BURO HAPPOLD

CIEN London Subregional Local Area Energy Plan

Final report

060112

18 December 2024

Revision P05

Revision	Description	Issued by	Date	Checked
P01	First draft for comment	AC	30/08/2024	JD/AY
P02	Draft to primary stakeholders	AC	20/09/2024	MM
P03	Final for comment	VK	29/10/2024	AC
P04	Final to primary stakeholders	VK	01/11/2024	AC
P05	Final issue	AC	18/12/2024	VK

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Contents

Table of Tables

Table of Figures

Glossary

Term	Definition
CAZ	Central Activity Zone
CIEN	Central, Inner East and North
DEC	Display Energy Certificate
DESNZ	Department for Energy Security and Net Zero
DFES	Distribution Future Energy Scenarios
DNO	Distribution Network Operator
DSO	Distribution System Operator
FES	Future Energy Scenarios
FTE	Full-Time Equivalent
GDPR	General Data Protection Regulation
GHG	Greenhouse Gas
GLA	Greater London Authority
GVA	Gross Value Added
HNZ	Heat Network Zoning
IMD	Indices of Multiple Deprivation
LAEP	Local Area Energy Planning
LIDAR	Light Detection and Ranging
LSOA	Lower Layer Super Output Layers
NEVIS	National Electric Vehicle Infrastructure Strategy
ONS	Office for National Statistics
PTAL	Public Transport Accessibility Level
SGN	Southern Gas Networks
SIC	Standard Industrial Classification
SLES	Smart Local Energy Systems
SOC	Standard Occupational Classification
TNO	Transmission Network Operator

Executive summary

Introduction

The Greater London Authority (GLA) is working in partnership with stakeholders on subregional local area energy planning (LAEP) across London. This programme aims to take a whole system, place-based approach to energy planning, assembling data and evidence to define optimised pathways and delivery plans for decarbonisation across London . The purpose of an LAEP is to identify the range of activities required to get to net zero and translate high level targets into on-the-ground action, and begins with the subregional data, evidence and analysis provided here.

This report covers the 'Central, Inner East and North (CIEN)' subregion which includes 11 boroughs: Royal Borough of Kensington and Chelsea, Westminster, City of London, Tower Hamlets, Newham, Hackney, Islington, Camden, Waltham Forest, Haringey and Enfield. It concludes Phase 1 of the programme, covering stages 1-4 of the Energy Systems Catapult's definition of Local Area Energy Planning [1].

The report focuses on a data driven approach, using the Mayor's 'Accelerated Green' decarbonisation pathway, to identify the actions that are required to enable a just transition to net-zero carbon emissions, the co-ordination required and the impacts on and evolution needed in London's energy systems at various scales. A particular focus is on integrating heat networks and the zoning policy into local area energy plans and to identify opportunities for multi-borough and cross-sectoral working to accelerate progress and make best use of resources.

The analysis provided here and in the LAEP Datahub will be fed into Distribution Network Operator (DNO) planning processes to influence electricity infrastructure investment decisions in London, as well as by boroughs to inform Local Plans and to form the basis for completing the LAEP process for their local contexts. It is expected that boroughs will evaluate the modelled pathways, recommendations and projects identified as part of the Phase 1 subregional LAEP, attach further local insights, develop multi-borough partnerships as appropriate and derive their preferred pathways. As such, technology deployment is expected to vary from the presented scenarios following analysis in line with stages 5-7 of the LAEP methodology and feasibility studies depending on each borough's preferred route.

Policy positions

This work recognises there is a complexity of net zero policy positions and targets across the subregion. The Mayor of London has a target for London to reach net zero by 2030 and it will need national, regional, and local stakeholders, to all play their part in tackling emissions in pursuit of this target. Targets for borough wide net-zero carbon emissions range between 2030 and 2045; only one borough has not set a borough wide target.

Engagement

This Subregional LAEP was developed in collaboration with multiple stakeholders, including close engagement with the 11 boroughs in the subregion, London Councils, UK Power Networks, Cadent as well as input from the Mayor's functional bodies (TfL, Met Police and London Fire Brigade) and other stakeholders such as the Department for Energy Security and Net Zero (DESNZ), National Grid and the Environment Agency. The work was also informed by the Talk London survey of over 1000 Londoners, exploring their opinions on energy efficiency in homes.

Baseline

The housing stock in the CIEN subregion is relatively old, with over half of the properties built pre-1944, suggesting a high proportion of solid walls which are expensive to insulate. Around 73% of homes are flatted with this figure reaching over 91% in Westminster suggesting that communal heat systems or heat networks are likely to be important in decarbonising heat. Only around 4.8% of homes are detached or semi-detached.

Around 75% of homes are heated by gas boilers, with around 16% using communal heating or heat networks. Around 8% use electric heaters and only 0.3% using heat pumps. The proportion using heat networks or communal heating is around 6 times higher than the UK average.

