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Enfield Local Area Energy Plan

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Executive Summary

Context

After declaring a climate emergency in summer 2019, Enfield has set the ambition to become a net zero borough by 2040. The core aim of this Local Area Energy Plan (LAEP) is to provide a framework for Enfield to achieve this target. This report and its accompanying documents provide the foundations for the decarbonisation of the energy system in Enfield.

An energy system is the system designed to supply energy to end users. In the context of this LAEP, that is the supply of electricity and heat to the people, businesses and industry within the London Borough of Enfield. The three key areas for decarbonisation covered by this work are heat in buildings, transport and power systems.

The LAEP places emphasis on the key first steps that will drive the decarbonisation process, whilst setting out those future actions and decisions that will ensure longer-term commitment to a net zero Enfield.

The starting point

In 2019 Enfield's annual emissions amounted to almost 1,200 ktCO$_2$e. Approximately 45% of these emissions come from transport, 28% from heating buildings and 17% from use of grid electricity. Enfield has already made some progress in reducing these emissions, however the rate and scale of change required is huge. Enfield will need to transform its approach to how buildings are heated, how people and goods travel and how energy is used.

How to achieve net zero by 2040

The technical analysis of the LAEP produced four decarbonisation "scenarios", i.e. ways to envisage the path to Net Zero. Demand reduction needs to be the starting point of the decarbonisation process, alongside the adoption of net zero technologies and techniques throughout the local energy system. As well as reduction in energy demand, each scenario looked at electrification as a way to reach Net Zero. This is because electrification ties Enfield's emissions to those of the national grid. Therefore, as there are already commitments to decarbonise national electricity generation, electrification is the most realistic way to achieve Net Zero. Whilst energy from waste incineration is not zero carbon, where waste incinerators already exist, such as in Enfield, it makes sense to capture the available heat for use in networks and use this as a transitional solution alongside electrification.

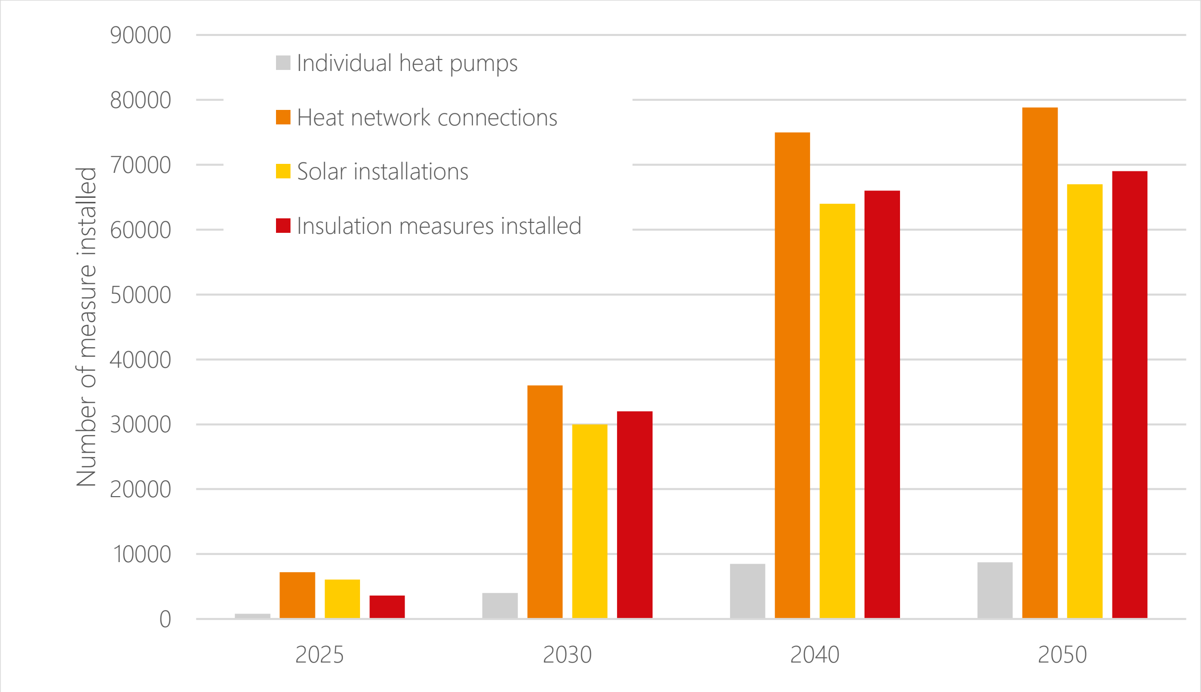
The decarbonisation scenario chosen as optimal for Enfield (mixed demand management) has the lowest overall costs for decarbonisation of the energy system. It combines a cost-optimising approach to insulation and heating with maximised generation of renewable energy across the borough. In this scenario there is a significant shift to active and sustainable modes of transport and the charging of electric vehicles (EVs) is flexible in order to ease the total demand on the electricity grid.

Results

The LAEP analysis shows that a mixture of district heating and standalone air source heat pumps (ASHPs) is the best way to decarbonise heat in buildings in Enfield. This is in conjunction with a cost-effective campaign of insulation. In addition, the widespread rollout of rooftop solar photovoltaic (PV) across the borough would generate zero carbon electricity locally. By reducing the electricity demand on the grid, rooftop PV would also help lower customer bills and contribute to fuel poverty alleviation. Transport is decarbonised primarily through electrification of most vehicles, as well as significant "modal shift", i.e. switching to alternative transport such as walking, cycling or public transport.

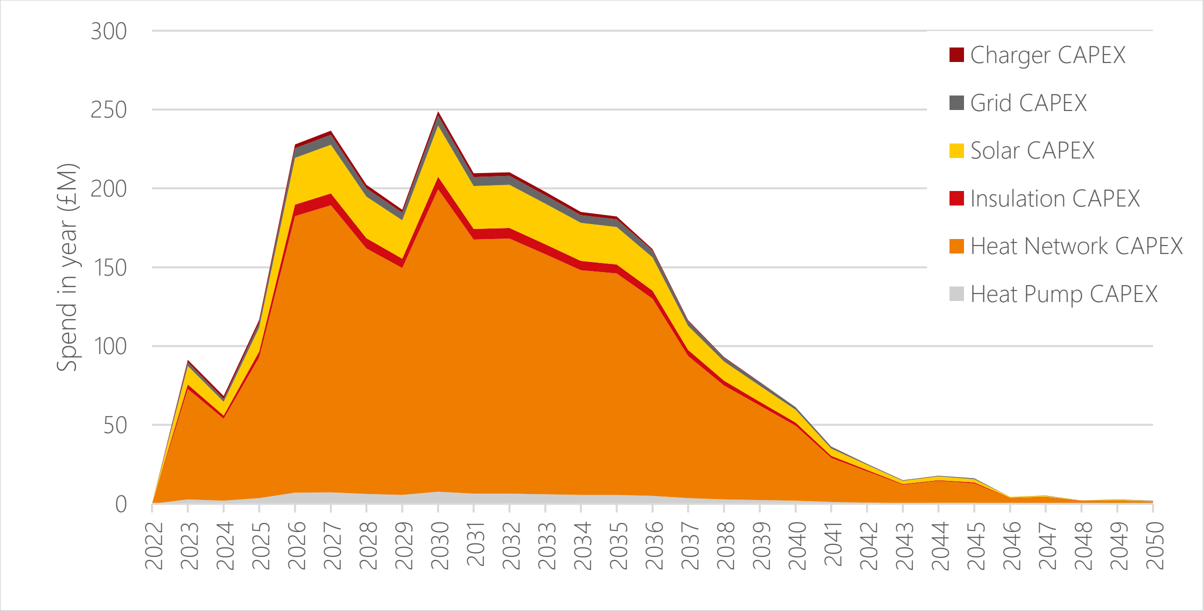
Figure shows targets for the technology changes required in Enfield in the key years of 2025, 2030, 2040 and 2050.

Figure A: Targets for net zero technology adoption in key years



Meeting these targets would cost in total £5.03 billion distributed over the period to 2050. Figure shows how the costs for each technology change would be distributed over time.

Figure B: CAPEX spend over time and per intervention

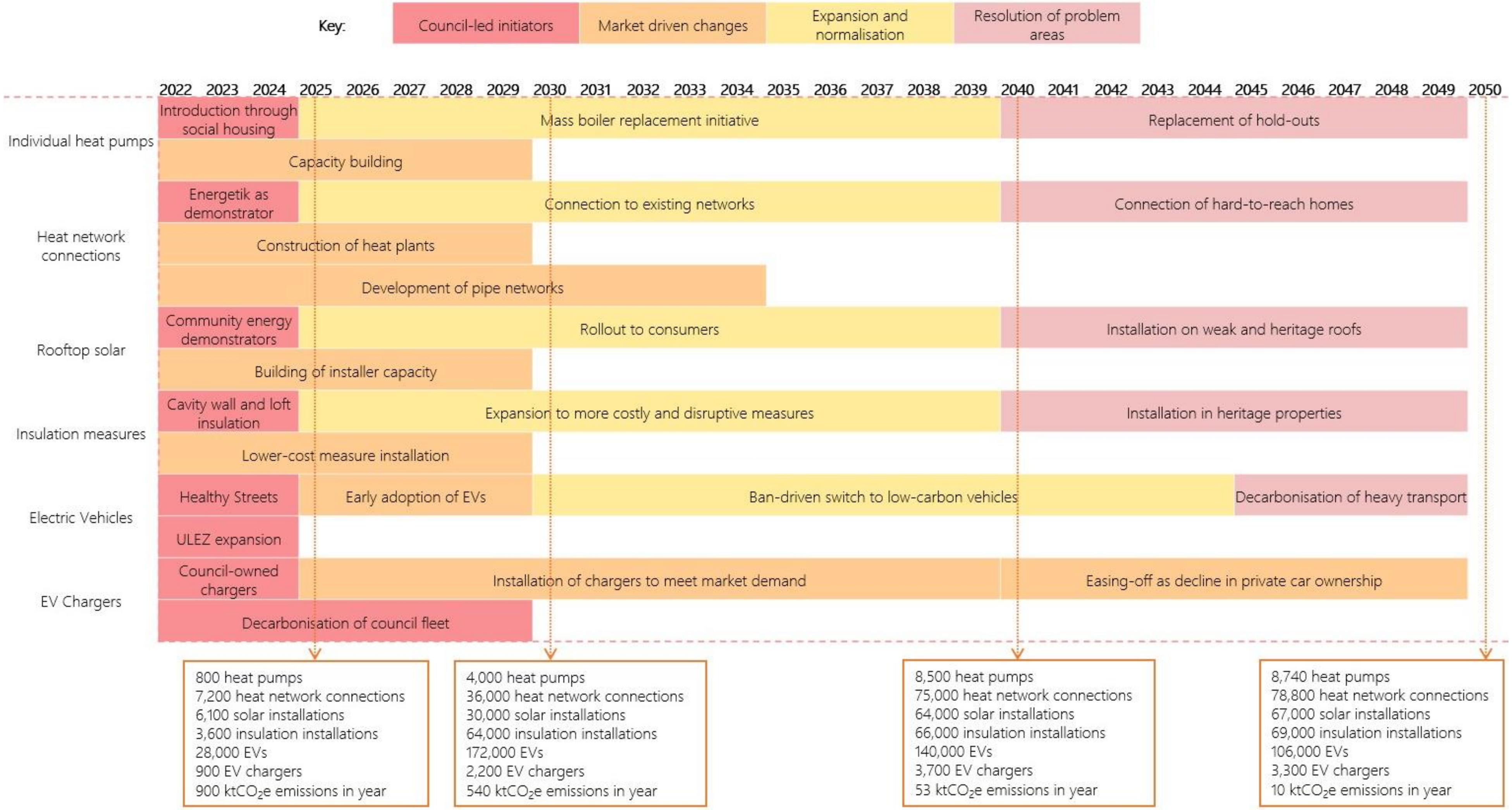


Whilst the mixed demand management scenario carries significant cost, it is cheaper than doing nothing. The total avoided carbon is estimated to be 19,085 $ktCO_2e$ by 2040, representing an avoided carbon impact cost of £6.26 billion.

A route map to Net Zero

Figure illustrates Enfield's route map to Net Zero. It was developed building on existing opportunities and addressing challenges to change. There is a focus on early interventions, introducing net zero technologies and initiating capacity building within the market to then spark wider adoption. The route map shows sequenced interventions that will enable the targets illustrated in Figure A to be met.

Figure C: Route map for a net zero Enfield



800 heat pumps
7,200 heat network connections
6,100 solar installations
3,600 insulation installations
28,000 EVs
900 EV chargers
900 ktCO$_2$e emissions in year

4,000 heat pumps
36,000 heat network connections
30,000 solar installations
64,000 insulation installations
172,000 EVs
2,200 EV chargers
540 ktCO$_2$e emissions in year

8,500 heat pumps
75,000 heat network connections
64,000 solar installations
66,000 insulation installations
140,000 EVs
3,700 EV chargers
53 ktCO$_2$e emissions in year

8,740 heat pumps
78,800 heat network connections
67,000 solar installations
69,000 insulation installations
106,000 EVs
3,300 EV chargers
10 ktCO$_2$e emissions in year

As the focus of the LAEP is on those first steps that will be key in driving decarbonisation efforts, the analysis finally zoomed in on three local areas and identified three projects as priority for further detailed investigation and implementation within a relatively short timescale:

1. A heat network opportunity area within Upper Edmonton
2. A combination of viable heat technologies at West Carterhatch
3. Large rooftop PV deployment at Highfield Primary School

Overall, the LAEP provides a framework for action that represents the first significant step towards decarbonising the whole energy system in Enfield. Following the recommendations presented in this plan will be crucial to keeping momentum and achieving Net Zero by 2040.

1. A Local Area Energy Plan for Enfield

The core aim of this Local Area Energy Plan (LAEP) is to provide a framework for Enfield to decarbonise the local energy system in line with the ambition to become a net zero borough by 2040. This report and its accompanying documents provide the foundations for effective and sustained local action for the decarbonisation of the energy system in Enfield, which comprises heat in buildings, transport and power systems.

This LAEP was developed in line with the guidance provided in the Local Area Energy Planning: The Method[1], as referenced in Ofgem's RIIO-ED2 Sector Specific Methodology Consultation[2] document and presents a vision for a net zero energy system in the London Borough of Enfield. Within this, the LAEP focuses specifically on the decarbonisation of heat in buildings, transport and power systems. An energy system is the system designed to supply energy to end users. In the context of an LAEP, that means the supply of electricity and heat to the people, businesses and industry of the London Borough of Enfield.

1.1. The LAEP process

Local area energy planning is a place-based process that informs, shapes and enables the transition to a net zero carbon energy system. The process focuses on the decarbonisation of the whole energy system at a local level (including the energy networks, buildings, transport, industry and local generation and flexibility opportunities). It recognises that places are different (the people, infrastructure, geography, ambition) and identifies what needs to happen, where and by when.

The Enfield LAEP was developed over several months and incorporates the outcomes of four key elements:

- A robust technical analysis based on available and viable zero carbon technologies and solutions, formulated in consultation with those stakeholders that have a key role in the local system changes required, and including more in-depth study of three projects identified as priority
- A comprehensive assessment of non-technical factors, including local and national conditions, developed collaboratively with key local actors and initiative takers to confirm and inform our understanding of the local area and identify the opportunities and barriers to the successful decarbonisation of Enfield

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[1] https://www.cse.org.uk/downloads/file/LAEP-method-final-review-draft-30-July-2020.pdf

[2] https://www.ofgem.gov.uk/sites/default/files/2022-04/Call%20for%20Input%20Future%20of%20local%20energy%20institutions%20and%20governance%20.pdf

- A continued process of effective stakeholder engagement that sought to secure ownership and commitment from local actors to the proposed plans and required radical changes for a net zero Enfield by 2040

- Proposals and recommendations for ongoing governance and delivery to ensure that the LAEP becomes a 'live' and evolving plan that is supported and implemented by local planning, investment and initiatives

1.2. LAEP report structure

This report presents a summary of the work undertaken over several months and is structured as follows:

- **The challenge**: this section provides a characterisation of the state-of-play in Enfield and provides an understanding of the scale of the challenge of decarbonising the local energy system

- **Technical pathways**: this section presents the outputs of various research and modelling exercises that sought to identify the potential for a range of technical measures to enable Enfield to reach the net zero target by 2040

- **Route Map to Net Zero**: this section outlines the key building blocks that should form the foundations for a strategic approach to decarbonising Enfield, as well as three local energy projects that can be implemented as priority, and an overview of the costs and benefits of decarbonising Enfield

- **Next steps**: this section summarises what immediate actions need to be taken to finalise delivery plans and drive the LAEP forward

For completeness, five documents accompany this LAEP report and underpin the work presented in this document:

- Technical evidence base
- Walking Around the Issues
- Detailed recommendations to 2040
- Stakeholder Engagement Report
- Local Plan review and policy recommendations

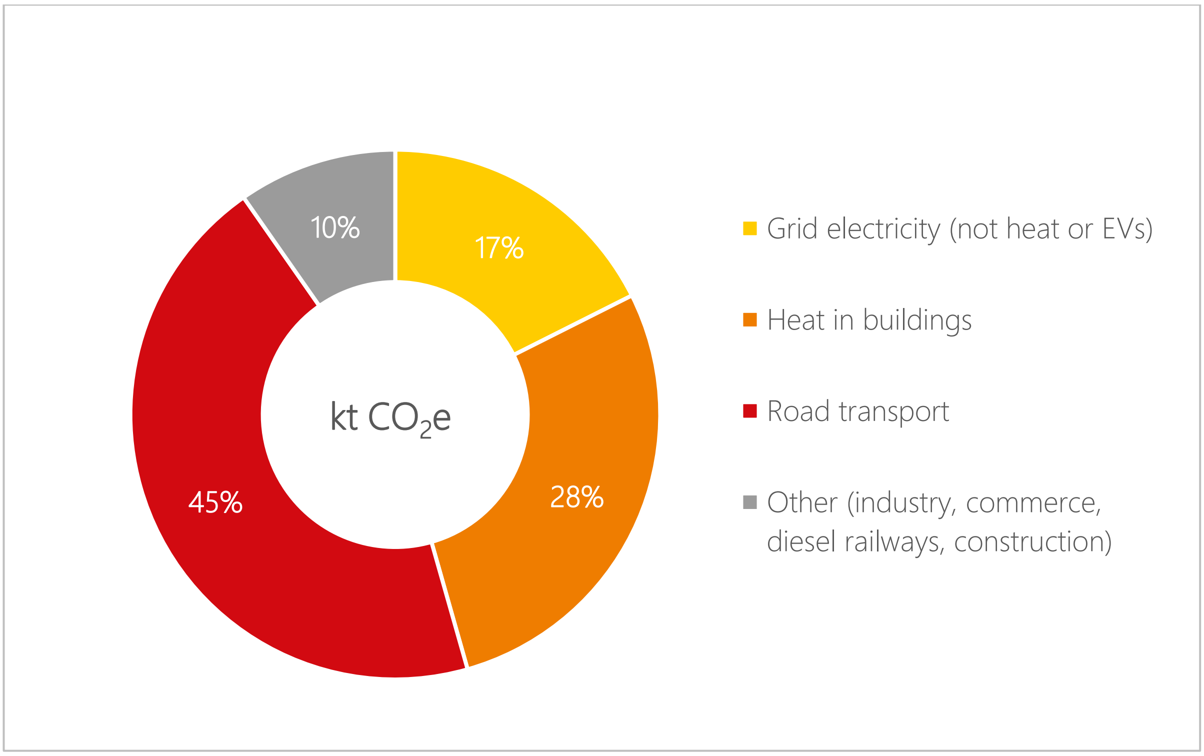
2. The challenge

Enfield Council declared a climate emergency in summer 2019 and published a detailed Climate Action Plan in the summer of 2020. The Climate Action Plan outlined steps the council would take to become a carbon neutral council by 2030 and carbon neutral borough by 2040.

As part of the Local Energy Accelerator programme[3], the Greater London Authority (GLA) provided funding for Enfield to prepare a Local Area Energy Plan to support the borough in becoming Net Zero by 2040. The purpose of this report is to inform the Climate Action Plan review process and act as an evidence base for the actions listed within it.

As set out in the Enfield Climate Action Plan (2020)[4], Enfield Council has already taken actions towards reducing its own carbon emissions as well as those of the borough as a whole. However, the path to a net zero Enfield remains challenging. In the baseline year of 2019 Enfield's total annual emissions amounted to almost 1,200 ktCO₂e. Figure 1 shows that the sector with the highest emissions is transport, followed by heat in buildings and then grid electricity[5].

Figure 1: Enfield carbon emissions by sector in 2019 (kt CO_2e)



The process of decarbonising Enfield will be challenging since the rate and scale of change required is huge. Enfield will need to transform its approach to how buildings are heated, how people and goods travel, and how energy is used. Demand reduction needs to be the starting

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[3] https://www.london.gov.uk/what-we-do/environment/energy/low-carbon-accelerators/local-energy-accelerator

[4] https://www.enfield.gov.uk/__data/assets/pdf_file/0011/4610/enfield-climate-action-plan-2020-environment.pdf

[5] The remaining emissions shown the figure as 'other' are beyond the scope of the LAEP and only account for approximately 100 kt CO_2e.

point of the decarbonisation process, alongside the adoption of net zero technologies and techniques throughout the local energy system.

