleets

10.6 Communicate benefits of low emission vehicles and support available for residents

10.7 Scale up public EV charging infrastructure across Dundee

10.8 Collaborate with neighbouring authorities and SGN to continue to monitor developments and consider options to support hydrogen for heavy transport

2024 — 2025 — 2026 — 2027 — 2028 — 2029 — 2030

5. Actions and recommendations
Descriptions of overarching actions

10. Deliver infrastructure to support a decarbonised transport system

Description

Delivering a reliable and accessible EV charging network in Dundee will be the key to enable a transition away from fossil fuel vehicles across the city. The process should begin with reviewing the Sustainable Transport Delivery Plan to ensure alignment between transport and energy strategies.

As only 43% of properties have access to off-street parking, a major focus should be on expanding public EV infrastructure.[12] This includes identifying areas that require on-street parking, charging points for multi-occupancy buildings, and scaling up EV charging provision at public sector sites and key destinations. Opportunities for securing funding and attracting private sector investment should be investigated, while ensuring that charging tariffs remain competitive and sustainable. The benefits of low emission vehicles and the funding available should be communicated to business and residents.

The city will need to work with SSEN to assess and plan for the electricity network impacts of public charger provision. Where possible, charging infrastructure should be co-located with local renewable generation to reduce impact on the grid.

To encourage wider adoption of electric transport, support and incentives for businesses to switch to electric fleets should be explored. HGV and bus charging provisions should continue to be increased. Additionally, in collaboration with neighbouring authorities and SGN, developments and options to support hydrogen refuelling infrastructure for heavy goods vehicles should continue to be monitored and considered as the technology progresses.

Key considerations

Benefits

Implementing this action would lead to reduced carbon emissions from the transport sector, improved air quality, and support for residents and businesses transitioning to low carbon vehicles. It could also position Dundee as a leader in sustainable transport infrastructure, potentially bringing economic benefits.

Risks

The main risks of this action include high initial costs for infrastructure development, potential disruption during installation of charging points and the possibility of technology becoming obsolete if not future-proofed. There may be challenges in ensuring equitable access to charging infrastructure across all areas of the city. Additionally, there's a potential for strain on the electricity grid if the increased demand is not properly managed.

Level of Council control

This action involves a mix of direct control, policy, influencing, and engaging. In reference to Figure 5.2 on page 64, the Council has *direct control* over public infrastructure delivery, can produce *policy* to drive development requirements, can *influence* business practices through incentives, and should *engage* with the DCLG and other key stakeholders for successful implementation.

Stakeholder involvement

Key stakeholders include local residents and businesses, SSEN and other energy providers, SGN, neighbouring local authorities, transport companies and fleet operators, property developers, and EV charging infrastructure providers.

Ask from others

SSEN and SGN will need to collaborate on network impact assessments, infrastructure development and necessary upgrades. The DCLG partners and other organisations should support delivery by considering transitioning to electric fleets and potentially hosting charging points. Property developers should integrate EV charging infrastructure in new developments. The Council will need support from neighbouring local authorities to coordinate on regional transport decarbonisation strategies and necessary infrastructure provision.

5. Actions and recommendations
Initial phases of implementation

Phased LAEP implementation

To implement these overarching actions, the Council and the DCLG should complete preparatory steps to secure the appropriate resources, funding, and governance. Figure 5.5 below sets out a suggested phased approach that could be followed over the six months following the adoption of this LAEP.