There are around 126,000 non-domestic properties in the subregion, with over 40% of them built pre-1900. Retail is the most prominent typology accounting for nearly 40% of the building stock, with offices also prevalent (~35%). Over 40% of the non-domestic properties in the subregion do not have a valid EPC score. The industry in the CIEN subregion is generally light and thus relatively easy to decarbonise.

Table 0-1 – Energy usage by sector and by end use type, Source: CIEN subregional LAEP analysis

Typology	No. of properties	Heat demand GWh	Electricity consumption GWh	Gas consumption GWh
Domestic	1,154,666	9,475	3,613	10,420
Non-Domestic	126,335	12,986	11,755	8,203

Energy usage by domestic and non-domestic sector is shown in Table 0-1. Electrified heating is more common in non-domestic properties than domestic. However, gas is still a large share of energy consumption across all typologies.

The borough owned housing stock performs substantially better than the non-borough subregional stock in terms of EPC rating. This shows that boroughs are generally progressing further towards their own targets.

Transportation varies significantly across the subregion, with excellent access to public transport across much of the subregion. Some areas of Enfield, Waltham Forest and Haringey have much lower levels of connectivity. Where connectivity is low, car use is higher with implications for shifting energy use to zero emission vehicles and modal shift. It should be noted that across the majority of these boroughs, public transport access is still superior to much of the UK. Most of the boroughs in the subregion are on track or have achieved the Mayor's sustainable modeshare target [2], however, public transport uptake efforts are still a key part of decarbonising the transport sector for some boroughs with lower connectivity.

Cars make up around 80% of vehicle miles across the boroughs, with Enfield having a slightly higher proportion of heavy goods vehicles. Transport emissions are dominated by car fuel usage.

There are 202 transport hubs for fleet vehicles identified across the subregion, the majority of which are emergency vehicles, health estates or bus depots, along with 235 large car parks with ~59,000 spaces between them.

Existing energy network infrastructure

The electricity distribution network in the subregion is operated by UK Power Networks (UK POWER NETWORKS). The natural gas distribution network in the area is operated by Cadent.

The majority of primary substations currently have headroom capacity at both transmission and distribution level. This indicates that these substations may be suitable for the connection of additional loads such as heat pumps or EVs. Analysis on the secondary distribution level was excluded from the work due to data unavailability; UK Power Networks has since published the higher resolution information. This will assist in the future stages of energy systems planning and technology deployment at the borough level, for example better understanding the trigger points for upgrade based on heat pump deployment.

[1] Guidance on creating a Local Area Energy Plan - Energy Systems Catapult

[2] Sustainable modes of transport (public transport, walking, cycling), Mayor's Transport Strategy | London City Hall

Some substations in the subregion are already constrained. It is likely that these substations will not be able to absorb additional load without intervention, either through flexibility or reinforcement. Planned reinforcement and network upgrades have been identified at 7no. primary substations[3].

Future energy system

Much of the value of the Subregional LAEP lies in the assembly of a standardised, whole energy system baseline dataset for the Subregion, which can be accessed and utilised by boroughs for their future work through a dedicated online data repository called the LAEP DataHub. This extensive data repository includes a broad range of mapped data layers, many down to Lower Super Output Area (LSOA) level, across the full range of sectors covered in the report. As an additional lens, five different scenarios are also examined in this Subregional LAEP to give an indication of the possible nature of the future energy system and these offer insight into decarbonisation opportunities and priorities which are agnostic over any timeframe. These pathways can be used by boroughs to help plan their trajectories to net zero, but construction of a preferred scenario to determine the pathway each borough will follow to reach net zero should be completed by individual boroughs as part of a Phase 2 LAEP.

Alongside the Mayor's chosen net zero 2030 pathway (Accelerated Green 2030), four additional post-2030 net zero pathways have been modelled: Base Case 2050; Net Zero 2040; Consumer Led 2040, and Network Led 2040. The four scenarios additional to the Mayor's Accelerated Green 2030 pathway are provided to reflect that the UK and different boroughs have different net zero targets: the national 2050 target (Base Case) and 2040 as an additional target year to respond to some London boroughs (Net Zero 2040). Investment costs and market readiness in relation to delivery are also explored (Consumer Led 2040 and Network Led 2040).

For Net Zero 2040 the same technology choices are made as in the Mayor's Accelerated Green 2030 pathway but it is the scale, speed and timeline for deployment that varies. Commentary is provided on the pace and scale of technical and non-technical activity required to achieve the 2030 Mayoral target including but not limited to the rapid rates of deployment required and the relationship with timings around existing trajectories, national and local policy alignment and available levers, carbon intensity and capacity of the electricity grid, procurement and market readiness, specifically from a skills and supply chain capacity perspective. It should be noted that strong supportive policies and action at the national level and/or more devolved powers and funding to London is important in all pathways but has always been highlighted as important in relation to the Mayor’s 2030 target. .