By establishing and maintaining high levels of engagement from key actors and the local community, Enfield will be able to fully unlock the potential for action that exists across all sectors. Implementing the changes required for a net zero Enfield will also yield critical wider benefits, such as fuel poverty reduction, improved public health, job creation and skills development.

2.1. Setting the scene: opportunities and challenges for a net zero Enfield

Planning for a net zero borough needs to respond to rapidly changing socio-economic and political systems at local, regional and national level. In order to understand the scale of the changes required for a net zero borough, the LAEP process analysed the current state of play in Enfield and the required conditions for successful decarbonisation of the local energy system. A full analysis of the wide range of non-technical factors that can influence the potential for and realisation of change is included in the accompanying Walking Around the Issues document. Based on that detailed analysis, the following sections provide an overview of the main opportunities and challenges that exist in the borough.

2.1.1. Heat in buildings

One of the main opportunities in Enfield for decarbonising heat in buildings comes from the well-established local energy company Energetik, which is owned by Enfield Council. Energetik has already invested in heat networks across the borough, including Meridian Water, Arnos Grove, Ponders End and Oakwood, and is looking to continue its expansion in the coming years. Although gas boilers still heat a majority of the buildings in the borough, district heating in Enfield is already leading the way in best practice across London.

In addition to district heating, there are opportunities to build on Enfield’s co-leading role in developing the Retrofit London Housing Action Plan that seeks to develop a home retrofitting programme in London that can achieve an average EPC B rating by 2030. There are also wider factors that play a supporting role in the decarbonisation of heat in the borough. As energy prices rise, net zero measures such as heat networks powered by net zero heat sources and insulation become more economically viable. The availability of wider funding schemes enhances the economics of net zero measures. Some examples of these schemes are the Local Authority Delivery Scheme (LADS), the Green Heat Network Fund, the Boiler Upgrade Scheme, and the Public Sector Decarbonisation Scheme. However, there is no long-term plan to maintain these funding sources, which is a challenge for local authorities. The creation and delivery of long-term plans for net zero measure funds at national level is therefore crucial for the successful decarbonisation of heat in buildings.

Despite these opportunities for change in the borough, there are challenges that Enfield needs to overcome to make progress towards zero carbon heating in all buildings. These include a limited supply chain for zero carbon heating technologies, both in terms of skills and materials, which at the moment is not able to support the scale of change needed. The currently limited funding for decarbonising heat is another critical challenge. The funding available is not extensive enough to cover the scale of change needed, especially as net zero options carry an upfront cost that is higher than conventional heating choices.

2.1.2. Transport

Transport is an area where it can be difficult to make significant change, due in part to it not being bound to a particular location or authority. However, there are many factors which present opportunities to decarbonise transport within Enfield. Within the borough, Enfield Council has already taken significant steps in promoting active travel, such as through the Cycle Enfield scheme. Through the LAEP process, Enfield Council has also laid the foundations for a strong partnership with the local electricity distribution network operator (DNO) UK Power Networks to ensure that electricity network can support plans for an expansion in electric vehicle numbers.

There are also opportunities for decarbonising transport in trends and factors that go beyond the borough boundaries. Electric vehicles are becoming cheaper to purchase and to run and can travel further. As people become more aware of environmental and climate issues, further growth of the electric vehicle industry is expected. Across London there have been many successful smart electric vehicle charging trials and pilots with promising results. As net zero transport becomes more common, road congestion may fall, leading to even more people feeling safer in taking up active travel such as walking and cycling.

However, there are existing challenges that could hamper Enfield’s ability to decarbonise local transport. In terms of decision making, as most of funding for transport in the borough comes from Transport for London, Enfield Council have limited agency over transport decisions, even within the borough boundaries. The transition to electric vehicles also presents challenges such as the ability of the electricity grid to support the large-scale adoption of electric vehicles, limitations in the supply chain and the lack of skilled technicians and after sales service agents.

2.1.3. Power systems

The decarbonisation of Enfield’s power systems will largely depend on the successful decarbonisation of the national grid, however there are opportunities for Enfield to make its own contributions. In terms of renewable energy generation, there are opportunities to build upon the success of deploying solar rooftop photovoltaic (PV) panels on school buildings and Enfield Council’s own buildings. In a broader context, rising electricity prices and falling battery costs are improving the financial case for generation of net zero energy.

The capacity of the local electricity grid to take the extra load of decarbonised technologies is a significant challenge. However, Enfield already has large industrial clusters, with a high grid capacity, as well as a large rooftop area for solar panels. There is also a mix of electricity users in Enfield, presenting many options for flexibility, and funding is available for grid flexibility initiatives.

There are wider challenges that impact the ability of Enfield to decarbonise the electricity system. The complexity of the electricity market and slow regulatory developments cause difficulties in innovation, which slow down the development of flexibility technologies, where commercial demand services are in early stages. There is also limited public interest in flexibility services and installation of renewable technologies, due to a lack of funding, understanding of the technologies and awareness of their benefits.

2.2. Overcoming the challenges

Although the scale of the challenge of decarbonising the whole local energy system is significant, if Enfield capitalises on its opportunities and carefully plans for Net Zero, carbon emissions for the borough can reach Net Zero by 2040. This LAEP is a fundamental first step towards this target. It sets out achievable trajectories for the decarbonisation of the three main energy use sectors and sets out what changes are needed to ensure the prompt delivery of Enfield’s net zero ambitions. To this end, the LAEP focuses particularly on those key first next steps that will need to be taken in the immediate future to build momentum and ensure timely progress in the implementation of the long-term plan.

3. Technical Pathways

The recommendations set out within this document are underpinned by a technical evidence base. This includes the outputs of several separate research and modelling exercises that identified, and where possible quantified, the potential for a range of technical measures to reduce emissions within the borough. It also sought to examine how a locally appropriate combination of measures could be applied that could enable the net zero target to be achieved by 2040. These combinations of measures are referred to here as 'scenarios', or 'pathways'. This section provides a high-level summary of the scenario analysis contained in the technical evidence base, along with a description of key technical outputs for the final selected scenario across the three domains of heat in buildings, transport and power systems. This section therefore provides a vision for a net zero Enfield.

3.1. Analysis of scenarios

The technical analysis produced four decarbonisation scenarios, which result from the combination of various choices that could be made in pursuing a net zero Enfield. Details of the combination of choices for each scenario, as well as the rationale behind their development, are in the "Technical Scenarios" section of the accompanying technical evidence base. The following sections provide an overview of the scenarios and what they mean for Enfield.

3.1.1. Visions of a net zero Enfield

To illustrate the way the four scenarios would affect Enfield, they are described below in terms of the changes that would be seen from today to 2040 (in coloured boxes). The four scenarios are: 'high demand management', 'medium demand management', 'low demand management', and 'mixed demand management'. These names refer to the amount of active control that can be taken over the energy demand from heating buildings, transport and power systems.

High Demand Management

Vision

This is a scenario which prioritises decarbonisation benefits over cost-efficiency. Heat demand reduction is prioritised by applying high levels of insulation, before then determining the cost-optimal low carbon heating. Renewable energy is maximised across the borough, and transport is decarbonised through high levels of modal shift and high usage of flexible EV charging.

Results

Fabric insulation measures have very high uptake, with the majority of buildings in the borough being insulated to the maximum level of insulation which is appropriate. Less of the borough is connected to heat networks than in other scenarios, as high levels of insulation favour individual heat pumps. Despite this, a small majority of buildings are connected to heat networks rather than receiving an individual heat pump. Rooftop PV installations would become very common, installed on about three-quarters of the buildings. Private car ownership would fall by about a quarter by 2040 and by nearly half by 2050. EV charging is well managed, leading to smooth demand profiles. Total CAPEX would be £3.17B.

Heat	Transport	Rooftop solar
39,963 individual domestic heat pumps 1,086 individual non-domestic heat pumps 46,500 heat network connections 37.3 p/kWh cost of heat from individual heat pumps* 18.7 p/kWh cost of heat from heat network connections** 155,000 insulation measures installed Heat changes CAPEX of £2.7B	3,761 public chargers installed 25% reduction in private car fleet 454 GWh per year of demand from EVs	311 MW of rooftop solar installed 5,218 social housing installations 40,842 owner occupied installations 11,440 privately rented installations 1,969 non-residential installations 7,121 other installations Solar CAPEX of £391M Grid reinforcement CAPEX of £75.4M

Total emissions	2040	52 ktCO2e	2050	10 ktCO2e

* Here the cost of heat is the average levelised pence per kWh of heat delivered from the heat pumps. This includes CAPEX, OPEX, REPEX of the heat pump installation and operation, divided by the total heat output over its lifetime, with both value streams discounted in the same way.

** This value is the average levelised cost of heat delivered through networks. It includes costs (CAPEX, REPEX, OPEX) associated with both the generation and distribution of heat.

Medium Demand Management

Vision

This is a moderate scenario which takes an entire-system cost-optimising approach, balancing the costs of insulation against those of increased heat demand. It also places higher requirements on economic performance for renewable energy. There is less ambition in transport with lower levels of modal shift and less optimisation of EV charging.

Results

Many buildings will have new insulation, but the total insulation installed would be about half of that installed in the high demand management scenario. However, the total-system optimisation leads to a lower overall cost. About 9 in 10 properties would be connected to a heat network, with the remainder receiving an individual heat pump. Rooftop solar would be more common than today, but only present on about 1 in 10 buildings. Private car ownership would fall by about 15% by 2040, and 35% in 2050. EV charging is managed giving smoother demand profiles than in the low demand management scenario, but not as smooth as high demand management. Total CAPEX would be £2.73B.

Heat	Transport	Rooftop solar
7,989 individual domestic heat pumps 751 individual non-domestic heat pumps 78,800 heat network connections 22.3 p/kWh cost of heat from individual heat pumps 17.4 p/kWh cost of heat from heat network connections 69,000 insulation measures installed Heat changes CAPEX of £2.5B	3,899 public chargers installed 15% reduction in private car fleet 467 GWh per year of demand from EVs	149 MW of rooftop solar installed 774 social housing installations 4,514 owner occupied installations 1,507 privately rented installations 1,482 non-residential installations 1,097 other installations Solar CAPEX of £155M Grid reinforcement CAPEX of £75.4M

Total emissions	2040	56 ktCO2e	2050	11 ktCO2e

Low Demand Management

Vision

This is a scenario of low intervention, whilst still reaching Net Zero. Heat in buildings is optimised by balancing insulation and heating. Very high economic requirements are placed on renewable energy. There is little modal shift within transport, and little optimisation of EV charging.

Results

The heat system is the same as that in the medium demand management scenario, because the mix of insulation and heating is determined in the same way. There is very little uptake of renewable energy, with installations largely limited to large non-residential rooftops. There would be a switch to electric vehicles to move transport towards Net Zero, however there would not be any collective modal shift, and there would be a 22% growth in the private car fleet by 2040. EV charging demand is very ad-hoc and produces very rough demand profiles. Total CAPEX would be £2.64B.

Heat	Transport	Rooftop solar
7,989 individual domestic heat pumps 751 individual non-domestic heat pumps 78,800 heat network connections 22.3 p/kWh cost of heat from individual heat pumps 17.4 p/kWh cost of heat from heat network connections 69,000 insulation measures installed Heat changes CAPEX of £2.5B	4,783 public chargers installed 22% growth in private car fleet 542 GWh per year of demand from EVs	63 MW of rooftop solar installed 2 social housing installations 23 owner occupied installations 6 privately rented installations 260 non-residential installations 91 other installations Solar CAPEX of £53M Grid upgrade CAPEX of £89.6M

Total emissions	2040	66 ktCO2e	2050	13 ktCO2e

Mixed Demand Management

Vision

The mixed demand management scenario is driven by optimising cost whilst still retaining high levels of good practice. This means that less economic renewable schemes are considered, and that hard-to-achieve changes such as modal shift are heavily encouraged. This scenario combines a cost-optimising approach to insulation with maximised generation of renewable energy across the borough. Modal shift uptake and EV charging flexibility are high.

Results

The heating system is the same as in the medium and low demand management scenarios, offering the most cost-effective mix of insulation and zero carbon heat sources. However, rooftop solar would be as in the high demand management scenario, with high capacity and many installations across differing property types. There would also be a shift to alternative transport as seen in the high demand management scenario, with reduction in the private car fleet. EV charging would also be very well managed, with smooth demand profiles. Total CAPEX would be £2.97B.

Heat	Transport	Rooftop solar
7,989 individual domestic heat pumps 751 individual non-domestic heat pumps 78,800 heat network connections 22.3 p/kWh cost of heat from individual heat pumps 17.4 p/kWh cost of heat from heat network connections 69,000 insulation measures installed Heat changes CAPEX of £2.5B	3,761 public chargers installed 25% reduction in private car fleet 454 GWh per year of demand from EVs	311 MW of rooftop solar installed 5,218 social housing installations 40,842 owner occupied installations 11,440 privately rented installations 1,969 non-residential installations 7,121 other installations Solar CAPEX of £391M Grid reinforcement CAPEX of £79.9M

Total emissions	2040	53 ktCO2e	2050	10 ktCO2e

3.1.2. Technical overview of scenarios

Further detail on the scenarios than is given here is available in technical evidence base. The scenarios have also been governed by a number of additional assumptions which are not directly controllable but will affect the analysis. These assumptions are:

1. **The price of electricity and gas –** Energy prices are currently rapidly rising, and it is impossible to constantly update the work alongside them. For the LAEP, a price based on April – September 2022 values was assumed. This is detailed in the technical evidence base section "Scope and methodology" for the power systems analysis. It should be noted that rising prices generally support the measures suggested in this LAEP.
2. **Carbon intensity of grid electricity** – As noted previously, decarbonisation is assumed to rely on the electrification of heat and transport. Therefore, the electricity grid that powers these measures must be decarbonised. The modelling uses carbon factors from the Committee on Climate Change's Balanced Pathway, which sees the grid achieve zero carbon in the 2030s (see power systems section for further details).
3. **Availability of hydrogen** – While light transport can be electrified, there is no currently viable solution for heavy, long-range transport other than hydrogen. The availability, cost and carbon intensity of hydrogen is uncertain, and at present it is not expected that heavy duty transport can be fully decarbonised by 2040. Hydrogen has not been considered for home heating because it is an emerging technology with little evidence for economic use in heating homes[6]

There are also underlying requirements such as funding, supply chains, public consent, and political will, that will be necessary to achieve the objectives of this LAEP. The analysis assumes these non-technical conditions are met, and the accompanying WATI and SWOT analyses set out how these can be developed in and around Enfield.

It should also be noted that there are several variables which are not explicitly considered – for example the value of electricity demand flexibility services. More detail on these is provided in the technical evidence base.

3.1.3. Optimal scenario

Based on the analysis, the mixed demand management scenario is recommended as optimal for Enfield. When examining the carbon trajectories under each scenario, there is little difference in total carbon emissions by 2040, as all scenarios are in line with the overarching net zero ambition for the borough. Instead, the scenarios were considered in relation to how cost effective they are for the end user. Certain interventions are likely to increase costs to the end user and others have the potential to decrease them. As higher end user costs would increase rates of fuel poverty in the borough, they are the least desirable, and therefore least optimal, option. For instance, heating changes and grid reinforcement investment increase costs to the

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[6] For a review of independent studies looking at hydrogen heating, see Rosenow, J. (2022) Is heating homes with Hydrogen all but a pipe dream? An evidence review. Available at: https://doi.org/10.1016/j.joule.2022.08.015

end user in proportion to the money spent to implement them. On the other hand, profitable solar installations have the potential to decrease end user costs because they offset electricity charges and are therefore particularly important where the heating system is electrified.

In terms of heating and power system upgrades, the mixed demand management scenario is the second cheapest option (only £4M more than the medium demand management scenario, which is the cheapest). Like the high demand management scenario, the mixed management one presents the highest deployment of solar PV, with 162MW of additional solar capacity. Through high levels of modal shift, it sees the biggest reduction in car usage and through high rates of flexibility, it generates the lowest electricity demand from EV charging. By combining these factors, the mixed demand management scenario was therefore chosen as the optimal scenario in keeping the costs to the end user low.

3.2. Heat in buildings

This section addresses the significant challenge of decarbonising the energy used for space and water heating in Enfield's almost 90,000 buildings. Table 1 summarises the baseline position and gives the scale of the challenge: the elimination of just under 350,000 tonnes of CO_2 emissions annually.

Table 1: Existing heat demand and carbon emissions in Enfield in 2019

Sector	Buildings	Annual Heat demand (GWh)	Energy Use Intensity (kWh space heat / m^2 floor area)	Emissions from fossil fuels (kt CO_2e)	Emissions from electric systems (kt CO_2e)	Total emissions (kt CO_2e)
Residential	84,805	921	102	295	19	314
Non-residential	2,753	208	65	10	12	22
Total	**87,558**	**1,129**	**90**	**305**	**31**	**336**

The analysis presented here is taken from the mixed demand scenario. It follows the core principles of Least Regrets and Least Cost set out in the technical evidence base, and identifies the most cost-effective combination of the following option across all buildings in Enfield:

1. Saving energy used for space heating by improving building fabric efficiency.
2. Using high efficiency electrically powered air-source heat pumps (ASHPs)[7].

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[7] Individual hydrogen boilers are not cost competitive with ASHP so have not been considered as per explanation in evidence base p. 14.

3. Deploying heat networks supplied from a combination of sources (such as large air/water/ground/waste source heat pumps, industrial/commercial waste heat, and hydrogen produced from excess renewable electricity generation).

Map 1 shows the geographic spread of demand for space and water heating across Enfield. Map 2 shows the distribution of low efficiency residential buildings. Taken together, these present a visualisation of the challenge this section addresses – that is, the reduction and decarbonisation of heat demand using the least-cost combination of the measures discussed above.

Energy from waste incineration is not zero carbon[8], because a proportion of its energy value comes from plastics which are derived from oil. However, where waste incinerators already exist (and are contracted to continue operating for a long period), it makes sense to capture the available heat for use in networks – the alternative is simply to vent it to the atmosphere, which would be a missed opportunity to reduce gas use elsewhere. This is the basis on which the Energetik network in Enfield currently operates and plans to expand. However, in the long-term such heat networks will need to transition to zero carbon energy sources, which is the basis of the modelling undertaken for this LAEP.

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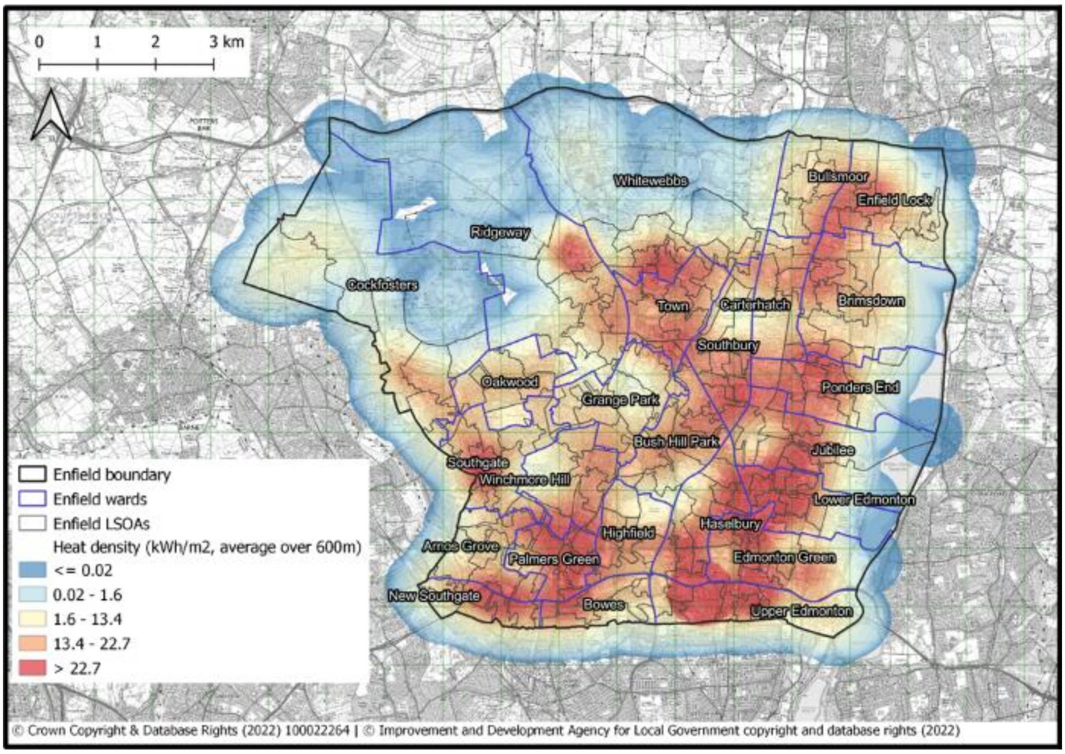
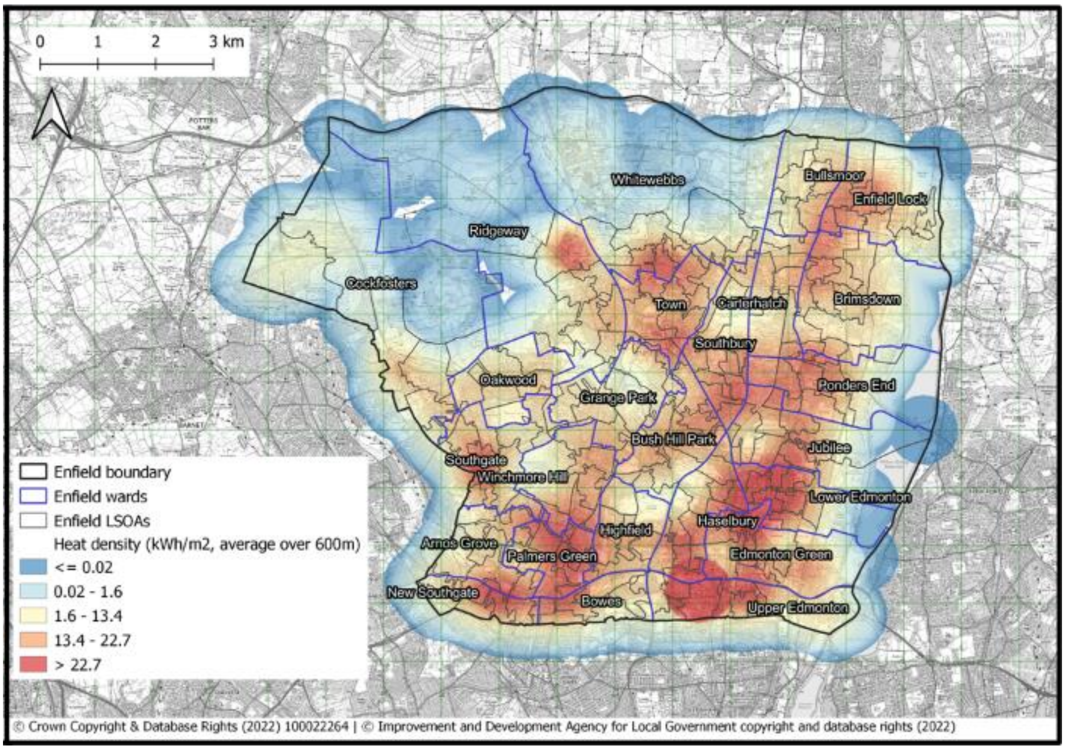
[8] Energy from waste is not considered a zero carbon heat source. Carbon factors from BEIS (https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022) place the carbon emissions at 21.28 $kgCO_2e$/tonne of household waste incinerated.