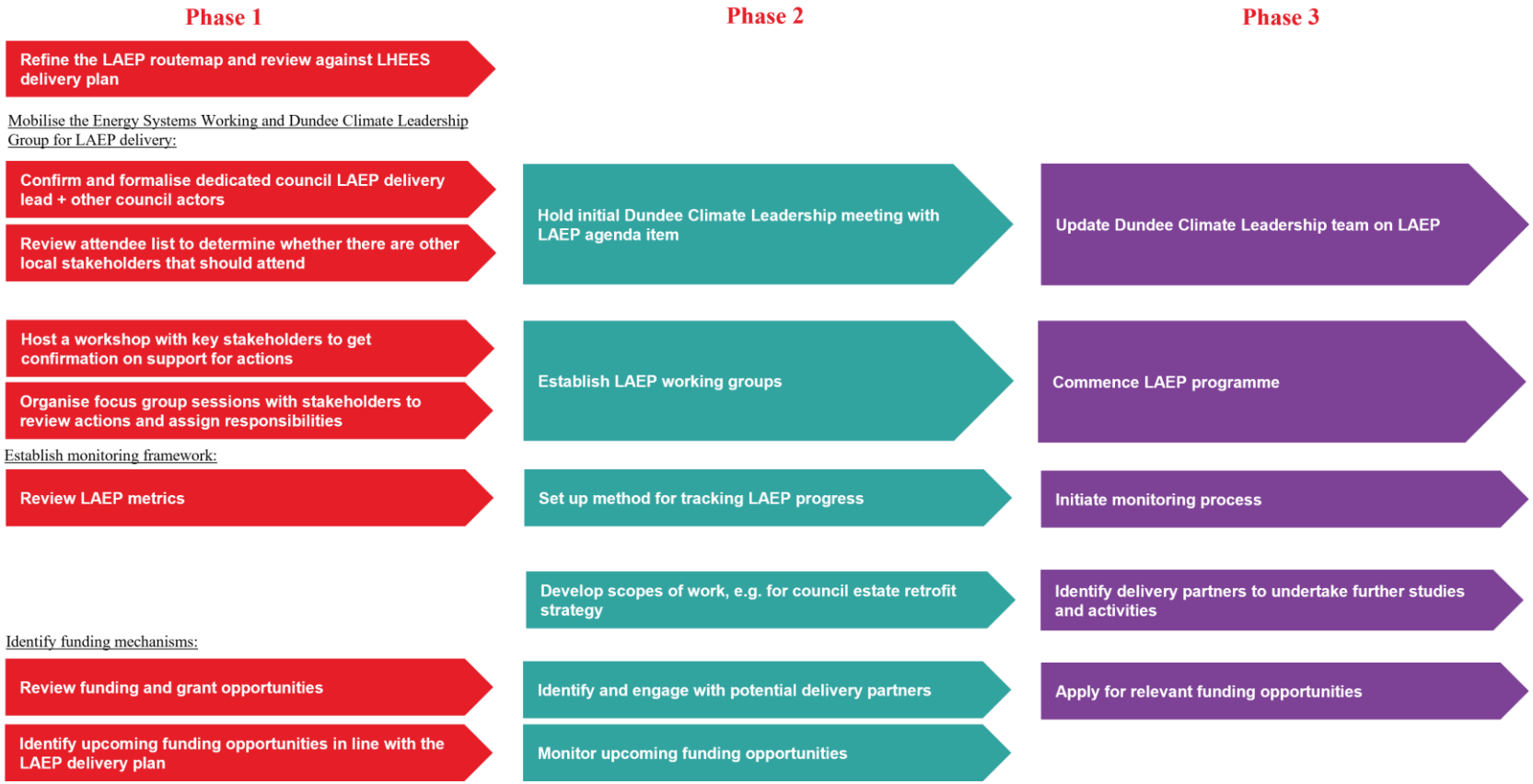


Figure 5.5: Phased LAEP implementation

5. Actions and recommendations
The structures required to deliver the LAEP

Governance

The Council recognises that it should have an integral role in shaping the strategic direction of the LAEP. To ensure effective implementation, the Council will ensure there is a dedicated LAEP officer in place to oversee the day-to-day execution of the LAEP.

The LAEP officer will be managed by the Council and will report on a regular basis to the Energy Systems Working Group, which is a subgroup of the Dundee Climate Leadership Group (DCLG). This group of key stakeholders has been actively involved throughout the development of the LAEP, contributing to the creation of energy system scenarios and the formulation of actions. Their extensive knowledge of the local energy system makes this group an ideal forum for overseeing the LAEP programme. Serving as an advisory body, the group will monitor and supervise the LAEP's execution.

The Dundee Climate Leadership Group will have ultimate authority over the LAEP programme. The Dundee Climate Leadership Group, which is the Strategic Leadership Group for the City Plan's theme of Tackling Climate Change, reporting into the Dundee Partnership Management Group, comprises of Dundee City Council, Abertay University, Creative Dundee, Dundee & Angus College, DC Thomson, Hillcrest Homes, Michelin Innovation Parc, NHS Tayside, Robertson Group, Scottish & Southern Electricity Networks, Scottish Water, SGN, Transition Dundee, and the University of Dundee. The Group's role will be to review project scopes, timelines, funding bids and budget allocations. The LAEP officer will provide regular updates on current project progress and planned activities as a recurring agenda item.