Analysis indicates that fabric retrofit can be an important enabler for low carbon technologies as well as reducing energy demand in its own right. From a total of over 1.25m domestic and non-domestic properties, there are around 956,000 identified fabric retrofit opportunities of which 65% are uninsulated solid walls. A further 183,000 single glazed homes, 88,000 uninsulated cavity walls and over 63,000 uninsulated roofs retrofit opportunities were identified. There are around 89,000 retrofit opportunities in council owned housing stock, with 43,000 of these being uninsulated solid walls.

Two different overarching fabric retrofit options are considered for the pathways:

- Shallow retrofit – focused on lower cost, lower disruption measures. These actions would typically be, e.g. additional loft insulation and draught excluders. These measures tend to be most cost-effective;
- Deep retrofit – more invasive measures as well as those suggested in shallow retrofit, causing more disruption but greater energy saving to allow further technology interventions for the least efficient building stock. Measures typically include single glazing upgrades and solid wall insulation.

Between 679,000 to 693,000 homes require a shallow retrofit with a further 105,000 to 137,000 selected for deep retrofit under all the modelled pathways.

[3] Long Term Development Statement, UK Power Networks, Aug. 24.

Hydrogen for space heating was excluded on the basis: it requires a national policy position and a decision on this is not expected until 2026. Additionally, as it has not currently been deployed at scale it raises concerns about deliverability for 2030 and 2040 targets.

The poor availability of EPC data, and the lack of detail about the specific building element condition for the non-domestic sector means the number of shallow and deep retrofits are very similar across all scenarios, with 116,000 shallow retrofits identified and 1,400 deeper retrofits focused on the worst performing non-domestic buildings classed as publicly owned..

The total number of new low carbon heating systems installations in the scenarios is ~1,050,000 (out of ~1,155,000 existing) for domestic and 34,000 (out of 126,000) for non-domestic. Domestic heat pumps represent around two-thirds of property installations, with around a quarter connected to heat networks and less than a tenth connected to communal heating.

Whilst the largest number of low carbon heat technologies proposed are property level heat pumps this is not reflected in the total heat demand. Property level heat pumps meet 5,484 GWh/yr of heat demand in 2050 under Accelerated Green whilst heat networks meet 11,378 GWh/yr, and communal systems meet 1,743 GWh/yr. This is due to large heat networks connecting the largest individual heat demands.

The transport elements of the scenario testing are very similar across all scenarios, aligning to the highest ambition national scenarios in terms of reduction in emissions from transport through switching to active travel and zero emission vehicles. Around 198,000 new EV chargers are estimated to be required.

The analysis expects around 235,000 new homes constructed and a further 7.1mil sqm of non-domestic floor area developed, increasing electricity demand rise by 3790GWh by 2040.

Under the Accelerated Green scenario, natural gas demand is eliminated by 2040. Annual electricity consumption is forecast to increase by around 60%, but overall energy use more than halves due to the reduction in demand from active travel and retrofit, and the increased efficiency of electrified heating systems and electric vehicles versus combustion systems.

Peak electricity demand is expected to increase by 4,100MVA (~4.1GW) by 2050. Around 1,060MW of solar PV potential was identified in the subregion.

Global warming is assumed to result in additional cooling demand across all scenarios, with ~650 GWh of additional potential cooling demand in 2050 for the subregion. Cooling is a major issue that should be explored in more detail, especially for the boroughs more affected by the urban island effect i.e. those in central London or those with larger urban areas[4]. Cooling poverty was raised as an issue in the borough engagement sessions. Socioeconomic factors, building typologies, and usage are considerations for the planning of building retrofit and heat decarbonisation in regard to future cooling demands in affected areas.

Investment costs

A common theme across all scenarios is that the heating system upgrades represent the largest area of investment. This is similar for all scenarios, with total spend of around £15billion in each scenario. Fabric retrofit is the second largest cost at around £7.5bn (although this could rise due to historic buildings in the subregion). Electricity network upgrade costs are around £3bn, although this is likely an underestimation – due to lack of visibility on conductor and secondary substation headroom. EV charging represents the smallest cost element at around £0.5bn (although purchase EVs themselves is not included). Costs related to modal shift have not been explored, as these are linked to TfL spending and/or borough transport programmes.

[4] Properties Vulnerable to Heat Impacts in London, Arup 2024

The report suggests an annual saving in operational cost by 2040 of around £0.86bn in Net Zero 2040 (compared to the Base Case 2050 scenario), with just under 12,000 jobs created in London.

Subregional priorities

Key opportunities and recommendations vary based on the characteristics of each borough. Areas with higher population densities tend to be priorities for heat networks making use of waste and low carbon heat sources; with less focus on building level solutions. More suburban areas are likely to benefit from retrofit at a building level, switching to heat pumps for heating, along with switching vehicle fuels. Common no-regret measures include a range of building fabric efficiency improvements and a shift towards active travel.