Map 1: Heat demand density in Enfield: baseline vs at Net Zero

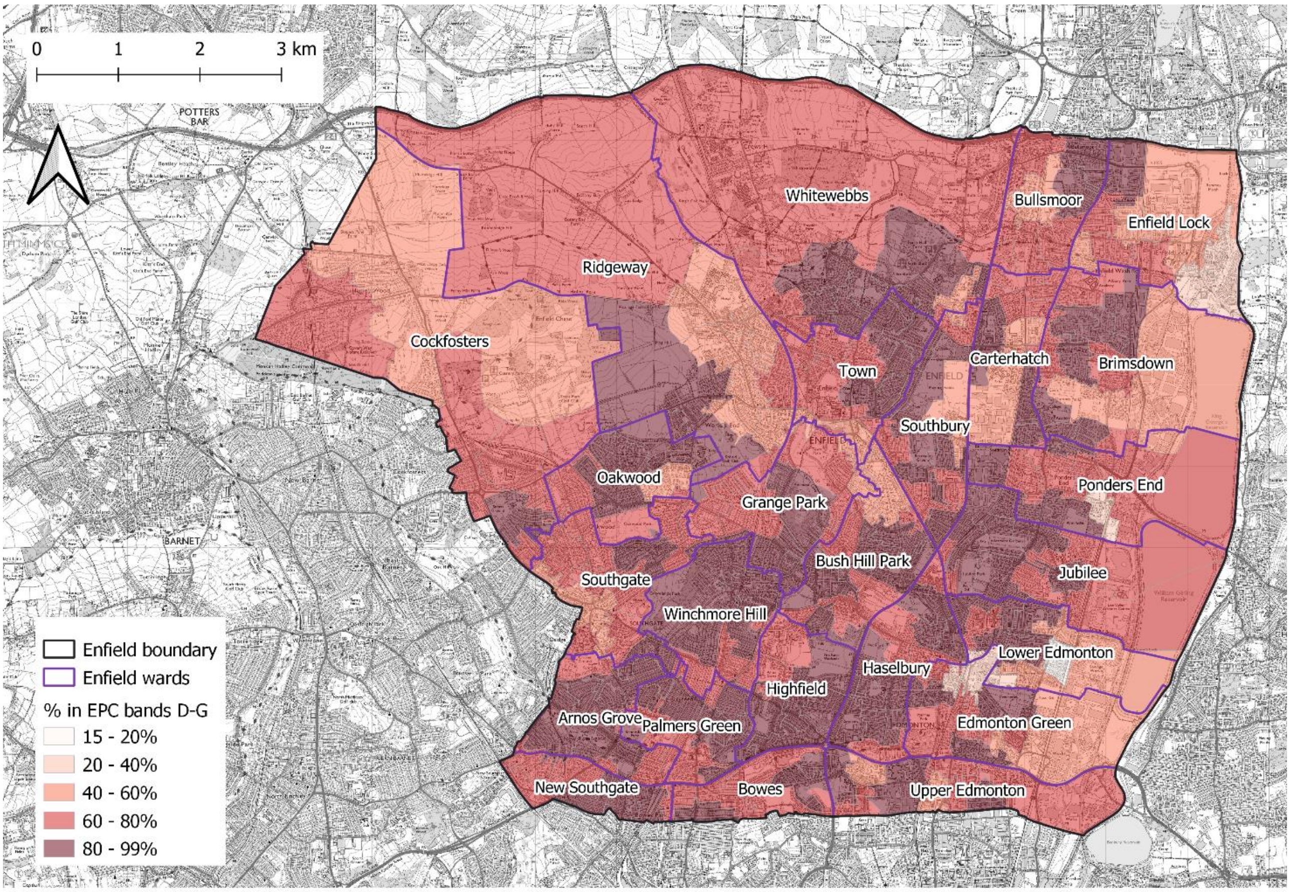
Baseline



At Net Zero:



Map 2: Proportion of buildings in EPC bands D-G by ward



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3.2.1. Method

To identify the most cost-effective mix of these options, a cost-minimising optimisation approach was used. The model automatically finds the best combination of insulation and heat supply for each and every building in the borough, while taking into account localised heat network routing options and costs. This uses the model underpinning CSE's widely used THERMOS heat network optimisation software. The detailed methodology is described in the approach in the technical evidence base.

The results presented here are taken from the mixed demand management scenario, which is the selected scenario. In this scenario only cost-optimal insulation is installed and heat networks are assumed to be able to obtain heat at a maximum levelised cost of heat[9] (LCOH) of 6p/kWh[10], with no limit placed on the amount of such heat available. This LCOH is a conservative estimate and allows flexibility in future policy decisions.

---

[9] Levelising is an approach to summarising costs which enables a comparison between items with different cost structures. In this case it involves summing (with optional discounting) the CAPEX, OPEX and REPEX cashflow for a heat supply option, and dividing this by the (also optionally discounted) sum of delivered heat

[10] 6p/kWh is the assumed levelised cost at which heat can purchased by the network operator from the heat generator, for the purposes of optimising the mix of heat networks and heat pumps across the borough. It represents the LCOH at the gate of the heat plant, and is calculated only from the costs (CAPEX, OPEX, REPEX) of building and operating the heat plant – it does not consider the heat distribution network. This is why it is lower

3.2.2. High level findings

Demand reduction

Insulation needs to be installed on around 50,000 of the 87,600 buildings in Enfield, reducing annual space heat demand by 108 GWh – this is 10% overall, with a typical reduction of 20% for the buildings that receive insulation. The capital cost of the insulation is just under £100M, with an average of around £2,000 per insulated building. This is summarised in Table 2 with a breakdown by insulation measures. The reduction in heat demand by the selected insulation measures comes at a cost of just over 6p/kWh of heating avoided. The cost per kWh of supplying heating from a heat network or individual heat pump is significantly greater than 6p/kWh, therefore there is a clear advantage to installing these insulation measures. The average change in energy use intensity is from a figure of 90 kWh/m^2 to 81 kWh/m^2 per year, across both residential and non-residential properties.

Table 2: Cost-optimal insulation measures by 2040 under the recommended scenario

Measure[11]	Installations	Cost £M	Cost average £	Total yearly GWh reduction	Average yearly kWh reduction
CWI	11,501	23	2,004	38	10,358
EWI	518	5	9,547	4	12,120
Floor	37,096	50	1,352	41	8,985
Glazing	53	1	25,927	2	85,298
Loft	16,759	18	1,050	23	10,186
Total	65927	97	-	108	-

Installing insulation reduces running costs. As a simple illustration, at current gas prices[12] a 20% reduction in consumption for a typical gas-heated home would be worth around £200/year[13]. For a home heated via an ASHP, the calculation is complicated by the fact that the insulation improves the operating efficiency of the heat pump as well as reducing demand. Taking this into account, the estimated annual saving would be around £400[14]. Long-term projections from BEIS[15] currently imply that prices return to trend – in this case estimated savings would be around two thirds of the above figures.

---

than the overall LCOH of networked heat given in the results (see below), which accounts for both heat costs and pipe costs.

[11] CWI stands for cavity wall insulation and EWI stands for external wall insulation. Further details are available in the technical evidence base document.

[12] October 2022: 10p/kWh for gas, 30p/kWh for electricity

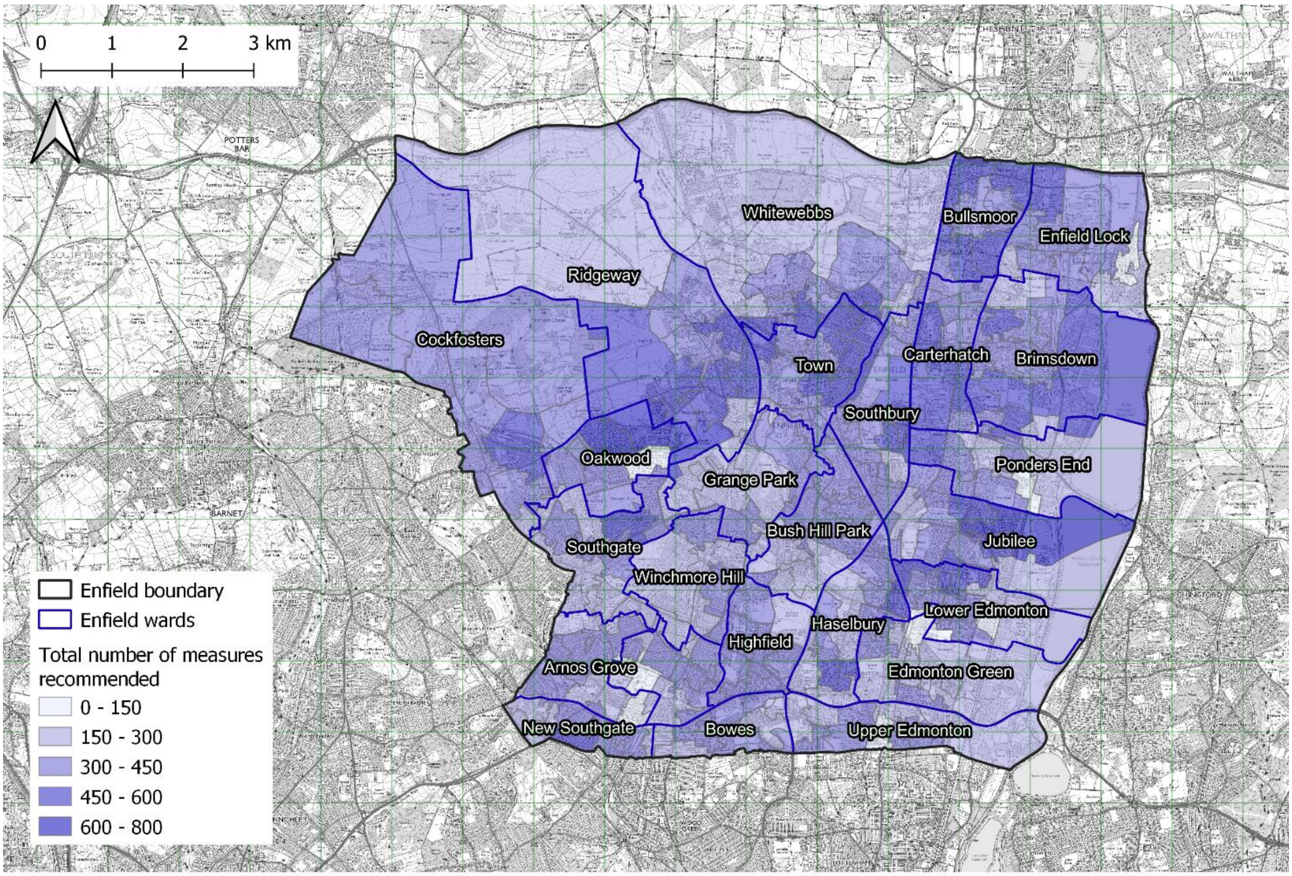
[13] 30p/kWh * 10,000 kWh/year * 20% = £300

[14] 10p/kWh * 10,000 kWh/year @COP 2.5 = £1,200. Cf 10p * 8,000 kWh * @COP 3 = £800

[15] BEIS Green Book Tables 4-8. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/793632/data-tables-1-19.xlsx

There is a balancing act in the choice of insulation, as some insulation measures, such as external wall insulation and double glazing, are very expensive to install. This means that the money saved on heating by insulating is less than the cost of insulation and therefore the installation of these measures is rarely recommended. The distribution of the insulation measures in the recommended scenario is shown in Map 3.

Map 3: Distribution of insulation measures recommended under the mixed demand management scenario by Net Zero



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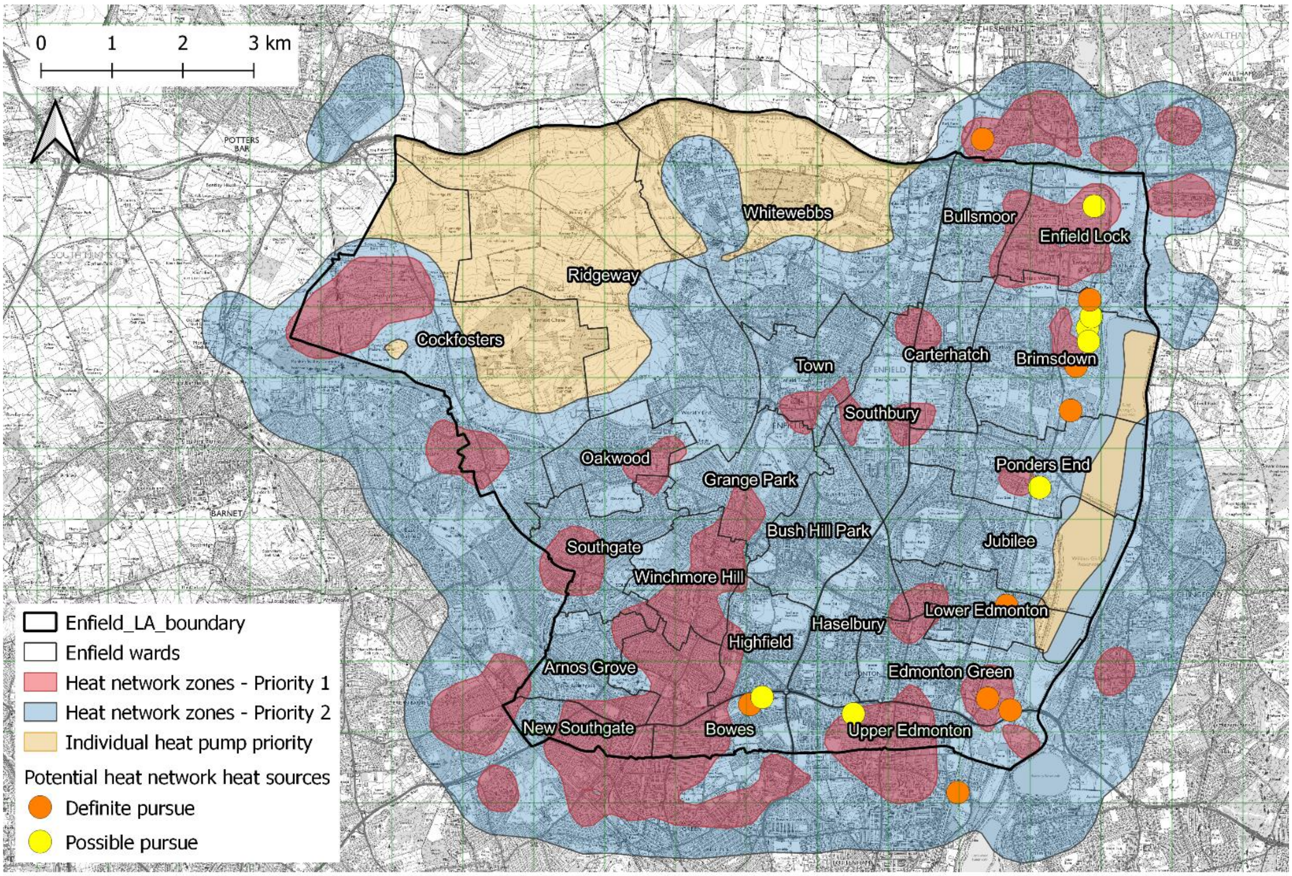
Heat supply

The mixed demand scenario results show that heat pumps are needed to supply around 10% of buildings, and 12% of demand, with heat networks supply 90% of buildings, and 88% of demand. These latter figures may appear high compared with earlier studies – this is partly because previous work has tended to focus on a competition between gas boilers (which are cheaper than ASHPs) and heat networks. It is also because the approach we have used for modelling the costs of heat networks are much more detailed than has previously been possible. The distribution of the differing heat supply solutions is shown in Map 4. Also shown are the locations of potential waste heat sources, which could provide low cost heat to heat networks. Heat networks are split into two priority levels in the map. Priority one areas are those where the economic performance of the heat network is very good and therefore should be developed first. The analysis aligns well with Energetik's plans for heat network expansion, which, if implemented, would serve several of the heat network priority areas identified.

Map 4: The distribution of heat supply technologies across Enfield under Net Zero



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Total capital cost of heat pump installations is £94M, excluding power network reinforcement, with an average levelised unit cost of around 21p/kWh. Heat networks supply just over 900 GWh, at a capital cost of £2.3Bn (excluding power network reinforcement), and an average levelised unit cost of 17.5p[16]. There are likely to be additional benefits to upgrading the heat system within Enfield that are notable even though difficult to quantify. These are some examples of co-benefits:

- Adding additional insulation to homes can help residents feel warmer (even beyond the benefit of increased heating efficiency).
- Centralisation of heating management through heat networks can also reduce stress and worry over boiler issues – as it is no longer the responsibility of individuals to negotiate maintenance and repairs.
- Further, the removal of gas heating reduces secondary issues related to failure.
- By using heat pumps powered by electricity, and heat networks where there is no internal boiler, issues related to carbon monoxide poisoning from boiler failure are eliminated.

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[16] This levelised unit cost refers to the cost at the end point of the distribution system. It accounts for the original levelised cost of heat at the gate of the heat plant, as well as the distribution networks, pumping systems, etc.

- Increased carbon dioxide levels within homes where gas is burned for heating and cooking are common and these will be eliminated with the elimination of in-home gas boilers.

3.2.3. Summary

To decarbonise space and water heating in Enfield by 2040, 50,000 buildings will need fabric insulation measures installed, at a cost of £100M. This will decrease the heating demand across the borough by 10%. 8,740 premises in the borough should be supplied by individual air source heat pumps, installed at a cost of £94M. Heating to the remaining 78,800 premises should be supplied from heat networks at a cost of £2.3bn.

3.3. Transport

The transport sector is the largest single sector source of greenhouse gas (GHG) emissions in Enfield, contributing 45% of total CO_2 emissions in the borough[17]. Enfield also has areas that exceed government objectives for air pollutants at busy roadside locations. Progress towards decarbonising the road transport sector in Enfield is therefore vital to the borough's overall net zero objectives. However, the transition to electric vehicles and resulting electricity demand will also contribute to the challenge faced by the energy system that must seek to facilitate rather than hinder decarbonisation activities.

3.3.1. Current situation

As shown in Figure 2, the bulk of Enfield's energy emissions associated with transport comes from cars (48%), which make up over 80% of the total fleet. Heavy goods vehicles (HGVs) are the next largest source of emissions (25%), despite only representing 2% of all road vehicles. Transport emissions in Enfield have been estimated based on the stock of vehicles primarily operating in the Borough. The 2019 London Energy and Greenhouse Gas Inventory (LEGGI) is another estimate of emissions that is based on based on overall traffic flows, average speeds and fleet composition. While the two approaches produce similar estimates, a comparison indicates that Enfield could be a net exporter of vehicle activity for cars, vans and taxis. However, the differences could also be explained by the other differences in the methodology of each calculation.