Support required for delivery

To deliver effectively and at pace and scale, it is likely that resources, skills and capacity within the Council will need to increase. The LAEP officer will integrate with existing teams to begin implementing actions set out in the LAEP.

Monitoring and review

The LAEP sets out a medium-term plan detailing actions to be delivered until 2030. This plan serves as the foundation for achieving the greater ambition outlined in the longer-term routemap. The Council and DCLG should identify indicators for each workstream that can be used to measure the programme progress in meeting the LAEP objectives. These metrics will be reported on in an Annual Monitoring Report. Examples of output metrics include:

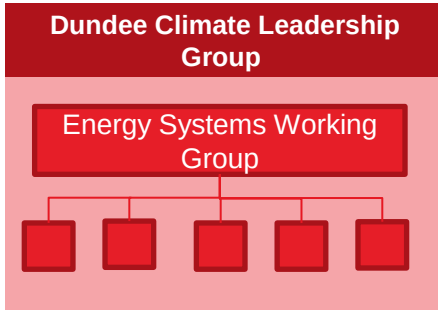
- Number of homes and non-domestic buildings retrofitted
- Number of public EV charging points installed
- MW renewables installed

To monitor these metrics publicly available datasets can be used, such as the Energy Performance Certificate Register and the Micro Generation Certification Scheme. The Council and the DCLG will need to develop a baseline understanding of these metrics based on existing data and monitor changes annually.

Carbon emissions reduction should also be tracked, however recognising that available data will lag a few years behind.

The whole LAEP will be updated at least every five years to take account of key factors, including:

- Policy changes both at a local and national level
- Changes in costs and effectiveness of technologies
- Progress to date



LAEP Steering Group

Advisory body responsible for overseeing the LAEP's delivery

Team of project officers delivering projects stemming from the LAEP

Figure 5.6: Proposed LAEP Delivery structure

Chapter 6: Conclusions

6. Conclusions

Delivering change in the face of uncertainty

Transforming Dundee's energy landscape

The challenge to achieve a net zero carbon emissions energy system in Dundee by 2045 is significant, requiring a fundamental restructuring of how energy is produced, managed and consumed in the city. This transition necessitates a shift from the current model of three largely independent systems for heating, electricity, and transport to an interconnected, holistic energy system. This approach will require significant coordination and collaboration across sectors, and delivery by a diverse set of stakeholders. The goal is for Dundee to become a pioneering net zero city while ensuring an equitable transition for all Dundee residents.

Dundee City Council declared a climate emergency in 2019 and to effectively respond to this with meaningful action, it is recommended that the Council and the DCLG partners embrace the LAEP's findings. The Council, in collaboration with the DCLG and its Energy Systems Working Group, play a vital role in facilitating system-wide action where it holds influence, as well as leading directly on initiatives within its remit. To realise the LAEP's objectives and effectively address the climate emergency, the Council and the DCLG partners must strategically redirect resources toward deployment of low carbon technologies, infrastructure development, community engagement and other transitional programmes. A significant increase in investment across all priority intervention themes will be required in the coming years.

Navigating change in an uncertain landscape

The LAEP outlines a transition of unprecedented scale and urgency, from increasing local renewable electricity generation, the electrification of heating and transport, to infrastructure rollouts and leveraging significant heat network potential. Delivering and retaining skills and capacity to deliver these solutions as soon as possible is crucial.

There are remaining uncertainties for the future of Dundee's energy system, including potential policy shifts at the UK and Scottish Government levels, advancements in low carbon technologies (including the emerging role of hydrogen), and associated costs. The willingness of private entities to adopt new technologies and energy consumption patterns also remains a key risk. However, these uncertainties should not impede immediate action. The LAEP's recommended routemap is designed to best meet objectives despite these unknowns. The LAEP prioritises no-regrets, short-term measures to initiate Dundee's journey to net zero. Regular monitoring and updates to the LAEP will be essential as influential policies evolve and breakthrough technologies emerge. By leveraging the collective expertise of the Council, the Climate Leadership Group, and its Energy Systems Working Group, the city is well-positioned to navigate these challenges and lead the way in sustainable energy transformation.

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