Fabric retrofit priorities are likely to focus on the social housing sector where progress is faster than in the private sector; this can help to develop the supply chain for retrofit. One area which should be considered for intervention is the private rented stock where limited incentives to invest exist without regulation. Noting the Warm Homes: Local Grant which is set to begin delivery of energy performance and low carbon heating upgrades in 2025 for low-income private sector homes[5]. The subregional LAEP should be used as an evidence base to aid lobbying for stronger regulation to target areas which are unlikely to progress quickly otherwise.

The number of heat pumps and EV chargers to be deployed suggests that investment in training and skills for installers should be prioritised; helping existing providers such as gas boiler installers transition to installing low carbon solutions.

Five priority strategic heat network areas have been identified including: from Newham along the river to Tower Hamlets (and potentially in toward the City of London and further west) making use of waste heat from data centres and wastewater treatment; Enfield from Energetik – with heat transmission mains extending south into central London (with potential routes highlighted through Waltham Forest and Haringey); the area around Olympic Park; Kensington and Chelsea and Westminster around the Royal Albert Hall and other significant historic buildings; and the major focus for heat demand density in Westminster, Camden, Islington, Hackney, City of London and Tower Hamlets. This last is one of the highest heat demand density areas in the UK. The limited land for energy centres and space for utilities makes it a complex opportunity to realise and would benefit substantially from a Subregional Delivery Plan approach – rather than borough by borough strategy. A planned approach could make the optimum use of limited resources such as waste heat and use of the River Thames to feed large-scale heat-pumps, and help prioritise routes for transmission corridors.

Westminster, Islington, City of London and London Legacy Development Corporation (LLDC) are already part of the advanced zoning programme and heat networks exist or are being developed in each of the areas identified already but not at the scale or pace indicated in the Accelerated Green scenario. The scale of these networks and their cross-boundary nature suggests a role for GLA, perhaps in co-ordinating their development and in working to secure infrastructure funding.

Investment in new public transport capacity and active travel routes is critical to achieve the carbon emission reduction targets and requires cross-boundary working and co-ordination. This is outside the scope of this study. however, it is recommended that in developing Phase 2 LAEPs boroughs actively engage with TfL to understand costs and opportunities.

Provision of on-street EV charging is a common issue in inner boroughs where there is limited off-street parking. EV charging priorities at subregional scale include opportunities for freight hubs to manage subregional deliveries, freight charging and public charging hubs along key transport corridors.

Given the significant reliance on electrification of heating and transport sectors, stakeholders in the subregion are encouraged to collaborate with the electricity distribution network operator, UK Power Networks, early to ensure there is sufficient network capacity to facilitate the transition to net zero. and to ensure that electricity capacity does not become a constraint on decarbonisation. It is likely that even with widespread deployment of heat networks substantial network reinforcement in central boroughs will be required. The focus on property level solutions in more suburban boroughs suggests that this might be focused in these areas. In the meantime, a more widely deployed approach to flexibility could make best use of the existing headroom in the network.

Next steps

The subregional LAEP provides a consistent baseline of data that can be used for developing detailed, borough level LAEPs by undertaking a 'Phase 2' LAEP which completes stages 5-7 of the LAEP methodology. Used in conjunction with the GLA LAEP DataHub, this will provide a sound set of data to develop localised approaches to net-zero at borough and neighbourhood scale.

Detailed Phase 2 LAEPs should provide a programme of investable projects for each borough along with a plan against which to co-ordinate with stakeholders, including major energy users, social landlords and infrastructure operators. Where there are specific cross-boundary and cross-sector opportunities joint delivery approaches should be considered to ensure the opportunities can be maximised.

By developing more granular planning there could be more collaboration with the electricity distribution operator, particularly in identifying where network constraints exist below primary sub-station level. Data on medium voltage (11,000V) and low voltage networks was not available at the time of this analysis[6] but is likely to be key to ensuring capacity on these networks does not become a constraint. Developments in demand side flexibility as smart meters and innovative tariffs are rolled out means this approach could be integrated into network planning, buying time before network reinforcement is required.

Given the emphasis on heating system decarbonisation, it will be critical to continue to co-ordinate with central government. Policy support for heat pump deployment in the form of existing grant programmes, as well as rebalancing of environmental levies away from electricity, are likely to be required to accelerate installation rates. Investment in skills training and removing barriers to SMEs in the sector should also be considered.

The GLA should continue to develop its approach to cross-borough coordination for different strategic initiatives. Heat network deployment will require continued policy support. The impact of heat network zoning is uncertain but is intended to help de-risk investment in networks at greater scale. There is a need to consider how cross-borough co-ordination of heat zoning will occur. The GLA could consider the deployment of a programme of investment in strategic heat transmission heat networks. This would have the purpose to distribute heat from relatively isolated waste heat opportunities to high demand areas which currently represent too large a risk and investment for individual boroughs or private sector actors. The importance of waste heat sources suggests that strong incentives or regulation will ensure waste heat can be accessed effectively across multiple boroughs and areas.