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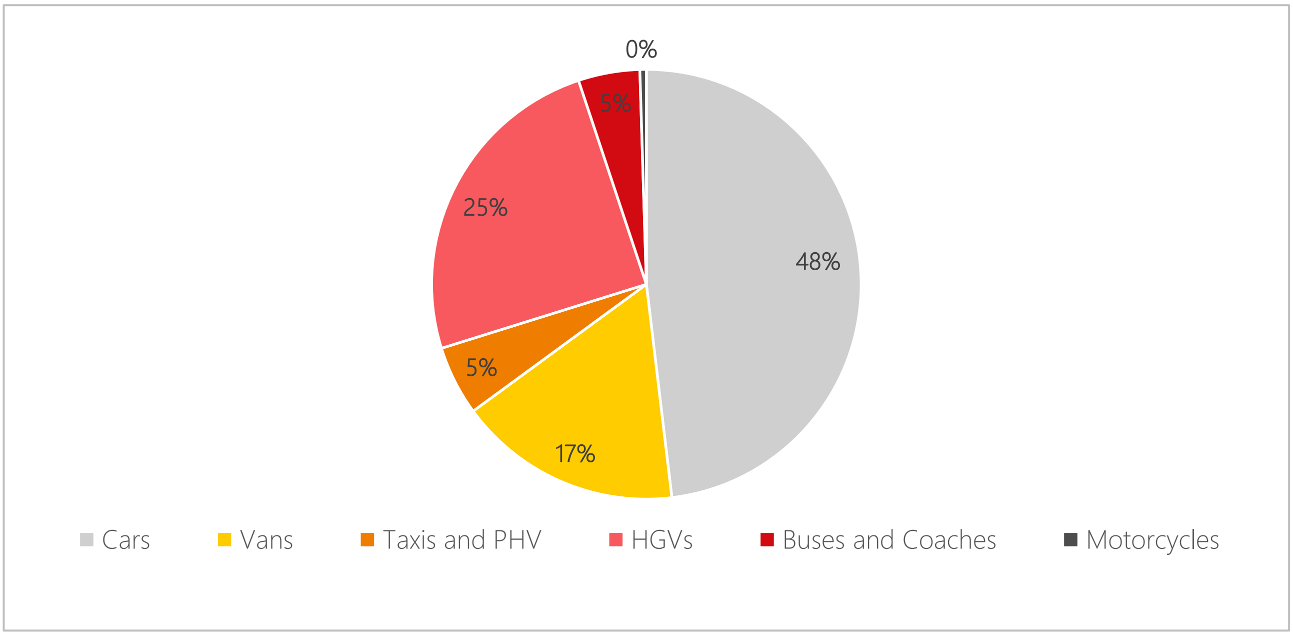
[17] BEIS (2019) UK local authority and regional carbon dioxide emissions national statistics: 2005-2019

Table 3: Total transport fleet size in the Borough of Enfield[18]

	Total vehicles	Electric vehicles
Cars	139,228	1,882
Vans	17,870	47
Taxis and private hire vehicles (PHVs)	5,433	590
HGVs	2,712	-
Buses & Coaches	641	-
Motorcycles	3,091	123
Total	**168,976**	**2,642**

Figure 2: Enfield Borough vehicle fleet contribution to emissions in Enfield (2020)



Enfield Council and external partners have already been promoting a shift away from car travel and towards public transport and other sustainable travel options (modal shift). To do this, the Councils support the extension of the Ultra Low Emission Zone (ULEZ) across the whole borough and have set up the Healthy Streets initiative to promote walking and cycling. Although it appears vehicle activity is increasing on Enfield's roads, the stock of vehicles licensed to addresses in Enfield (i.e. that are owned or leased by local residents) has actually been stable and slightly decreasing over the last 5 years[19]. This trend may be the result of key spine roads that carry large vehicle numbers through Enfield.

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[18] Ricardo estimations from UK Power Networks DFES scenarios (UK Power Networks, 2020) and DfT vehicle licensing statistics (DfT, 2021)

[19] DfT (2021) Vehicle licensing statistics (Table VEH0105)

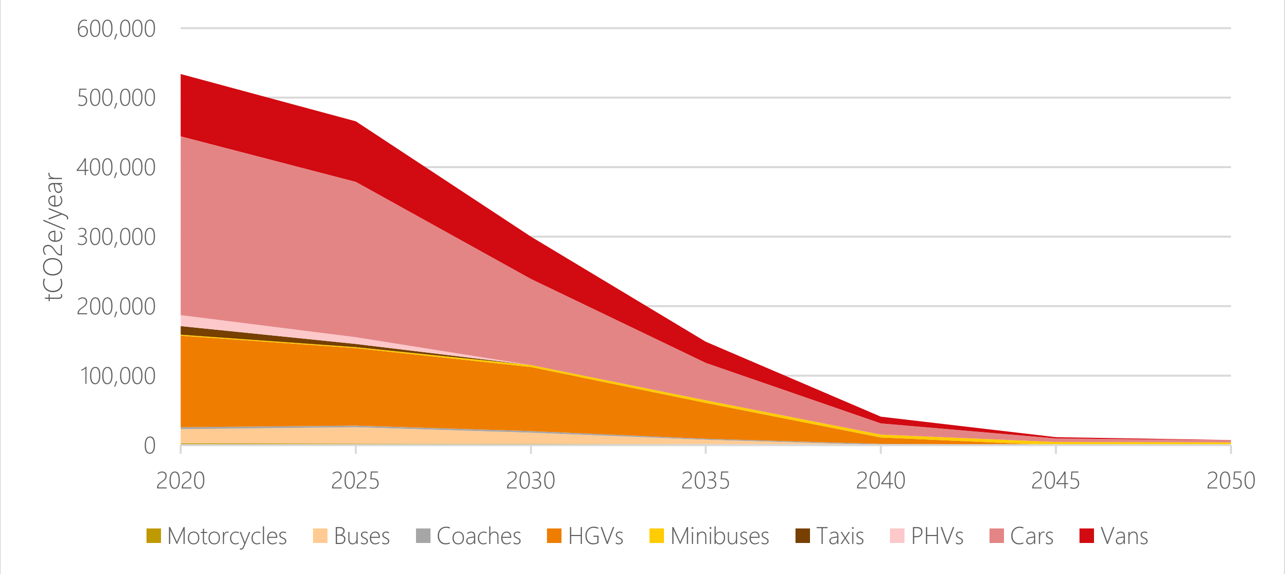
If Enfield is to achieve its net zero ambitions, as well as effective modal shift, any vehicles in the borough must be switched to zero emissions alternatives. For most road vehicles this will be electric vehicles, although for some larger vehicles hydrogen is likely to be a viable option. This transition to electric has already begun and is expected to accelerate as we move towards the end of new petrol and diesel car and van sales in 2030. However, with electric vehicles representing only a fraction of total vehicles in Enfield today, the scale of the challenge is clear.

To establish what the future of transport in Enfield needs to look like in line with the mixed demand management scenario, we have considered several key variables:

- The level of modal shift away from private vehicles
- The pace of transition to zero emission vehicles
- The uptake of smart charging for electric vehicles to manage peak electricity demand events[20]

To achieve its 2040 net zero ambition, Enfield will need a 92% reduction in GHG emissions from vehicles between 2020 (534,000 tonnes CO_2e) and 2040 (41,000 tonnes CO_2e). Figure 3 shows that emission reductions from the HGV fleet only begins to accelerate after 2030, while emissions from light duty vehicles drop consistently from 2020.

Figure 3: Total tailpipe GHG emissions from vehicles in Enfield – high scenario (based on UK Power Networks Leading the way DFES scenario[21])



3.3.2. Method

A statistical model was used to assess a range of potential futures (scenarios) for the transport system in Enfield. Four scenarios were developed that are described in more detail in the

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[20] Vehicle-to-grid impacts have not been modelled due to a lack of data on expected uptake (from a technology and driver user perspective) or network impacts of such services. Further investigation is required. In the latest UK Power Networks DFES, the export capacity available from vehicle-to-grid at system peak is equivalent to 36% of the total in the Leading the Way scenario.

[21] UK Power Networks (2020) Distribution Future Energy Scenarios

Analysis of scenarios section. The model considers how the number and type of road vehicles in Enfield may develop over time, what charging infrastructure will be needed to support electric vehicles, and how the electric vehicles will place an additional burden on the electricity network. The detailed methodology is described in the technical evidence base.

3.3.3. Transitioning to a net zero transport sector

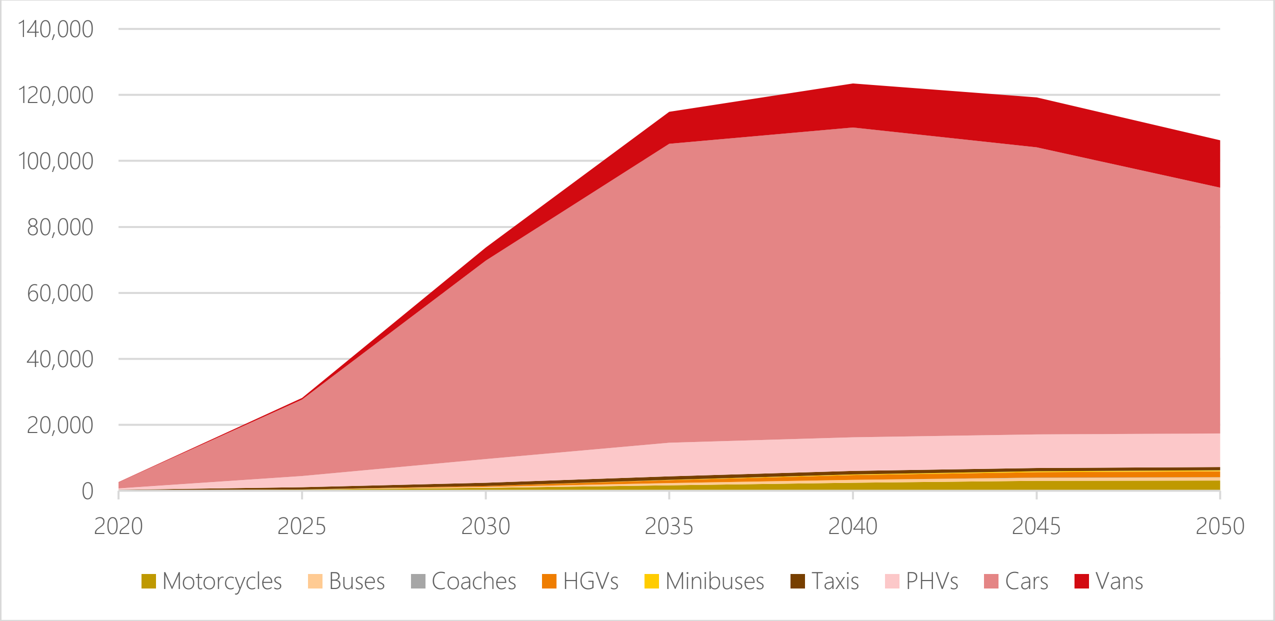
As described above, it is vital that there is a shift away from the reliance on private cars towards more sustainable modes, such as public transport, walking and cycling. This should also be a focus for the Council as they have more direct influence over how the way people travel, rather than the type of vehicle people purchase. As well as supporting the extension of the ULEZ, the Council should make sure there are convenient electric vehicle charging options across the Borough. The Council will also need to work with stakeholders to ensure that the electric vehicles use the limited electricity network capacity effectively and do not result in expensive network upgrades.

3.3.4. Modal shift and EV uptake

Strong measures that encourage the use of public transport, walking and cycling can reduce the total fleet size from almost 170,000 in 2020 to 110,000 in 2050. There is a short-term increase in vehicle numbers before a steady decline from 2025. A reduction in private car use is supported by an increase in buses and private hire vehicles, responding to higher demand for these services. The key metric to monitor modal shift will be 45% percentage reduction in private car mileage between 2020 and 2050, which in practice may be reflected by fewer vehicles on the road, lower average mileage or a combination of both. In contrast to the 2020 report, the most recent UK Power Network DFES report assumes no decrease in total vehicle numbers, although kilometres travelled are assumed to reduce. Figure 4 shows the rapid increase in electric vehicles, which make up almost 90% of the total fleet by 2040 and 95% by 2050. This is driven by national policy (such as the ban on new petrol and diesel sales), a maturing electric vehicle market, and local policies that ensure EVs are convenient to use.

While electric vehicles still produce non-exhaust emissions of particulate matter, they have the potential to significantly reduce emissions of air pollutants (particularly nitrogen oxides, NOx) as they replace conventional internal combustion engines. In addition to environmental benefits, the resulting health benefits are one of the key drivers behind policies such ass (ultra)low emission zones. There is also likely to be the opportunity to make better use of space within Enfield. Active travel and public transport usage uses less space than personal vehicles. Therefore, portions of existing infrastructure such as car parks can be converted to other uses such as green space, further improving wellbeing. A change in transport modes is likely to have significant secondary benefits beyond reaching Net Zero that are difficult to quantify at this stage. Increased use of alternative travel such as walking and cycling can improve public wellbeing and health, in particular reducing levels of obesity. Changing to active travel for commuting can also reduce commuting costs, increasing the level of disposable income within the area. Finally, modal shift presents an opportunity to make better use of space within Enfield, as infrastructure allocated for private car use (i.e. roads and parking) can be converted to other uses such as green space, which can further improve local wellbeing.

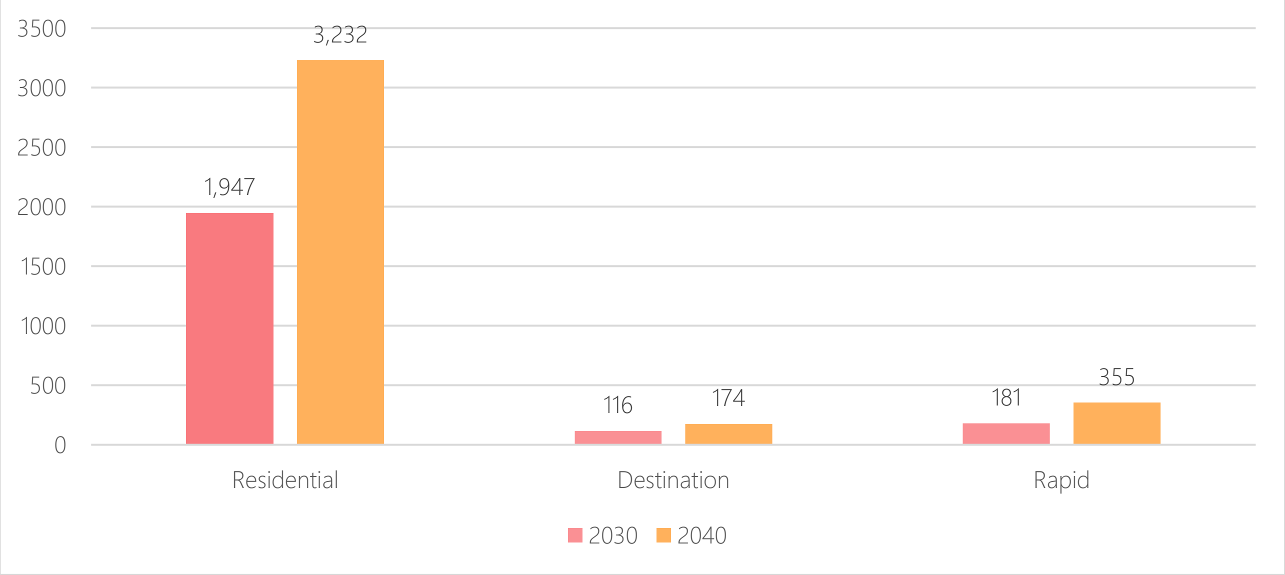
Figure 4: Electric vehicles in the fleet



3.3.5. Charger deployment

Based on the future estimated number of electric vehicles in Enfield shown in Figure 4, Enfield will require around 2,244 public charge points in 2030, rising to 3,761 in 2040. Enfield currently has just over 100 public charge points[22], of which over 80% are slow chargers. Figure 5 shows that the majority of these will be residential slow charge points, with far fewer destination and rapid chargers strategically deployed across the borough.

Figure 5: Number of public charge points required by type, in 2030 and 2040



Map 5 shows the concentration of these charge points across Enfield in 2040, divided into the catchment areas of primary electricity substations that each charger would be connected to.

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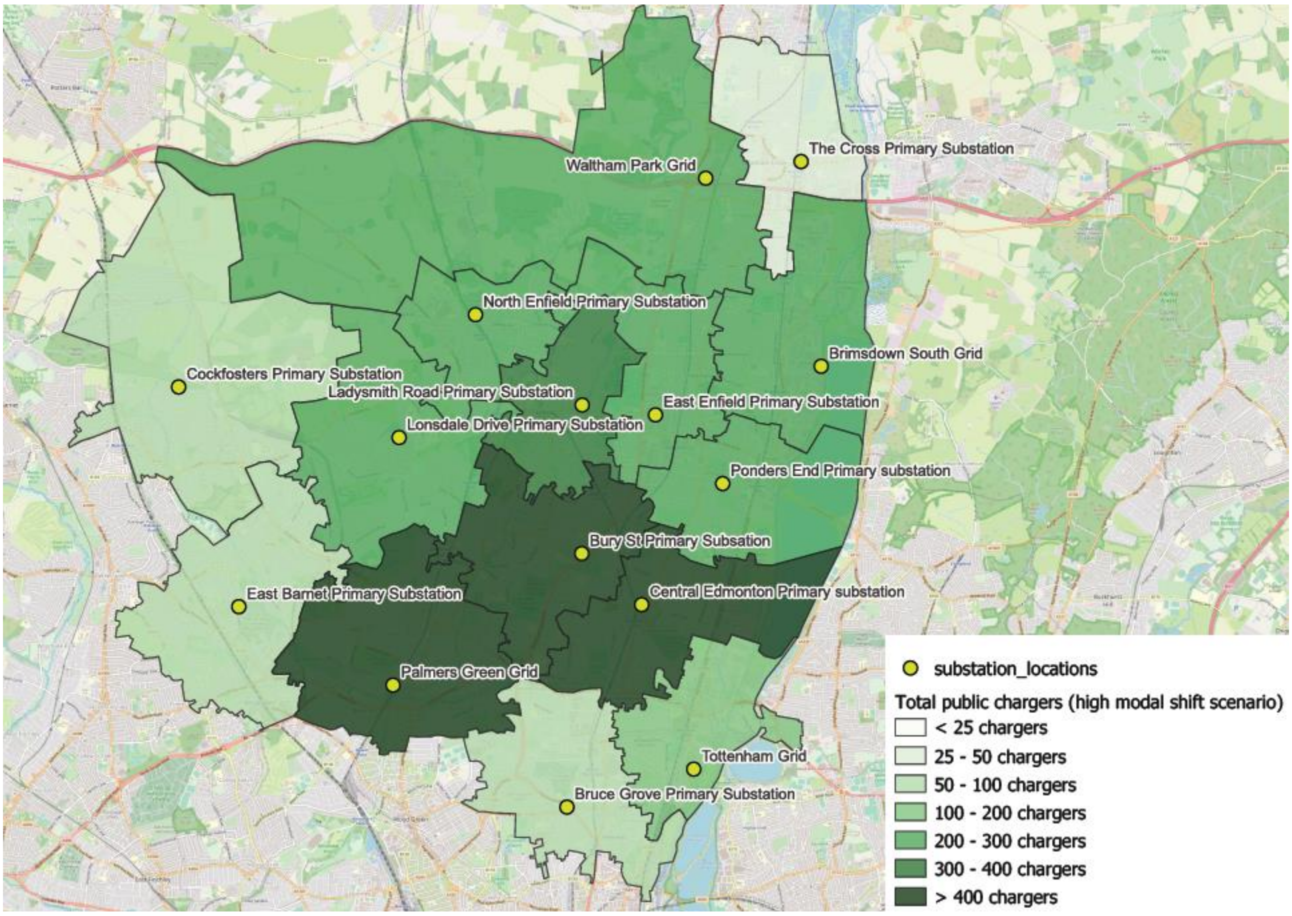
[22] London Borough of Enfield (2022) Enfield EV Chargers Asset Register

Most chargers will be required in the south of the Borough across Palmers Green, Bury St and Edmonton.

Map 5: Public charge points required in 2040



By 2040, the total investment required to deploy these charge points would be £30 million. If Enfield is only responsible for the deployment of residential on-street chargers, then a total investment of £16 million would be required by 2040, with the private sector funding the remaining £14 million for destination and rapid charge points. Currently there is funding for on-street residential chargers through ORCS (on-street residential charging scheme) of up to 60% of CAPEX. This scheme is due to be replaced by the LEVI fund (local electric vehicle infrastructure fund), which may have different funding capabilities.

Table 4 shows the estimated numbers of public charge points required across each substation catchment area in 2040 for residential, destination and rapid chargers. Naturally, areas with high demand for chargers will require a greater overall power capacity to accommodate these charge points. This is particularly the case for higher-powered chargers that are usually required for larger vehicles such as HGVs. For this reason, substation catchment areas with a large number of HGVs registered (such as Brimsdown South Supply Area) could have a very high power capacity requirement in future in the HGVs transitioned to electric vehicles by 2040, particularly when the private depot chargers are considered.

Table 4: Number of charge points required per substation catchment area in 2040

Substation	Residential	Destination	Rapid
Cockfosters supply area	79	5	8
Waltham Park grid supply area	203	12	22
The Cross	41	2	4
Waltham Abbey Supply Area	0	0	0
Lonsdale Drive Supply Area	254	16	26
North Enfield Supply Area	196	12	20
Ladysmith Road Supply Area	280	18	29
East Enfield Supply Area	252	15	27
Brimsdown South Grid supply area	219	10	33
Ponders End Supply area	209	9	24
Chingford Supply Area	0	0	0
East Barnet Supply Area	73	4	8
Palmers Green Grid Supply Area	503	29	52
Bury St Supply Area	377	21	39
Central Edmonton Supply Area	389	15	41
South Chingford Primary Supply Area	0	0	0
Watsons Road Supply Area	0	0	0
Cranley Gardens Primary Supply area	0	0	0
Bruce Grove Supply Area	72	3	8
Tottenham Grid Supply area	83	4	12

Note: this table only covers public charge points required. There will be considerably more private home chargers and depot chargers required in the area to serve the future electric vehicle fleet.

By 2040, the total investment required to deploy the public charge points would be £30 million. If Enfield is only responsible for the deployment of residential on-street chargers, then a total investment of £16 million would be required by 2040, with the private sector funding the remaining £14 million for destination and rapid charge points. Currently there is funding for on-street residential chargers through ORCS (on-street residential charging scheme) of up to 60% of CAPEX. This scheme is due to be replaced by the LEVI fund (local electric vehicle infrastructure fund), which may have different funding capabilities.

There are several different business models and approaches to deploying public charge points[23]. For example, the recent EV Charging Infrastructure Strategy announced by the UK Government has indicated that the public sector is stepping away from supporting destination charging, as the market for these types of chargers are developing naturally[24]. There is also a better financial case for rapid chargers, given the higher throughput of electricity enabling a greater return on investment for the private sector. Residential charge points are more likely to require public funding and support to implement. These are usually deployed as lamp post chargers or standard bollard-style chargers. Each type of charge point has different investment strategies and costs to end-users.

3.3.6. Supporting flexibility

Flexibility or smart charging involves shifting charge events to a different time, when there is lower overall demand on the electricity system, or higher levels of renewable energy generation. This can help to ease the total power demand on the electricity network, potentially avoiding the need for costly upgrades to network assets. EV drivers may be rewarded with cheaper electricity. Figure 6 shows the daily charging demand profile (in MW per hour) across all substations in 2040 and demonstrates the impact of a great uptake of smart charging practices. The chosen (high) scenario has a significantly smoother daily charging profile with reduced peaks in the morning and evening. This results from a greater uptake of smart charging during private charging events (i.e. residential, work and depot). This could include vehicles charging during off-peak hours to benefit from cheaper electricity rates, or managed charging of vehicles that can disable charging during peak events. In June 2022, new laws introduced a requirement for new private chargers (excluding rapid) to have smart functionality. This is expected to increase the uptake of smart charging. There is a role for Enfield Council to support awareness raising of the benefits of smart charging to EV owners.

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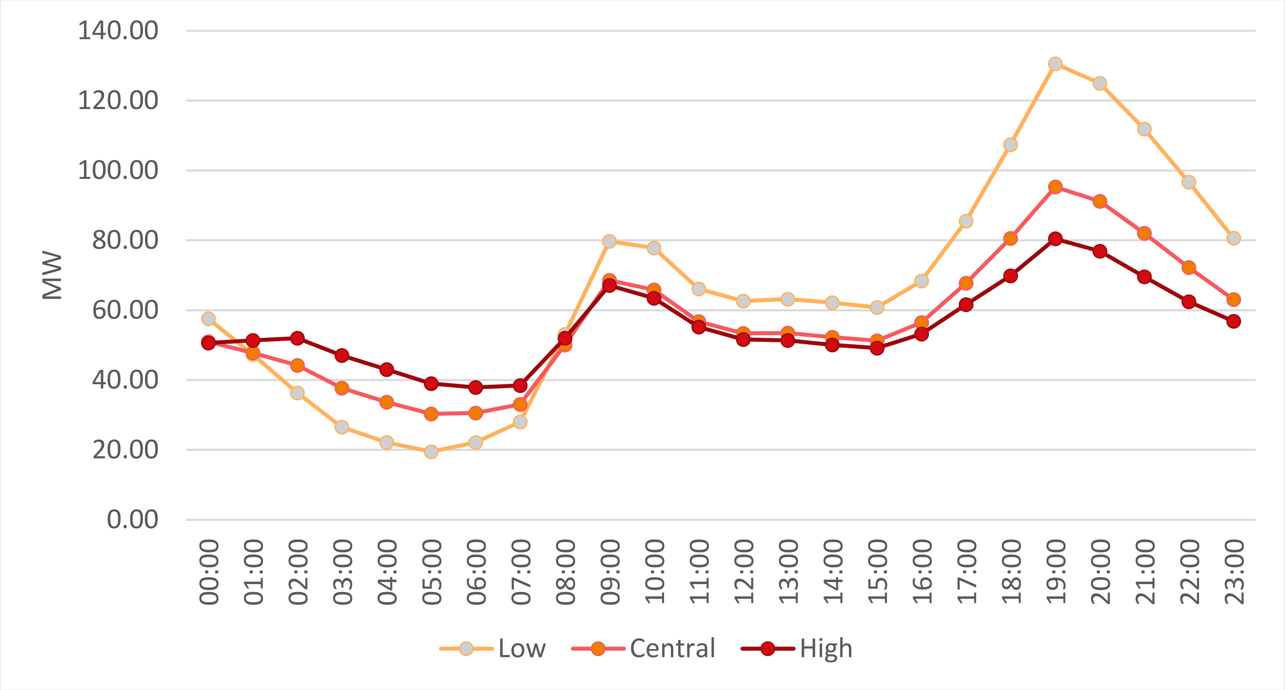
[23] https://www.theccc.org.uk/publication/costs-and-impacts-of-on-street-charging-ricardo-energy-environment/

[24] https://www.gov.uk/government/publications/uk-electric-vehicle-infrastructure-strategy

Figure 6: Total peak power required per day on typical weekday (MW, all substations, 2040)



3.3.7. Summary

The chosen mixed demand management scenario presented is characterised by:

- Effective modal shift away from private cars resulting in 60,000 fewer cars on the road, or 45% reduction in distance travelled by cars by 2050 compared to 2020[25].
- Fast uptake of electric vehicles to comprise 90% of the total fleet by 2040 and 95% by 2050.
- Broad uptake of smart private charging, delivering a reduction in evening peak power demand of almost 40% relative to a limited smart charging uptake scenario.

In this scenario, a 92% reduction in GHG emissions from road vehicles can be achieved by 2040, broadly aligned with Enfield's net zero target. The total investment for public charge point deployment would be around £30m over 20 years, while smart charging would help to keep down network upgrade costs. Grants for capital costs of charge points are available through the LEVI fund (formerly ORCS), and often charge point operators (CPOs) will agree to pay the operational and maintenance of the chargers. Therefore, Enfield could expect that a large share of the £30m investment required would be attributed to grant funding or the CPOs themselves.

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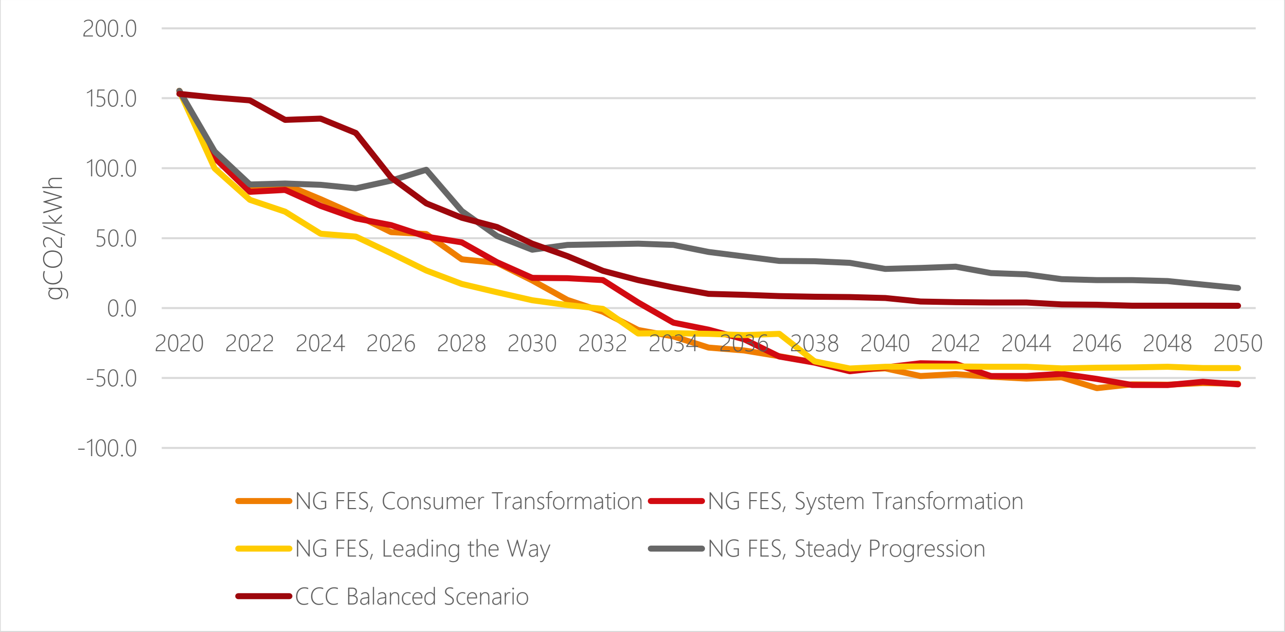
[25] The high modal shift scenario was based on DFES leading the way scenario, but with a higher ambition (10% higher modal shift by 2050 = 45% shift). This aligns more closely with the Mayor's Transport strategy as well as Enfield's greater ambition for modal shift relative to other London Boroughs.

3.4. Power systems

Enfield's ability to achieve Net Zero will ultimately depend on the decarbonisation of electricity consumed within the borough as it displaces the direct use of fossil fuels for transport and heat. For the latter, as the results presented in the Heat in buildings section show, this will happen both through the replacement of individual gas boilers with air source heat pumps, and via electrified zero carbon heat networks – including replacement of the heat that is currently supplied from waste incineration (see Heat in buildings section). Over time, as both heat and transport progress on the path to electrification (and accounting for population growth projections), the scale of demand for electricity is expected to increase significantly. Enfield's chosen route to decarbonisation will have a direct effect on the shape and size of this increase.

The decarbonisation of Enfield's electricity use will be largely dependent on the rate of decarbonisation of the whole electricity system in Great Britain. The pace of this change relies on a large number of variables and so there is some uncertainty as to when and how grid electricity will become zero carbon. Figure 7 shows how the carbon intensity of grid electricity (in gCO_2/kWh) could fall under scenarios produced by the National Grid and the Committee on Climate Change.

Figure 7: Grid carbon intensity trajectories

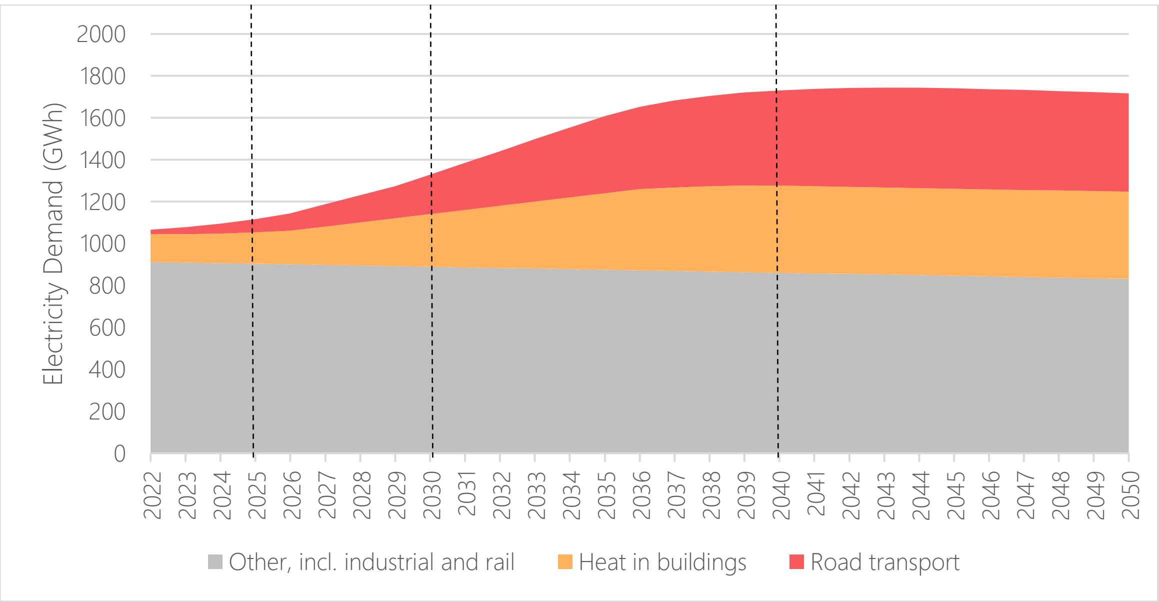


These scenarios consider different types of strategy for cutting carbon in the power sector, with the National Grid's 'Consumer Transformation' scenario considered to be most in line with the suggested strategy for Enfield. This scenario assumes widespread electrified heating, changes in consumer behaviour, high energy efficiency and increased uptake of demand flexibility services. These changes direct the decarbonisation of the national electricity supply, leading to decreasing carbon emissions from any electrical power consumed. Zero carbon grid electricity is achieved in the early 2030s, slightly ahead of the UK Government's 2035 target. Whilst these predictions are a valuable tool for energy planning, at present there is little clarity in policy as to the expectation of the supporting role of individual local authorities like Enfield and its citizens and businesses.

3.4.1. Current situation

Figure 8 sets out how the demand for power might change in Enfield over time under the Mixed DM scenario, where the measures described in the previous two sections are implemented. The key target years of 2025, 2030 and 2040 are marked by the dotted lines.

Figure 8: Demand for grid electricity in Enfield under the chosen scenario



By 2040, demand for power is expected to increase to approximately 1600 GWh per year. In order to achieve Net Zero by 2040 as cost effectively as possible, Enfield will need to better manage both its demand for power, and its local supplies.

Based on the most recent available data, around 0.003% of Enfield's electricity demand was matched by renewable generation within its own boundary in 2020 (i.e. 31.3MWh out of 1,054GWh). Given the largely urban nature of the borough, scope for developing large-scale renewable energy projects is relatively limited. However, if Enfield is to achieve its net zero target, then opportunities for increasing locally-generated power need to be exploited to a much greater extent than they currently are. Table 5 provides a breakdown of existing renewable capacity by technology type. At the time of writing, a small number of additional projects are listed within the Renewable Energy Planning Database (REPD), which may provide additional capacity in the near future (a list of these is contained in the evidence base).

Table 5: Existing renewable capacity within Enfield, 2020 data from regional renewable statistics[26]

	Renewable Electricity: Installed Capacity (MW)
Photovoltaics	6.0
Sewage gas	3.0
Plant biomass	0.3
Total installed capacity (MW)	**9.3**

3.4.2. Method

A full resource assessment covering all types of renewable electricity generation is outside of the scope of this LAEP. However, the potential for the deployment of roof-mounted solar PV within the borough was modelled at building level. The PV model combines building data with shading information and estimates for each roof what is the most suitable size of PV array. The model also calculated annual generation potential for each building, subject to financial assumptions and constraints. The figures presented in this LAEP include only those installation opportunities which would be financially attractive[27]. The full dataset is available to Enfield Council.

The scenario analysis did not seek to quantify the potential for non-thermal non-transport electricity demand or supply-side flexibility measures in Enfield. However, these are considered to be an essential component of the decarbonisation strategy and are to some extent implicit in our use of carbon factors from the National Grid's 'Consumer Transformation' scenario. Flexibility consists of mechanisms to reduce peak demand and hence lessen both distribution network capacity and electricity generation requirements. For example, this can be in the form of stored energy that is deployed during times of peak demand, or mechanisms to add diversity to the timing of electricity demand to reduce the size of the peaks. Implementation of demand-side flexibility within Enfield's own boundaries is considered to hold the most potential, and there is scope for Enfield Council to influence its uptake. This could, for example, consist of time-of-use (TOU) tariffs, smart appliances or domestic/small-scale battery systems. Additionally, peak loads can be shifted through smart EV charging and vehicle-to-grid systems, as set out in the Transport section of the technical evidence base.

The costs associated with upgrading Enfield's power network infrastructure to accommodate the LAEP proposals have also been estimated and are presented below.

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[26] https://www.gov.uk/government/statistics/regional-renewable-statistics

[27] These have an estimated internal rate of return (IRR) of at least 4%, based on the assumption that those with a lower IRR would be unlikely to receive investment. 4% IRR is considered an acceptable level of investment risk and is commonly used for Government investments.

3.4.3. Increasing renewable generation at a local level

As noted above, opportunities for large-scale renewable generation within Enfield are limited, with rooftop solar PV considered to have the greatest potential within the borough. Table 6 provides summary figures from the modelling for the Mixed DM scenario (assuming IRR of 4% or above).

Table 6: Total technical potential for rooftop solar PV in 2040, assuming an IRR of 4% or above

	Total installed capacity (MW)	Total estimated generation (GWh/yr)	Number of installations	Total CAPEX (£M)
Total	311MW	272GWh	66,590	£391M

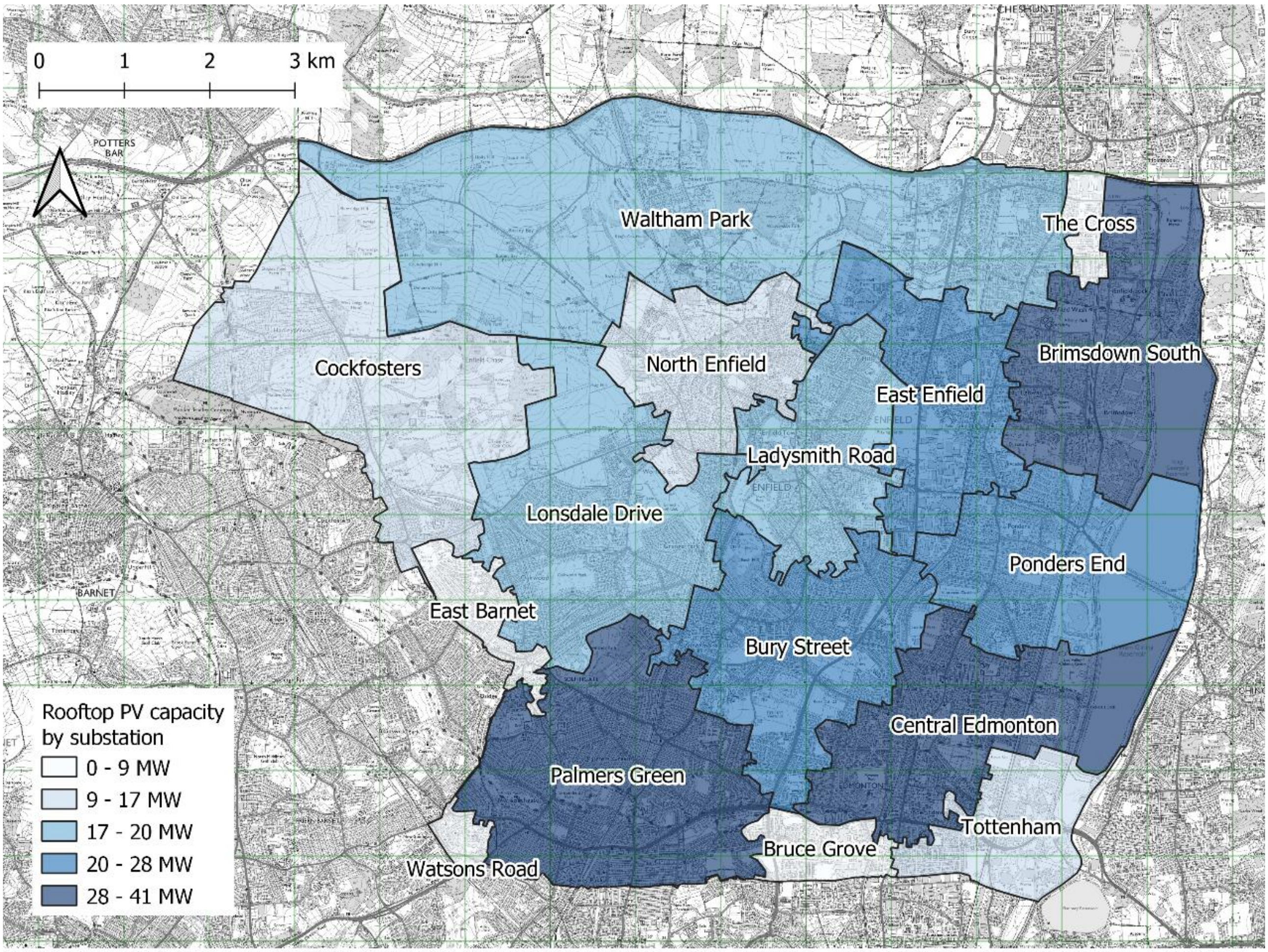
It's important to note that the figures above represent the technical and financial potential, and that the figure for total deployable capacity is likely to be somewhat lower due to building-specific factors such as planning restrictions for listed buildings or those within Conservation Areas, or individual roof conditions.