[5] https://www.gov.uk/government/publications/warm-homes-local-grant
[6] UK Power Networks Secondary Site Utilisation has become available meanwhile and will be available in the DataHub.

1 Introduction

1.1 The subregional local energy planning vision and goals

The Greater London Authority (GLA) is working in partnership with boroughs and other stakeholders on subregional local area energy planning (LAEP) across London. The ambitious vision of this work is to plan for shared net zero and growth objectives in a coordinated way, taking a whole system, place-based approach to energy planning, to define optimised pathways and delivery plans for decarbonisation across London. Through the subregional approach, the intent is to establish an energy planning hierarchy that promotes coordination in planning, use of data, and stakeholder engagement, and this approach has strong support from London Councils and boroughs across London

The four subregions are defined and shown in Figure 1—1.

This report details the LAEP for the Central, Inner East and North (CIEN) London subregion and forms part of a parallel project including the South London subregion LAEP which is being completed concurrently. The LAEP for West London subregion pilot was previously completed in 2023. It is proposed the Outer East LAEP is commissioned in 2024/2025.

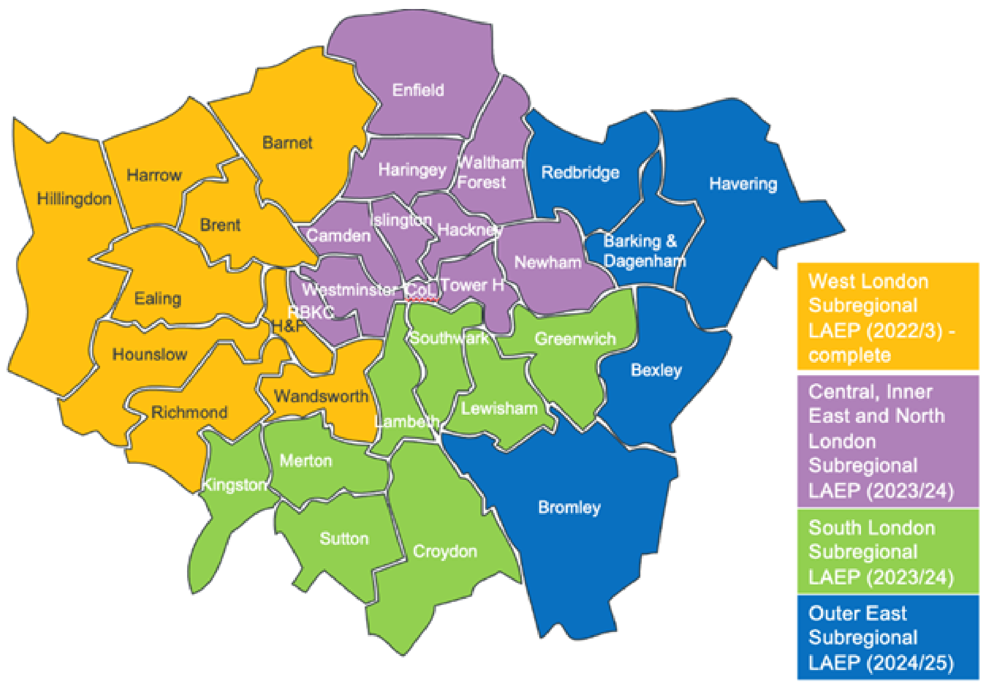

Figure 1—1 GLA defined subregions for local area energy planning (LAEP).

In summary the overall goals of the subregional approach are:

1. Establish a coordinated approach to local area energy planning across London
2. Understand the impacts of implementing the Mayor of London's *accelerated green* decarbonisation pathway at a variety of scales, to identify the effects of this pathway on London's energy systems and wider built environment.
3. Integrate heat network zoning programmes and activities into local area energy planning, to support a whole-system analysis and improved understanding of the wider benefits of proposed heat networks.
4. Identify opportunities for cross-sectoral and cross-boundary working to maximise progress to net zero and secure efficiencies in use of stakeholder resources
5. Secure wider stakeholder awareness and community understanding of the changes required to achieve decarbonisation targets and understand priorities of these groups.
6. Support boroughs in identifying resourcing and skills requirements to deliver an LAEP and raise awareness/gain buy-in of senior decision makers.

1.2 Subregional LAEP scope

This report details the LAEP for the CIEN London subregion.

The LAEP methodology is a collaborative seven stage process to identify the most cost-effective pathway to decarbonise a region, covering power, heat, transport, and buildings. This is defined by Energy Systems Catapult[7].

The subregional LAEP focuses on the first 4 stages which is referred to as Phase 1 (see Figure 1—2) which will provide a common evidence base which will enable boroughs to deliver full LAEPs covering stages 5-7 with greater efficiency, at lower cost, and higher levels of confidence, with consideration of key interdependencies and wider energy system factors.