Table 7 shows how these figures can be broken down between tenure types, and Map 6 shows the distribution of this capacity across Enfield's substation areas.

Table 7: PV summary data by tenure/building use in 2040

Tenure	Number of installations	Total installed capacity (MW)	Average capacity per building (kWp)	Total estimated generation (GWh/year)
Council / housing association	5,218	21.3	4.1	18.7
Owner occupied	40,842	126.1	3.1	111.3
Privately rented	11,440	41.3	3.6	36.3
Non-residential	1,969	69.3	35.2	60.1
Buildings with unknown use	7,121	52.7	7.4	45.7

Map 6: Rooftop solar PV capacity recommended within each electricity substation area in 2040



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There are a number of potential means by which Enfield Council could enable large-scale deployment of roof-mounted solar PV. For example, this might include an expansion of the proposals already contained within Enfield's Climate Action Plan to target funding collected to offset the Council's own carbon emissions (including Scope 3 emissions) towards solar PV installations, or actively working with other stakeholders to encourage the establishment of community energy projects locally.

Community energy projects can entail significant co-benefits in terms of skills development and employability, increased community resilience, reduced bills for community buildings such as schools (allowing more money to be spent on other support services), and alleviation of fuel poverty and consequent improved health and wellbeing of residents.

In terms of the potential for the deployment of other renewable generation technologies, a study carried out by AECOM in 2010[28] highlighted some limited opportunities for biomass production and large-scale wind in particular, although the technical potential (in MW) associated with these opportunities has not been quantified. It notes the presence of Grade 3 agricultural land in the north of the borough, which may be suitable for the growing of energy

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[28] AECOM (March 2010), Renewable and Low Carbon Development Study for London Borough of Enfield

crops such as Miscanthus or willow short rotation coppice (SRC), and the potential for the use of chipped arboricultural waste from council contracts to be used for the generation of heat and power. Enfield Council are also currently investigating the potential to install floating solar PV arrays, in conjunction with Thames Water, at the William Girling and King George V reservoirs.

Support to encourage greater deployment of renewable technologies at scale – not necessarily all within Enfield's boundary – could take the form of encouraging wider uptake of renewable tariffs by households and businesses in Enfield, consideration of the use of private-wire arrangements and storage for locally-generated power or involvement with other types of power purchase agreements (e.g. sleeved PPAs), and lobbying central government for policies to support a faster rate of decarbonisation at GB grid-level.

the main co-benefit to the installation of renewable generation at a local level is the reduction in emissions beyond greenhouse gases. An example is the reduction in sulphates released into the atmosphere, which cause acid rain, among other issues (this is however not confined locally and is dependent on the reduction in fossil fuel use at a wider scale). Another example is the reduction in the emissions of carbon particulates, which cause lung issues. Whilst local renewable energy contributes to this co-benefit, it still relies on wider scale adoption.

3.4.4. Upgrading Enfield's power networks

To avoid the risk of Enfield's electricity distribution infrastructure becoming a constraint on deployment, significant investment in network upgrades will be required (note that these upgrades and costs are beyond the influence of Enfield Council and that network costs are covered by all consumers). Table 8 provides a summary of the estimated costs of electricity network reinforcement as a result of the additional peak demands added by decarbonising heat in buildings and transport under the Mixed DM scenario.

Table 8: Estimated network upgrade costs

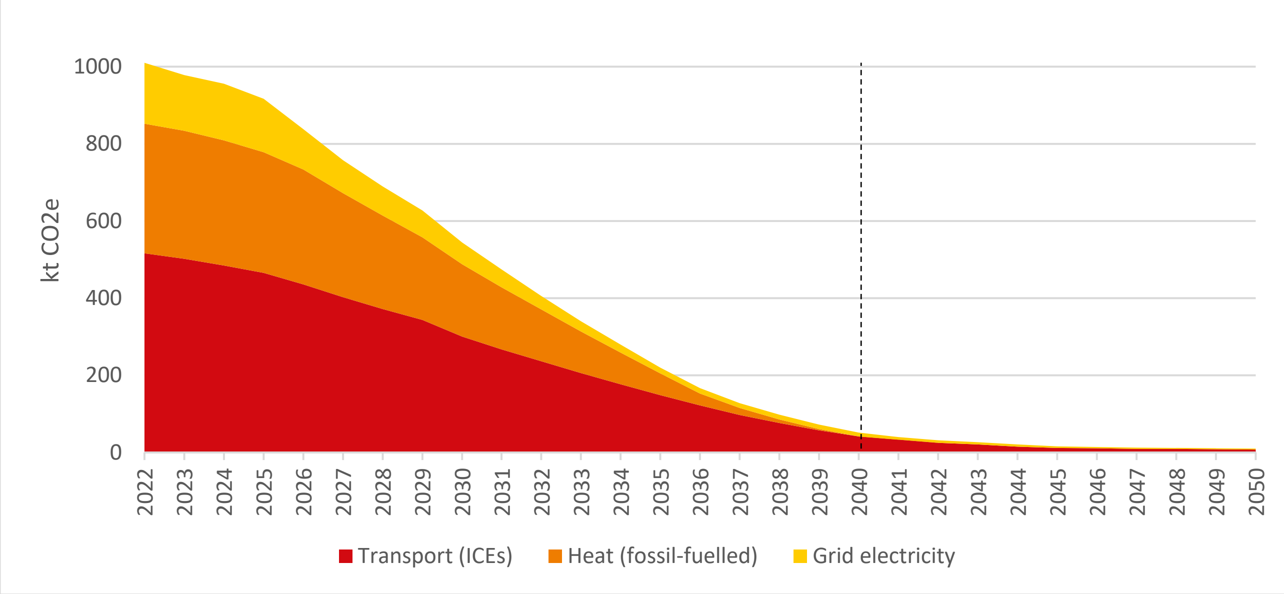
	Total cost
Secondary connection costs	£20,090,000
High voltage (HV) connection costs	£23,620,000
Primary reinforcement costs	£20,150,000
Extra high voltage (EHV) reinforcement costs	£16,000,000
Total	**£79,860,000**

3.5. Carbon pathways

3.5.1. Emissions trajectories in Enfield

The emissions trajectory that results from the implementation of the measures set out in the optimal mixed demand scenario is shown in Figure 9, with the emissions split by sector. This trajectory is based upon the decarbonisation projections in the CCC's Balanced Pathway projections.

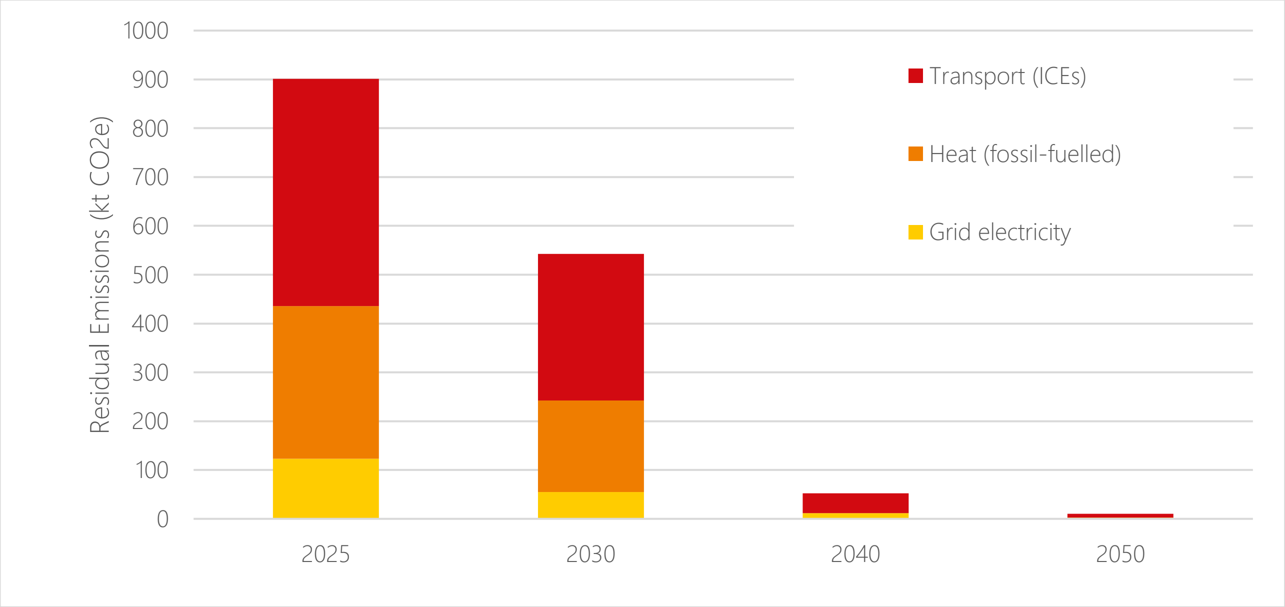
Figure 9: Carbon emissions projections in the mixed demand management scenario



In 2040 there remain approximately 50 kt CO_2e of residual emissions, which are largely accounted for by difficulties in decarbonising transport and a small amount of emissions remaining within grid electricity. By 2050, this falls to approximately 10 kt CO_2e, due to a lack of hydrogen to decarbonise heavy transport. It is possible to decarbonise heating completely by 2040, so that direct emissions from this sector are zero.

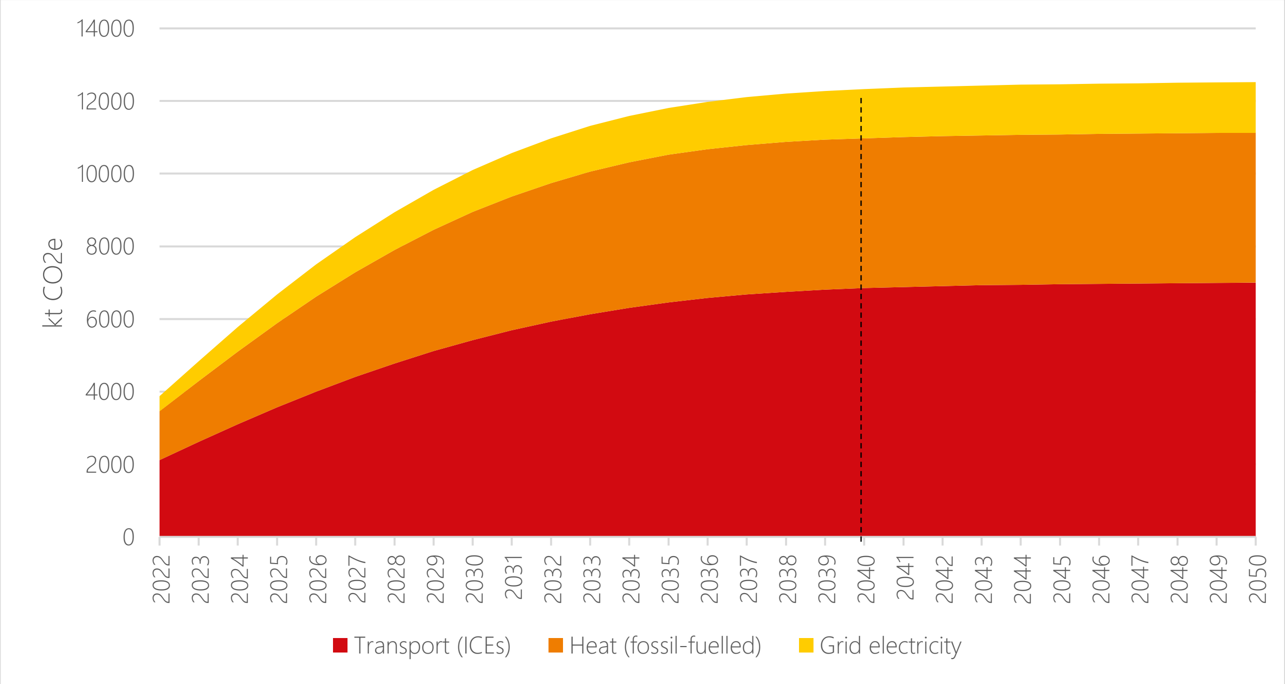
To help with setting targets and tracking progress towards Net Zero, the residual emissions in key target years, split by sector, are shown in Figure 10.

Figure 10: Residual emissions in key target years in the mixed demand management scenario



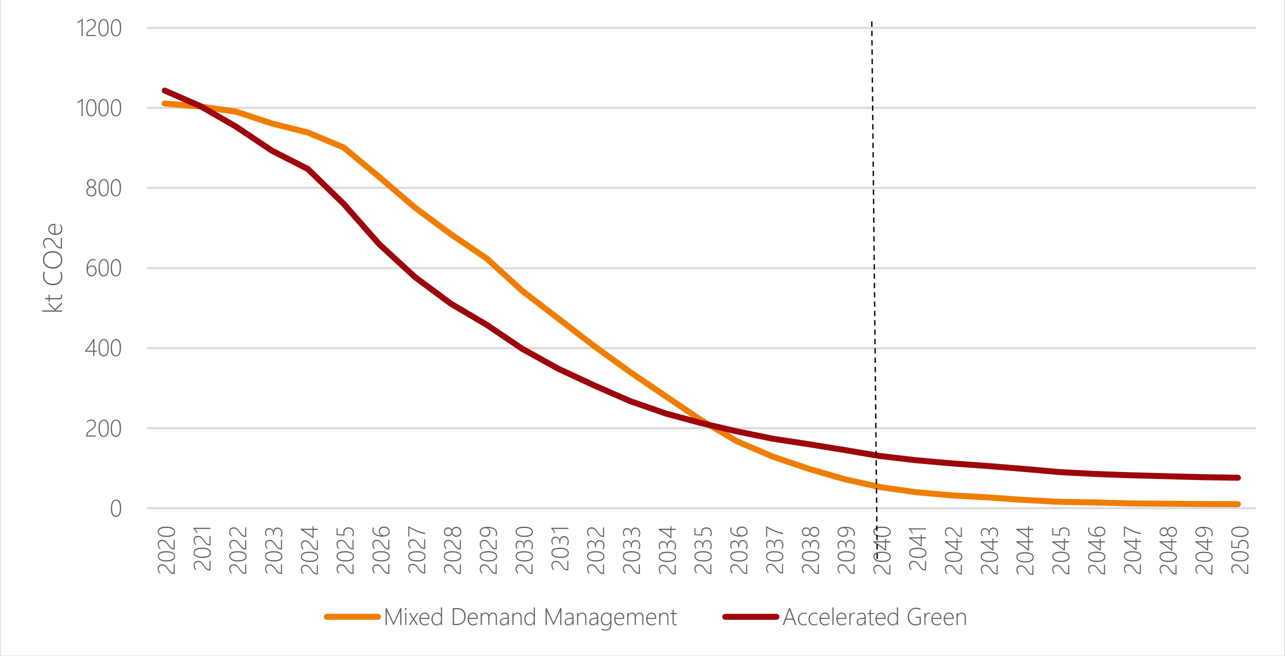
To view the total impact of carbon emissions until 2050, the cumulative emissions, split by sector are shown in Figure 11. This shows that the decarbonisation approach leads to emissions that decrease at a faster rate throughout the 2020s and 2030s. Cumulative emissions mostly level off prior to 2040, at around 12,000 kt CO_2e emitted over the period 2022-2050.

Figure 11: Cumulative carbon emissions in the mixed demand management scenario



There are numerous methodologies for calculating emissions, each of which uses different data sources, assumptions, scenarios and scopes. For the purpose of this report, we have established a baseline using London Energy and Greenhouse Gas Inventory (LEGGI) data and based changes in net zero technology and grid decarbonisation on Climate Change Committee forecasts. It should be noted that the GLA set a 2030 target for Net Zero and since this LAEP was commissioned selected the Accelerated Green pathway as their preferred pathway. The mixed demand management scenario is compared to this pathway in Figure 12, however a direct comparison is not advisable, because they consider slightly different emissions sources, giving different results. the accompanying technical evidence base provides further details on this in the section ‘Comparison to other emissions trajectories and pathways’.

Figure 12: Carbon emissions pathways under the mixed demand management scenario and the Accelerated Green pathway



4. Route Map to Net Zero

4.1. Ten building blocks for Net Zero

The ten key building blocks identified in Figure 13 represent the foundations for a net zero Enfield by 2040, building on existing opportunities and addressing challenges to change. In combination, these will ensure delivery of the radical and transformative approach required to address the gap between the current state of play in the borough and what needs to happen in Enfield to achieve Net Zero by 2040.

The building blocks underpin a list of recommended interventions that are required to ensure timely delivery of Enfield's net zero ambitions. This full set of recommended interventions for Net Zero is included in the accompanying Detailed recommendations to 2040 document. The focus of the LAEP recommendations is on those next steps that create the conditions in which Enfield can successfully achieve its long-term decarbonisation ambitions. For each decarbonisation sector, the recommendations are grouped into three categories:

- **Do**: actions that can be taken now with relatively immediate impact
- **Prepare**: steps needed now to ensure Enfield is ready for more immediate actions in the next few years
- **Explore**: activities that create the conditions now to pave the way for future impact

The accompanying Detailed recommendations to 2040 document also assigns a lead for each item as the organisation that should take early responsibility for initiating action (often working with others) to implement the interventions.

Figure 13: Ten building blocks for Net Zero

1 Secure timely implementation of the LAEP by convening a LAEP progress board to maintain momentum and build ownership of the outcomes. This will ensure that across Enfield all key players take on responsibility for action towards Net Zero.

2 Develop a long-term engagement strategy for climate communications, including clear and consistent messaging on Net Zero and the changes needed in the borough. This will create a borough wide sense of purpose in the transition to Net Zero.

3 Ensure that Net Zero and the findings of the LAEP are embedded in all of the Council's existing and future plans and funding. Planning policy, procurement planning and Council team plans need to be built around net zero ambitions.

4 Build on the three Priority Projects presented in the LAEP as a starting point for funding proposals. Pursuing these projects will enable Enfield Council to lead by example in transforming the local energy system.

5 Enable the decarbonisation of heat in buildings by continuing to support Energetik in developing planned routes for heat network expansion, based on the areas of the borough identified in the LAEP as priority for heat network.

6 Accelerate low carbon housing retrofit. Building on the Retrofit Accelerator programme and in consultation with existing local retrofitting expertise, establish and develop a well-trained local supply chain.

7 Tackle fuel poverty at its roots by ensuring fuel poor households receive all the support and funding available. Targeted retrofit programmes will be key to mitigating fuel poverty whilst transitioning to Net Zero.

8 Coordinate the growth of electric vehicles, starting with the development of an EV charging infrastructure delivery plan, alongside encouraging and supporting a shift to active and sustainable modes of transport.

9 Realise Enfield's potential for renewable energy generation, starting with large scale programmes of rooftop solar PV deployment across all sectors and tenures, as identified in the LAEP analysis.

10 Ensure the electricity network is ready for the required electrification of heat and transport. Demand-side flexibility services, smart demand management and local electricity storage will support Enfield in becoming more self-sufficient in energy.

4.2. Route map for a net zero Enfield

Figure 14 shows the decarbonisation route map to 2050 for the local energy system in Enfield, based on the theory of the development of technology adoption within society. The figure illustrates the likely key stages of the rollout of net zero technologies in Enfield over the coming years.

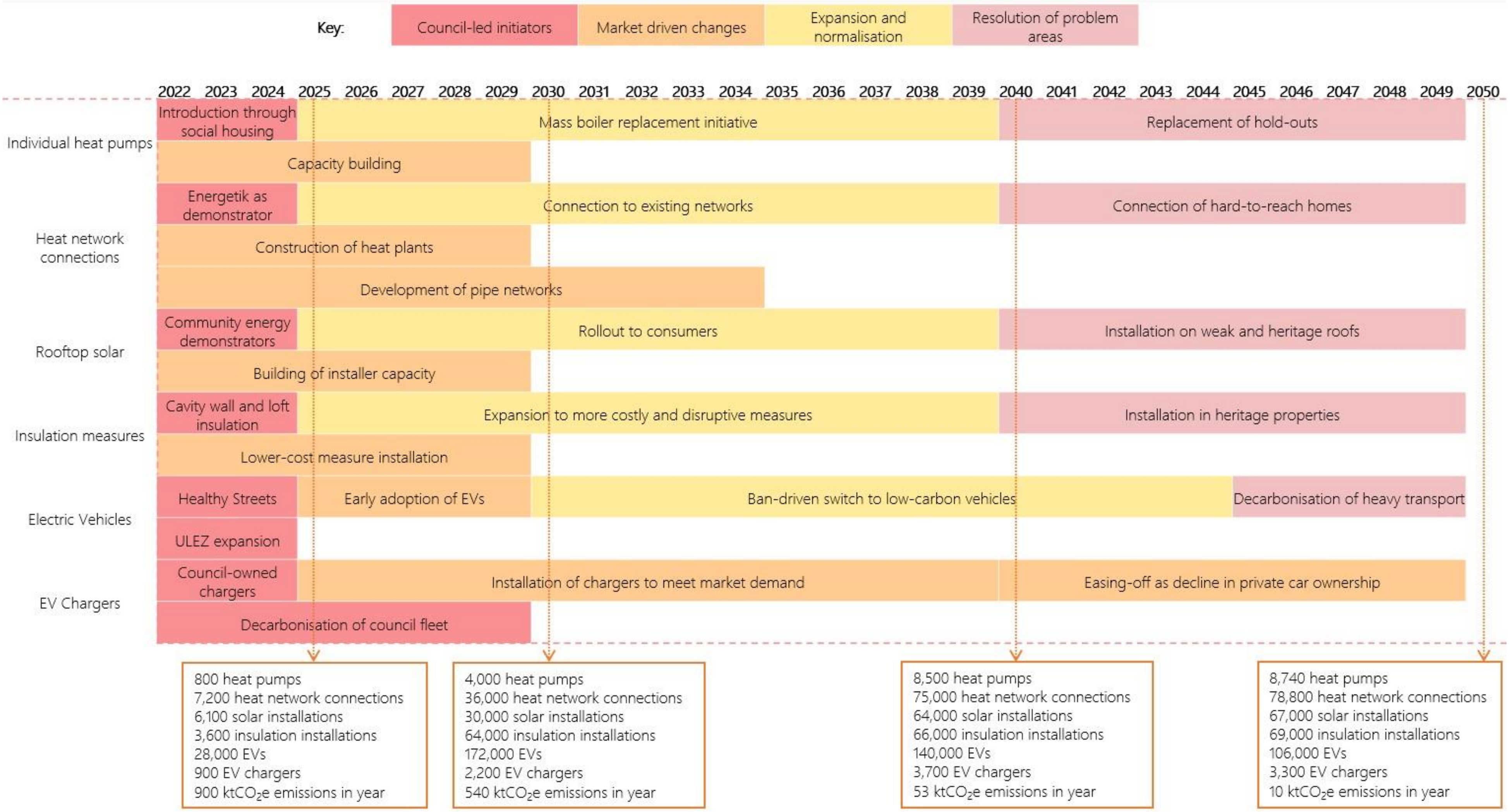
The route map illustrates how, in line with the results and recommendations of the LAEP, a series of early interventions can introduce net zero technologies and initiate capacity building within the market. This can then spark wider adoption, with more rapid changes developing across society. Finally, "laggard" adopters (those with some barrier to adoption) will need extra attention to ensure they are not left behind. This profile supports the targets shown in for technology adoption in key years.

Table 9: Targets for net zero technology adoption in key years

	Individual heat pumps	Heat network connections	Rooftop PV installations	Insulation measures installed
2025	800	7,200	6,100	3,600
2030	4,000	36,000	30,000	32,000
2040	8,500	75,000	64,000	66,000
2050	8,740	78,800	67,000	69,000

It should be noted that these targets should be regarded as ambitions rather than "hard" targets and should not be considered fixed. The pace of societal adoption of technologies is difficult to predict and should be based on observation. Policies and actions can speed or slow the trend and therefore targets should be updated as part of the LAEP review process.

Figure 14: Route map for a net zero Enfield



4.3. Priority projects

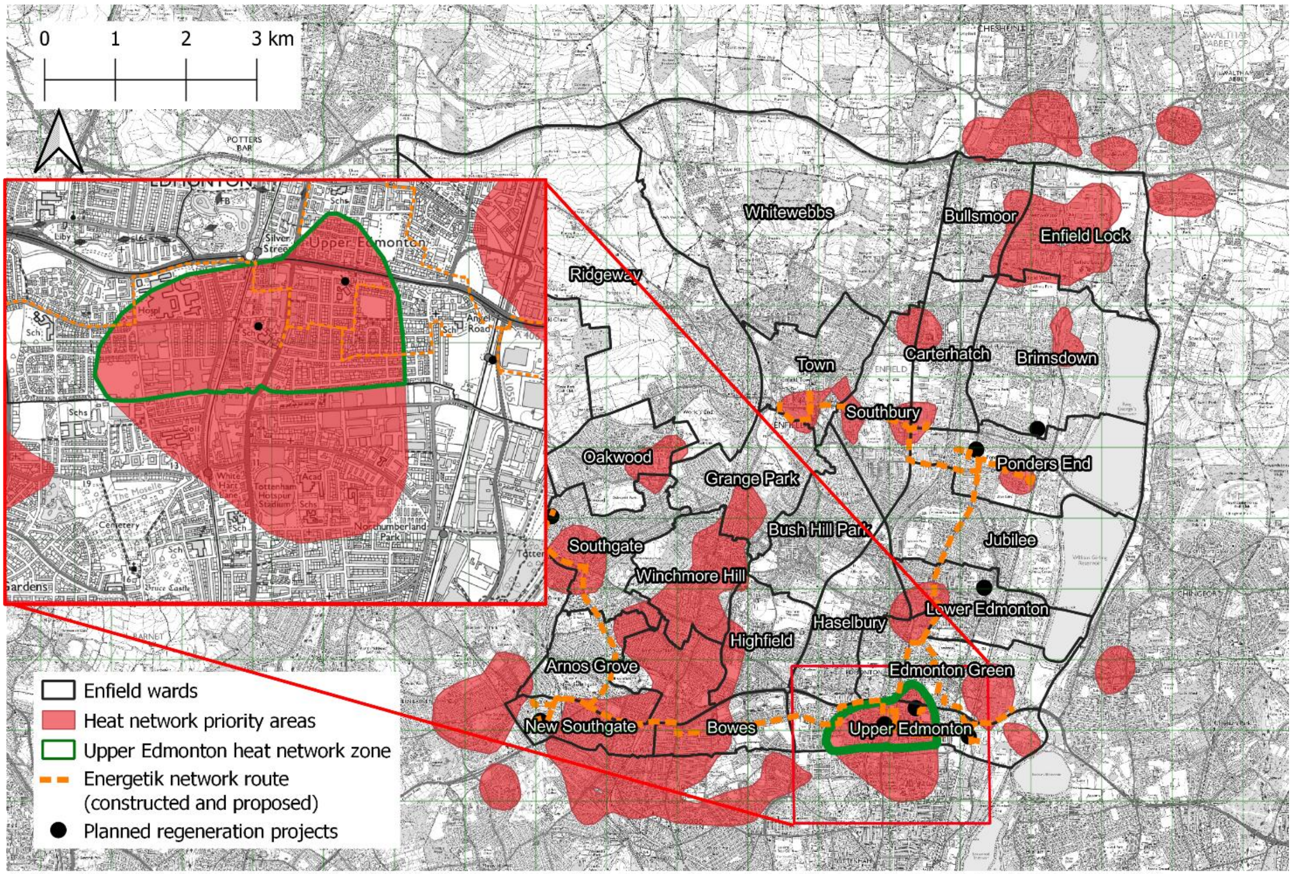
Driving implementation of the LAEP is a key outcome of this report. The first few steps in the implementation of the LAEP will be crucial to the successful decarbonisation of the local energy system. In order to ensure that initial momentum is gained, three projects were identified and are proposed as priority for detailed investigation and implementation within a relatively short timescale.

4.3.1. Priority Project One: Upper Edmonton Heat Network Opportunity Area

Project analysis

The heat network opportunity area within Upper Edmonton is shown in Map 7. This priority project has been selected to show the benefits that a heat network can offer an area. This area has been selected as a Priority Project because it represents a significant opportunity to demonstrate the use of heat networks as a tool for decarbonising heat, in an area where there is a relatively high level of fuel poverty. In addition, the area is already targeted for regeneration by Enfield Borough Council and lies on the route of Energetik's heat network. Although the identified network opportunity area spans the Enfield-Haringey boundary, reporting here covers buildings falling on the Enfield side of the boundary. In contrast, network costs are analysed as a whole. More detailed pre-feasibility work will be required to determine the actual scope of the network to be constructed.

Map 7: Location of priority heat network areas, with Upper Edmonton area highlighted



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There are 2,565 addresses on the Enfield side of the area, of which 2,402 are residential. Very few of these addresses are recommended an individual heat pump, leaving 2,323 addresses connecting to the heat network.

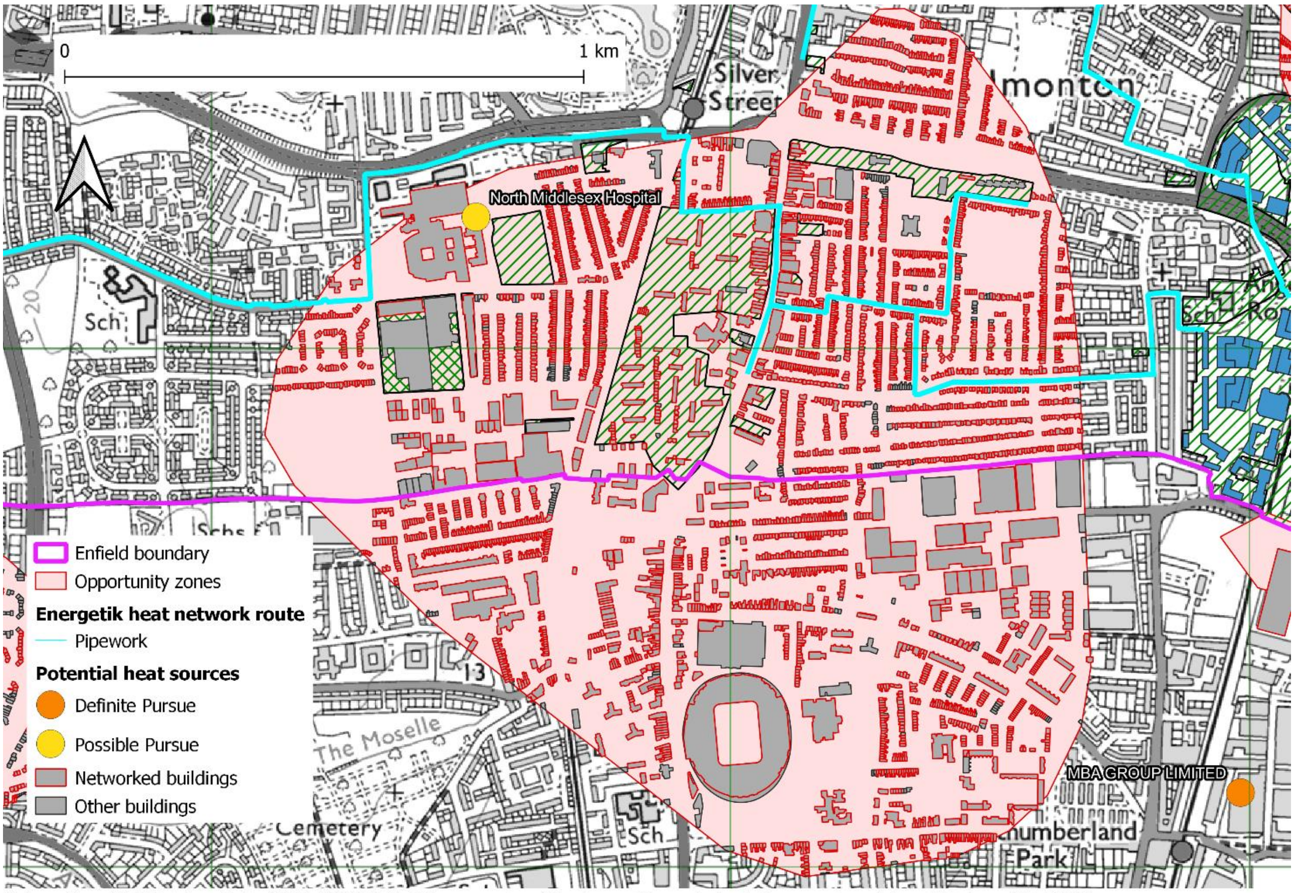
Table 10 summarises the least-cost heat decarbonisation options for these residential users.

Table 10: Recommended decarbonised heat source by tenure type

Tenure Type	Heat Network Connections (Fuel Poor)	Individual Heat Pumps (Fuel Poor)
Owner occupied	1,485 (372)	61 (9)
Privately rented	536 (153)	12 (2)
Social housing	223 (72)	6 (1)
Unknown tenure	79 (0)	0 (0)
Total	2,323 (597)	79 (12)

The modelled capital cost of the heat network within the area is £65.4 million. This capital cost is based upon a supply plant using technologies at the more expensive end of the scale, so it should be regarded as a conservative estimate. Annual operational expenditure is modelled to be £2.6 million. The heat area is shown in more detail in Map 8.

Map 8: The heat network opportunity area shown in more detail



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The number of addresses recommended each type of insulation, and the capital expenditure of the insulation, by tenure type and decarbonised heat source are shown in Table 11.

Table 11: Number of each insulation measure of total tenure type connected to that heat source by decarbonised heat source and tenure type (numbers for fuel poor households in brackets)

Decarbonised heat source	Tenure type	Cavity wall insulation (fuel poor)	Loft insulation (fuel poor)	Solid wall insulation (fuel poor)	Double glazing (fuel poor)	Floor insulation (fuel poor)	Roof insulation (fuel poor)	Insulation CAPEX (fuel poor) (£1000)	Total tenures of type (fuel poor)
Heat Network	Owner occupied	74 (13)	227 (60)	1,403 (362)	109 (29)	850 (215)	75 (14)	1,103 (239)	**1485 (372)**
	Social	34 (6)	37 (11)	157 (61)	31 (6)	110 (36)	8 (3)	412 (38)	**223 (72)**
	Privately rented	31 (10)	87 (22)	510 (146)	66 (13)	298 (85)	50 (16)	546 (122)	**536 (153)**
	Unknown	0 (0)	0 (0)	0 (0)	3 (0)	0 (0)	0 (0)	49 (0)	**79 (0)**
	Subtotal	139 (29)	351 (93)	2,070 (569)	209 (48)	1,258 (336)	133 (33)	2,110 (399)	**2323 (597)**
Individual Heat Pump	Owner occupied	0 (0)	0 (0)	8 (8)	0 (0)	4 (4)	0 (0)	8 (8)	**9 (9)**
	Social	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	**1 (1)**
	Privately rented	1 (1)	1 (1)	2 (2)	0 (0)	1 (1)	1 (1)	3 (3)	**2 (2)**
	Unknown	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	**0 (0)**
	Subtotal	1 (1)	2 (2)	11 (11)	0 (0)	5 (5)	1 (1)	11 (11)	**12 (12)**

Next steps

1. Discuss this opportunity with Energetik to align with their strategy. Currently, the Upper Edmonton area is well located to be supplied from waste heat from the Edmonton Eco Park. Decarbonisation of the heat source should be explored, as noted below.

2. Further investigate the potential heat sources of North Middlesex Hospital and MBA Group Limited to see if they are suitable waste heat sources.

   a. Establish temperature of supply.

   b. Establish quantity of supply.

   c. Establish cost of heat.

3. Commission a pre-feasibility study to examine the on-the-ground viability of this heat network.

4. Commission an on-the-ground study of the actual insulation measures installed in buildings in the area and the effect of upgrading installation measures.

   a. A study of stakeholder attitudes should form part of this assessment.

   b. It would also be advisable to seek advice on how best to target different tenure types.

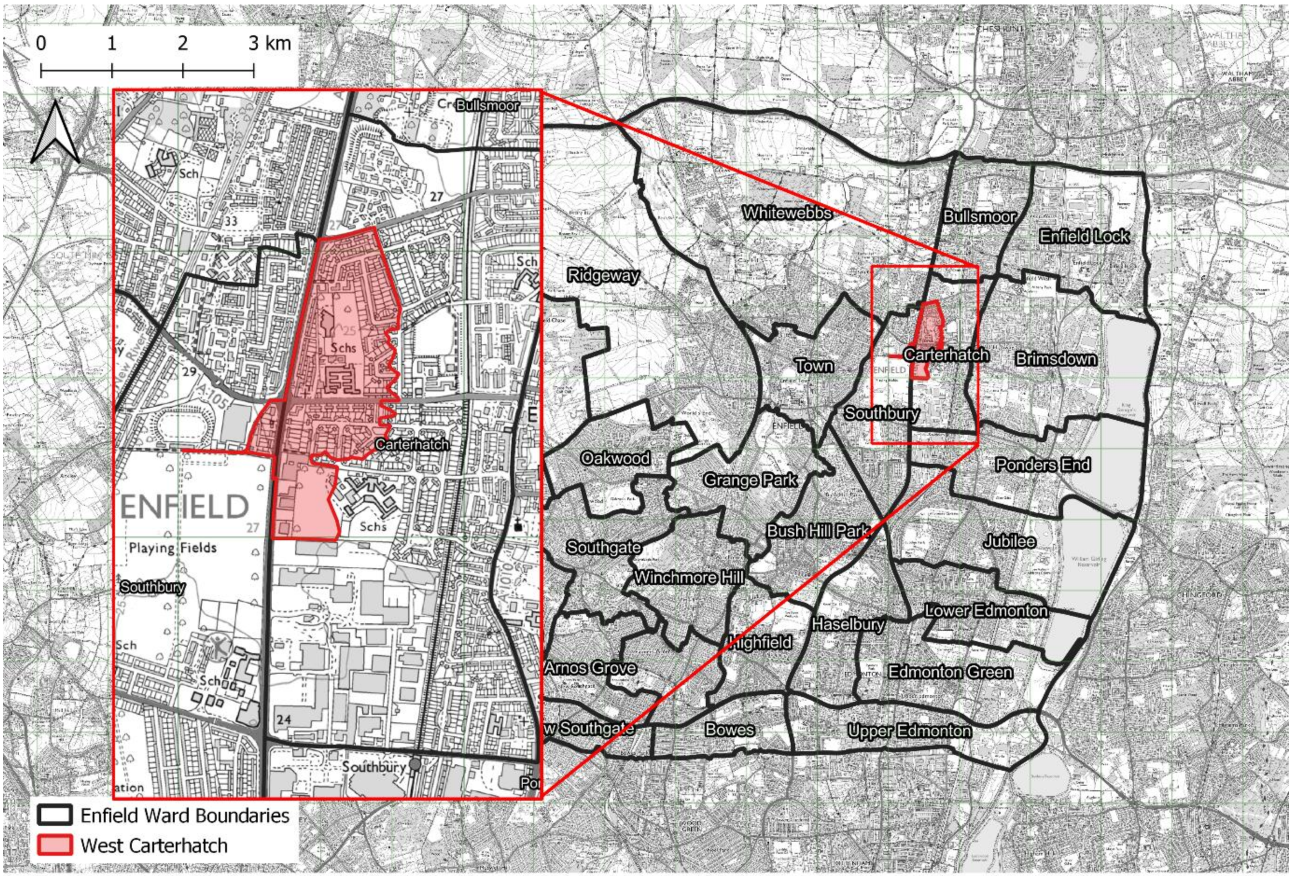
   c. As part of this, establish if funding through schemes such as HUGS/LADS would be able to be used in insulation schemes.

4.3.2. Priority Project Two: West Carterhatch Combined Measures

Project analysis

West Carterhatch has been selected as a priority project where there are a combination of viable heat technologies, including properties which are unlikely to be cost-effective for connection to a heat network. The installation of an air-source heat pump (ASHP), alongside solar photovoltaic panels (to reduce electricity costs), and the installation of insulation measures both to minimise demand and maximise the efficiency of the ASHP. Of particular interest are the potential benefits for social housing occupants, where Enfield Council will be able to lead the way in supporting lower-income households. The specific area of analysis is the Lower Super Output Area (LSOA) called Enfield 005D, the extents of which are shown in Map 9.

Map 9: Location of West Carterhatch area within Enfield



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This area has 648 households in 559 buildings, of which 188 households (about 30%) are likely experiencing fuel poverty by the low income, high-cost methodology (though note that with recent price rises, this number is likely to have grown). Most households within the area are heated using mains gas (625). The current total heat consumption in the area is about 825MWh per year. The number of addresses which are recommended each action are broken down by tenure type in Table 12.

Table 12: Recommended action by tenure type (numbers for fuel poor households in brackets)

Tenure Type	Social housing (fuel poor)	Owner occupied (fuel poor)	Private rental (fuel poor)	Total (fuel poor)
Heat pump installations	27 (12)	78 (11)	43 (8)	148 (31)
Heat network connections	104 (41)	317 (17)	79 (24)	500 (82)
Cavity wall insulation	76 (27)	112 (30)	38 (10)	226 (67)
Loft insulation	11 (5)	48 (13)	21 (5)	80 (23)
Solid wall insulation	17 (7)	224 (53)	69 (23)	310 (83)
Double glazing	13 (5)	16 (4)	11 (3)	40 (12)
Floor insulation	45 (16)	58 (62)	238 (24)	341 (102)
Roof insulation	5 (1)	12 (5)	9 (4)	26 (10)

It is useful to know how the choice of heating system affects the recommendation to install insulation. Table 13 shows the number of addresses where each insulation type is recommended by heating system.