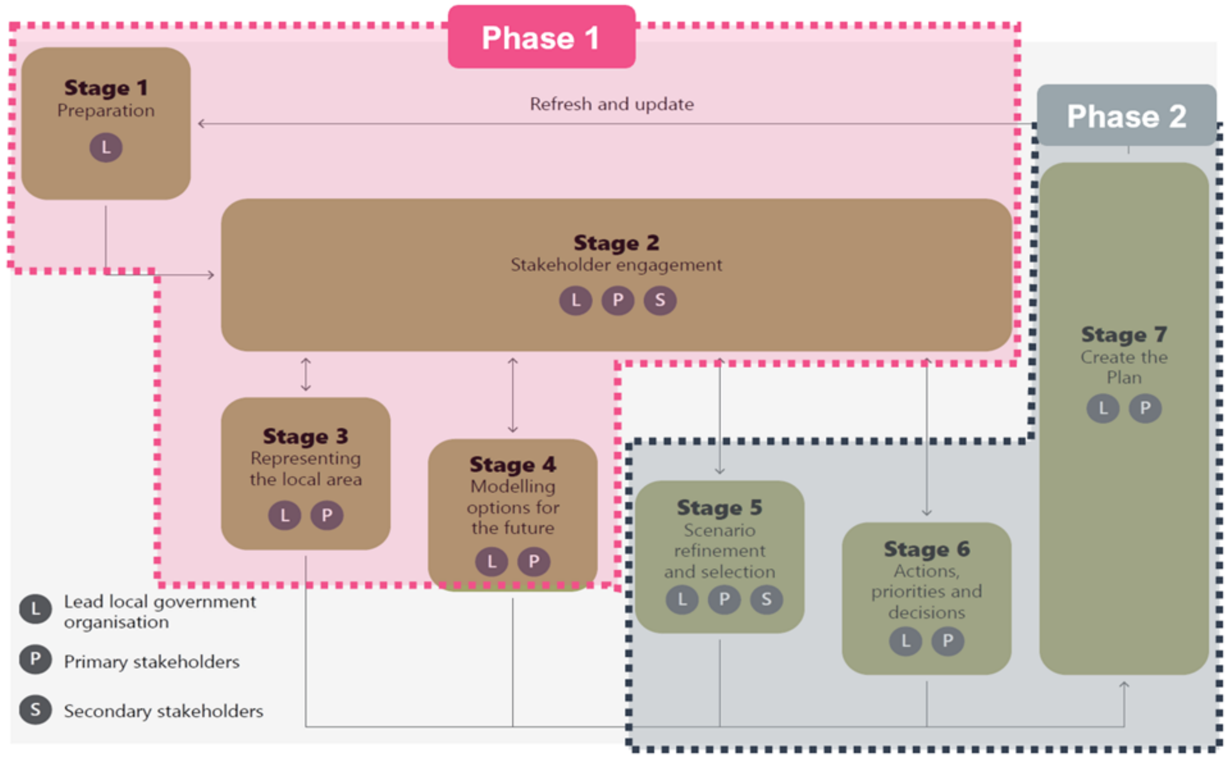

Figure 1—2 Phase 1 and Phase 2 of LAEP.

1.3 Value and context of the subregional approach

In recent history, energy in the UK has been transmitted and distributed through dedicated gas and electricity networks throughout the country. Along with an established transport fuel infrastructure model, there is need to consider the net zero carbon energy transition at appropriate scales which represent both the existing and future demands for electricity, heat, and transport.

The UK *electricity* grid is a nationally integrated network, with distribution and transmission right across the UK from mostly centralised power plant which is reducing with significantly increases in large scale renewables such as onshore

[7] https://es.catapult.org.uk/tools-and-labs/local-area-energy-planning/

and offshore wind, large scale solar PV, and small-scale community and building scale technology. The UK supply is also supplemented with nuclear power from France.

Heat, which is the most challenging aspect of the energy system to decarbonise is generated with either the use of electricity or, more commonly, natural gas – which follows a similar transmission and distribution model. Whilst emerging technology such as individual heat pumps will be part of the decarbonisation solution at building scale, the transmission and distribution of electrified heat though district heat networks will become an increasingly important part of the decarbonisation approach.

If the use of the *gas* network is phased out without networked hydrogen it will require large scale decommissioning. From a technical perspective understanding the scale of decommissioning and where this will happen first at a subregional scale is important factor for respective stakeholders to consider.

In particular, it is important to examine heat networks at a subregional, rather than just a borough level, as there is often a misalignment between heat sources and dense heat demand (which is most suitable for heat networks). By undertaking subregional analysis and consideration of heat networks a more strategic approach can be created. This well help reduce some of the challenges of heat networks where proposed building connections can be across administrative boundaries, utilise shared heat sources and necessitate strategic approaches to improve longer investment models and economies of scale.

With high levels of electrification for heat and transport and possibly industry, a subregional approach is also important from an electricity network perspective. Decisions at a property level across multiple boroughs have a cumulative impact by not only putting strain on UK Power Networks distribution network but also National Grid's transmission network. The addition of newly proposed very high demand land uses (such as data centres) makes this even more significant.

It is also important to understand how different targets align at a borough scale and how these fit into a subregional pathway. With the scale of transition needed and limited workforce this can help improve strategic approaches.

With a coordinated approach there is an enhanced potential for data sharing, and improved understanding of adjacent borough aspirations. For example, growth overlapping borough boundaries may be a trigger factor for electricity network upgrade or deployment of a heat network.

A subregional approach also opens up the ability to consider wider data sets, which would be challenging for individual boroughs to access and disaggregate and interpret. This can include larger scale grid capacity or industrial activity.

Borough level and subregional actions are provided in this report. This helps remove the burden of so many actions on boroughs, with greater ownership and opportunities for regional and subregional bodies like the GLA, London Councils and the London Waste Authority having actions to progress. The outputs have also been used to inform UK Power Networks network plans and forecasting activities, including the Distributed Future Energy Scenarios (DFES). In order to confirm how the Subregional LAEP outputs should inform UK Power Networks network planning, the outputs were tested by UK Power Networks to understand whether the forecasts were materially different from the 2024 DFES forecast and whether there was sufficient confidence that the forecast demand will come forward. The forecasts were found to be materially different (in particular, in terms of heat and power) and the forecasts are deemed to be sufficiently confident, therefore the results will inform UK Power Networks network plans. The annually updated DFES, with inputs from the LAEP, will be published by UK Power Networks in 2025.

With a coordinated approach, boroughs and the GLA will be able to provide a basis for more impactful stakeholder engagement, development of common funding and procurement approaches. This will enhance confident and awareness across sectors and industry.

Detailed borough level actions are most likely to be determined in Phase 2 LAEPs, which will build on the subregional approach to create more localised, borough specific, LAEPs. The subregional LAEP approach will be a key stepping stone for each borough to then make decisions based on local needs The presence of base data and initial scenarios means there can be a focus on enhancing data with local insights and selecting the most suitable local scenario (for which the subregional scenario can provide context). The GLA LAEP DataHub which is being developed will provide access to data and reduce the duplication of input of boroughs.

1.4 An overview of the subregional challenge

The relative carbon emissions per borough are shown in Figure 1—3. This indicates a range in carbon emissions density which begins to show the variation of sector activity and density of development across the subregion. Although not normalised according to area – higher carbon emissions are indicated in particular for Westminster and Tower Hamlets. Both Westminster and Tower Hamlets particularly dense in terms of buildings and activity, compared to for example, Hackney and Waltham Forest.

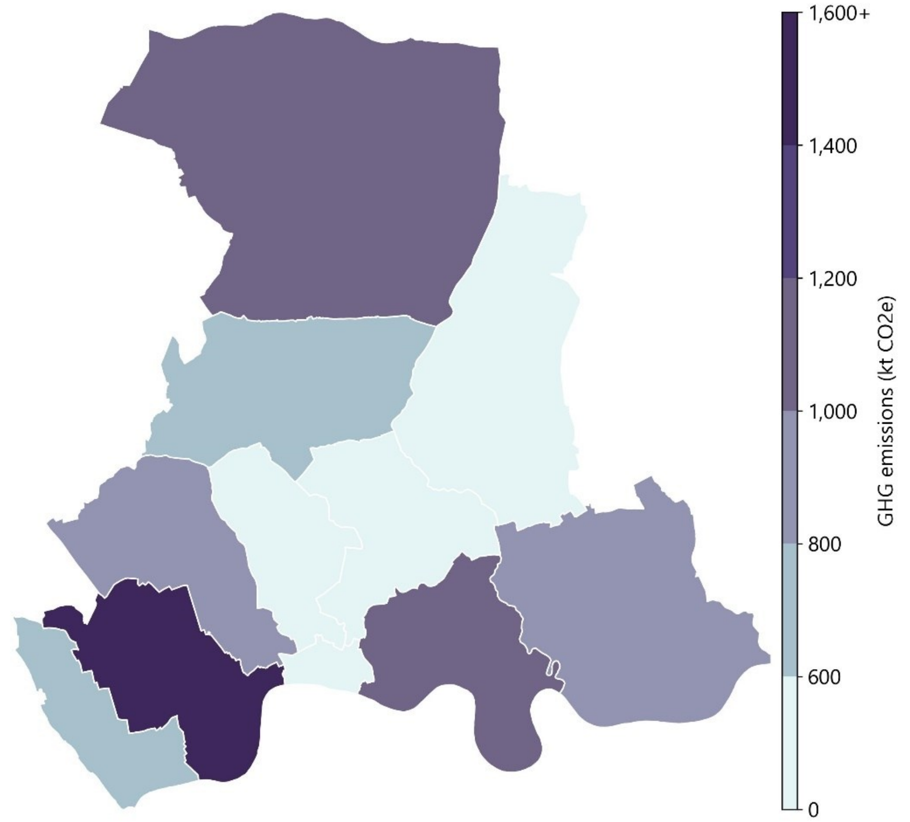

Figure 1—3 Total Green House Gas (GHG) emissions for the eleven CIEN London boroughs (2021, ktCO2e), Source: LEGGI Mar 24.