Table 13: Recommended insulation by heating system

Recommended insulation	Heat pump	Network connection	Total
Cavity wall insulation	66	160	226
Loft insulation	23	57	80
Solid wall insulation	56	254	310
Double glazing	15	25	40
Floor insulation	73	268	341
Roof insulation	2	24	26

As there is only one rooftop but potentially many addresses per building, it does not make sense to break down the rooftop solar statistics by count of addresses. However, to give an indication of where the benefits of rooftop solar will lie, Table 14 shows the capacities, areas, and costs and benefits of solar installations, with subtotals showing the distribution against the presence of socially rented addresses, and households at risk of fuel poverty. The layout of panels (including panels on commercial buildings not considered in this analysis) is shown in Figure 15.

Table 14: Rooftop solar statistics showing the distribution among social housing and fuel poor

	PV Installed Capacity (kW)	PV CAPEX (£1000)	PV yearly revenue (£1000)	PV Area (m^2)
All Buildings	1,020	1473.9	117.8	5,100
Buildings including social housing	202	276.6	23.4	1,010
Buildings including fuel poor	289.6	421.6	33.2	1,448
Buildings both SH and FP	76.9	113.0	8.9	385

Figure 15: Layout of rooftop solar in West Carterhatch (red line = West Carterhatch boundary; blue shading = rooftop PV installations)

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As with rooftop solar PV, insulation measures generally pertain to the building, rather than to individual addresses. The costs are broken down as with rooftop solar in Table 15.

Table 15: Economic factors for the installation of insulation and heat pump systems

	Insulation CAPEX (£1000)	Heat Pump CAPEX (£1000)
All Buildings	691	874
Buildings including social housing	125	171
Buildings including fuel poor	201	246
Buildings both SH and FP	47	84

There is potentially significant support available to cover the upgrades necessary to decarbonise the area. The Boiler Upgrade Scheme (BUS) could provide funding to many owner occupied properties which would need to upgrade to a heat pump – with the £5,000 of funding available covering most of the average cost for a heat pump (approximately £5,900). Under the most recent round of Local Authority Decarbonisation funding, support was available for low income households, likely to be in fuel poverty, with low EPC ratings. This analysis shows that across all sectors there is a significant need to install insulation (which indicates low EPCs) in homes likely to be in fuel poverty. Hence significant numbers of homes would qualify for support under this funding scheme, and the area could be recommended for future phases of funding.

Next steps

1. Convene a project team with representatives from the relevant council departments and determine a scope for housing upgrades in the area.
2. Within this scope, review the funding opportunities.
3. Plan refinements to the technical plan for insulation, air-source heat pumps and rooftop solar.
4. Engage with the local community and businesses working with the required net zero technologies involved to understand the barriers within the local context.
5. Advance knowledge of the feasibility through site surveys.
6. Perform feasibility studies on the specific buildings involved in the project.

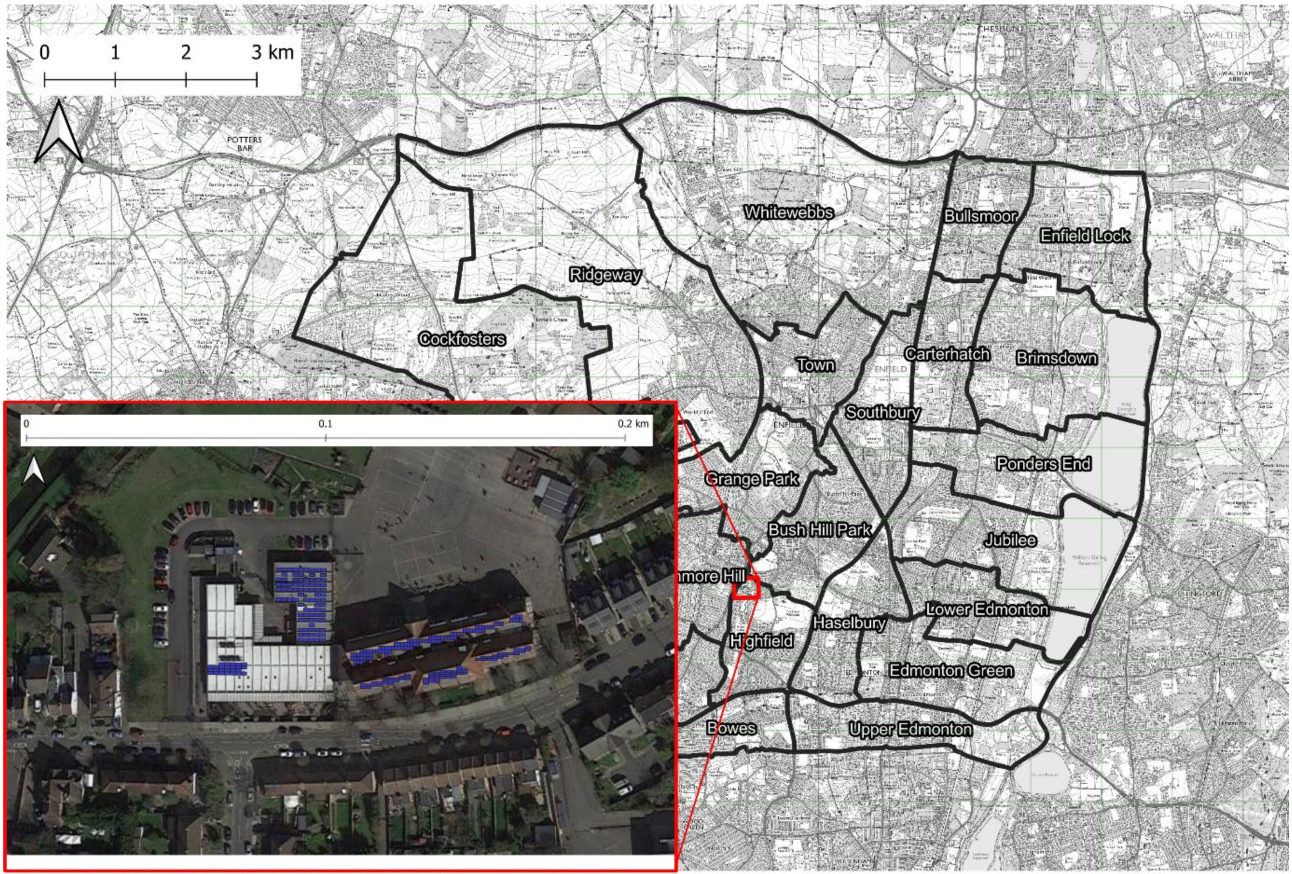
A review of funding is likely to centre on schemes such as BUS, HUGS, and LADS. For schemes such as BUS, the council could establish support for owner occupied homes (particularly those at risk of fuel poverty) to ease applying to funding. For schemes such as HUGS and LADS, the team would be responsible for identifying suitable properties for retrofitting and to coordinate funding applications and distribution. Site surveys would help to refine the technical plans for the upgrades and would go on to contribute to funding applications.

4.3.3. Priority Project Three: Highfield Primary School Rooftop Solar

Project analysis

Highfield Primary School has been selected as an example of where larger PV deployment is viable. This is suggested as a priority project because it is an example of where a community energy project could be fostered on a council-owned property. It is a school which is maintained by the local authority, which therefore provides funding and has influence over operations. Highfield has been selected from the borough-wide PV modelling results as it shows a promising rate of return on investment. The location of the school, and the layout of the proposed panels is shown in Figure 16.

Figure 16: Map showing the location and layout of rooftop PV on Highfield Primary School



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The total area of the proposed panels is approximately 525m^2 with an installed capacity of 105kW. The installation has been modelled as producing 95.8MWh per year. The capital expenditure to install the panels would be approximately £88,500. Under the assumed solar PV electricity value of 13.5p/kWh used in this report, the annual benefit would be £13,000, giving a simple payback period of under seven years. Because there is likely to be variation in electricity prices, the economic performance of the panels for different assumed values of electricity is shown in Table 16.

Table 16: Variation in economic performance with price of electricity

Assumed value of generated electricity (p/ kWh)	Annual value (£)	Payback Period (Years)	NPV (£)	IRR (%)
5.5	5,300	16.8	4,600	3.9
13.5	13,000	6.8	140,000	14.3
17.6	17,000	5.2	210,000	18.9
21.4	21,000	4.3	270,000	23.1
29.7	28,000	3.1	410,000	32.1

At lower electricity prices, the economic viability of the project is reduced. However, it should be noted that the estimated lifetime of solar panels is more than 20 years. This means that even under the lowest electricity value modelled, the installation would still more than pay for itself. This minimum price is based on the standard Smart Export Guarantee (SEG) rate of 5.5p/kWh.[29]. BEIS predicts a future electricity price of 21.4p/kWh to 2050[30]. Octopus Energy currently offers 15 p/kWh to its own customers. The estimate of 13.5p/kWh used here is therefore considered conservative.

Next steps

1. Establish the annual hourly demand profile of Highfields Primary School to understand how demand coincides with solar production hours.
2. Refine the returns estimates given here based on the above data by correcting the exported vs imported assumption on an hourly basis.
3. Arrange a site survey by several PV installers to verify the conditions for panel verification and to get a more accurate estimate of solar potential of the specific site.
    a. Based on the demand-production profile, investigate if a battery could prove cost-effective for the site and, if so, factor this into installer estimates.

Enfield could also consider using this priority project to build a community energy initiative within the borough. School projects are well established within the community energy sector and often provide the focus for new initiatives. The Council could reach out to existing groups in London that have a track record in setting up new local projects or groups (Power Up North London, Stokey Energy, Repowering London, Solar for Schools, for example) or approach Community Energy London to discuss the opportunity. The GLA runs the London Community

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[29] Solarguide (2022) Compare Smart Export Guarantee Tariffs. Available at: https://www.solarguide.co.uk/smart-export-guarantee-comparison#/

[30] BEIS (2021) Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal, Data tables 1 to 19. Available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Energy Fund which an Enfield based group could apply to for feasibility funding or capital funding for the school PV array & battery. They might also want to explore Energy Local clubs where residents could purchase any exports above the SEG, but below market cost. This could be a useful mechanism to cover the summer holidays when school PV arrays have maximum output but minimum onsite demand.

4.4. Costs and benefits

This section presents a brief assessment of the relative costs and benefits of the actions proposed in the Enfield LAEP. In doing this, we assumed for simplicity that expenditure would follow the same trajectory as emissions reductions (see Carbon pathways section). We used BEIS's social cost of carbon[31] to approximate the value of the damage caused by carbon emissions in a given year. Note that we consider these values to be optimistically low. We also ignored the fact that inaction (i.e. the continued use of natural gas) itself has significant operational costs (i.e. the purchase of the gas and the replacement of the boilers over time). We therefore see the results presented here as a conservative estimate of the value of action on emissions.

Capital expenditure in the mixed demand management scenario is £2.97 billion, with operational expenditure of £2.06 billion to 2040. Taken together this puts the total cost of decarbonisation at £5.03 billion. This includes insulation, heat networks, heat pumps, power network upgrades and solar PV. It excludes transport costs. Table 17 sets out the relevant quantities, with a discount rate of 0% (see below for discussion). Figure 17 shows how these costs are broken down over time, and by intervention.

Table 17: Comparison of costs versus avoided costs

Quantity	Value[32]
Total expenditure from mixed demand management scenario	£5.03 billion
Avoided carbon emissions to 2040	19,085 ktCO$_2$e
Total value of avoided carbon emissions to 2040	£6.26 billion
Cost per tonne of CO$_2$ avoided	£264
Average avoided cost per tonne of carbon	£328
Cost per avoided cost	£0.8 of cost per £1 of avoided cost
Return on investment	24%

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[31] https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation

[32] In £ 2020

While the total cost of the decarbonising Enfield is clearly significant, it is significantly cheaper than the costs of the damage which would result from inaction. When considering these values, the cost may be seen as an investment yielding a 24% return. If the costs are discounted at a rate of 3% per annum, the total sums to £3.49 billion, and the returns to £3.66 billion. This gives a simple return of 4.8%.

There is significant debate about applying discounting to investments that impact society. As time exceeds a certain horizon for an investment, the discount becomes so large that it reduces future values to essentially zero. This would imply that society should never take action in the present to protect against consequences beyond some arbitrary time horizon – a position that would be absurd, as well as at odds with the idea of a climate emergency.

Figure 17: CAPEX spend over time and per intervention

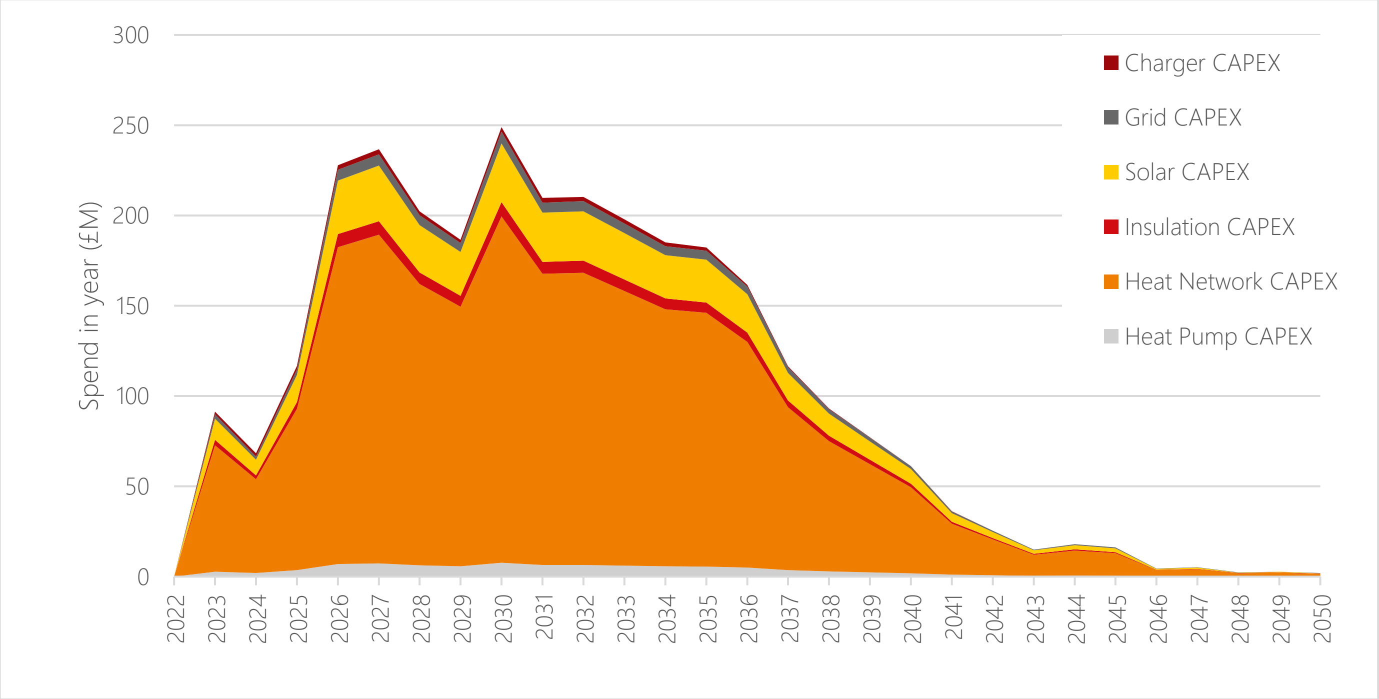
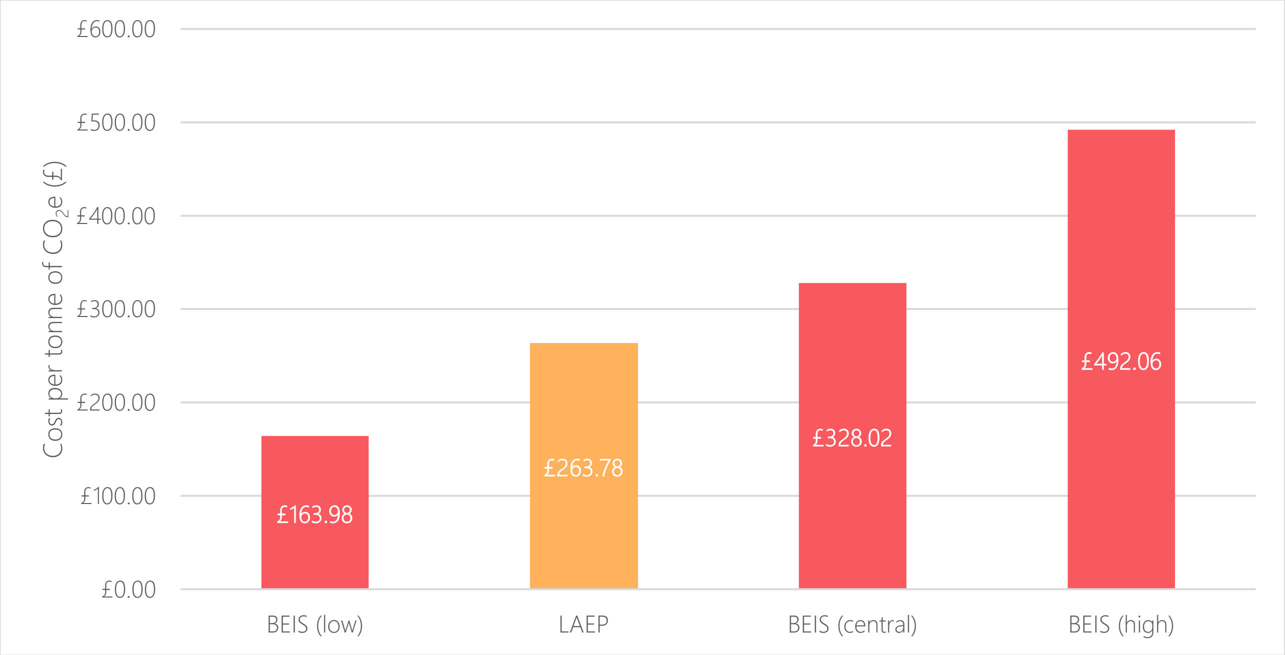


Figure 18 compares the £264/tCO_2 carbon abatement cost of the LAEP against different modelled future average costs from BEIS, placing it at the lower end of the range of values anticipated. This suggests that under a wide range of future conditions, the LAEP will prove better value than not taking action to abate carbon.

Figure 18: Costs per tonne of CO_2e in the future



A direct socio-economic benefit of implementing the LAEP will be in job creation. Some jobs will be permanent, and some temporary. A detailed socio-economic analysis was not within the scope of the LAEP, however in order to give an indication, employment multipliers may be used. These give an estimate for the number of jobs created per million pounds of spend[33]. The factors are applied in the highest year of spending, to represent the "peak" job creation. This method of estimating jobs will give a figure for jobs "created" in each year of spending. However, the jobs created in each year are more likely to be the same jobs carried over year-to-year rather than new jobs. For example, if in one year there are 200 jobs created related to insulation and the next there are 250, it is more likely that 200 jobs were carried over from the first year to the next with 50 new jobs.

In the peak spending year, a total of 1,850 jobs would be created. 310 of these jobs would be created in solar installation, 40 in upgrading the existing electricity grids, 50 in heat pump construction and installation, 1,360 in heat network construction, operation and maintenance and 90 in insulation installation. These figures include direct and indirect jobs. Direct jobs are those involved in the installation and operation of these new measures. Indirect jobs are those created in the supply chain – such as in heat pump manufacturing.

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[33] Employment multipliers are taken from International Energy Agency (2020) Sustainable Recovery: World Energy Outlook Special Report. Converted to GBP from USD by applying a conversion factor of 1.28 USD per GBP. As no figure is given for heat networks, it is assumed that this will be the same as for heat pumps – because it is assumed that the heat networks will be supplied by large scale heat pumps.

5. Next Steps

The LAEP provides a framework for action that represents the first significant step towards decarbonising the whole energy system in Enfield and achieving Net Zero by 2040.

Following on from the ten key building blocks and detailed recommendations set out in the plan, the following next steps will be crucial to keep momentum and ensure implementation of the LAEP:

- Identify and assign appropriate resources to ensure the timely delivery of the LAEP. These can come from allocating a dedicate resource within Enfield Council, outsourcing to an external organisation, or working in partnership with one.
- Produce a timetable with assigned responsibilities for monitoring, reviewing and chasing progress of implementation of the LAEP.
- Identify and engage with all local stakeholders that need to play a key role in decarbonising Enfield by 2040. Understanding power structures, level of influence and scale of local agency of different stakeholders should be a first step towards ensuring that responsibilities and actions are realistically assigned.
- Secure endorsement of the LAEP from the local stakeholders that will need to implement the plan. They need to make meaningful commitments to successfully take forward those actions in the plan which are within their reach.
- Set out clearly what further work is required in the immediate term. This will include additional tailored studies, feasibility analysis and detailed design work that is required to develop the plan and its recommendations into delivery outputs.
- Lobby central Government for continued consistent long-term funding and support programmes for the decarbonisation of heat, such as the Social Housing Decarbonisation Fund (SHDF) and the Public Sector Decarbonisation Fund (PSDS).
- Lobby central Government to devolve powers need to enable local authorities to enforce heat network connections for existing buildings, ensure robust consumer protection for heat network users and relate Council Tax bands to energy efficiency and carbon emissions in buildings.
- Lobby the GLA to ensure continued funding of relevant organisations and initiatives working towards the decarbonisation of transport, such as TfL and Healthy Streets.
- Update the plan at regular intervals (recommended every three years) to reflect the inevitable changes in local and wider circumstances, such as technology availability and costs, funding opportunities, and local and national policy.