A further analysis of each borough (see Figure 1—4) indicates energy consumption in GWh is varied through the sub-region which reflects the variation in density and predominant activity and resident population.

City of London, Westminster and Kensington and Chelsea are very heavily dominated by commercial activity. Other boroughs have a more balanced fuel consumption versus domestic. Transport is relatively equal aside the outer borough Enfield which reflects the higher commute and commercial transport requirements.

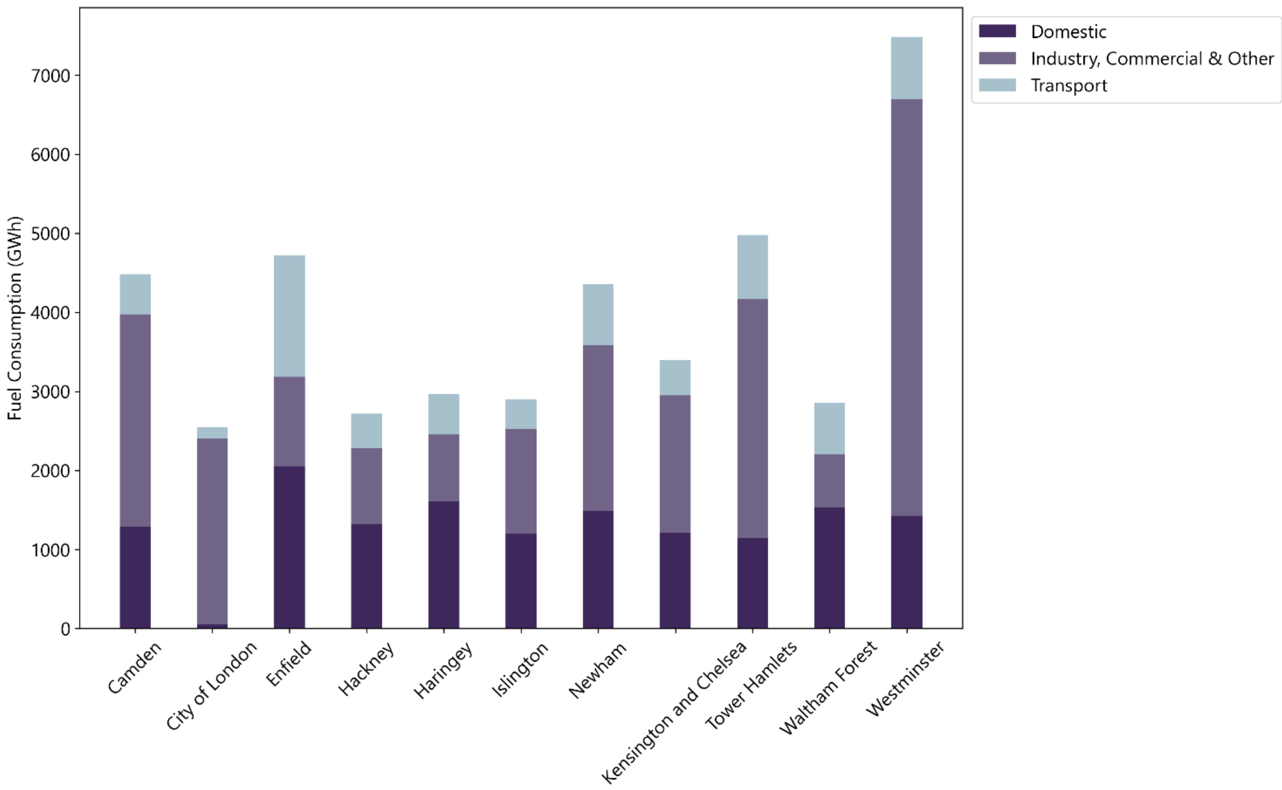

Figure 1—4 Fuel consumption breakdown per borough.

Translating this to carbon emissions breakdown by borough (see Figure 1—5) indicates the need to develop coordinated approaches for different areas, with Domestic and non-domestic buildings, and Transport sectors having particular impact on the overall carbon emissions for the subregion. Whilst not immediately connected via traditional energy systems to each other, have the potential to be integrated through a coordinated approach to electrify heat and transport, and use of flexibility markets to influence energy use in the home and modal shifts or modal choice in transport. Evidently agriculture in this context has very little or no impact on carbon emissions.

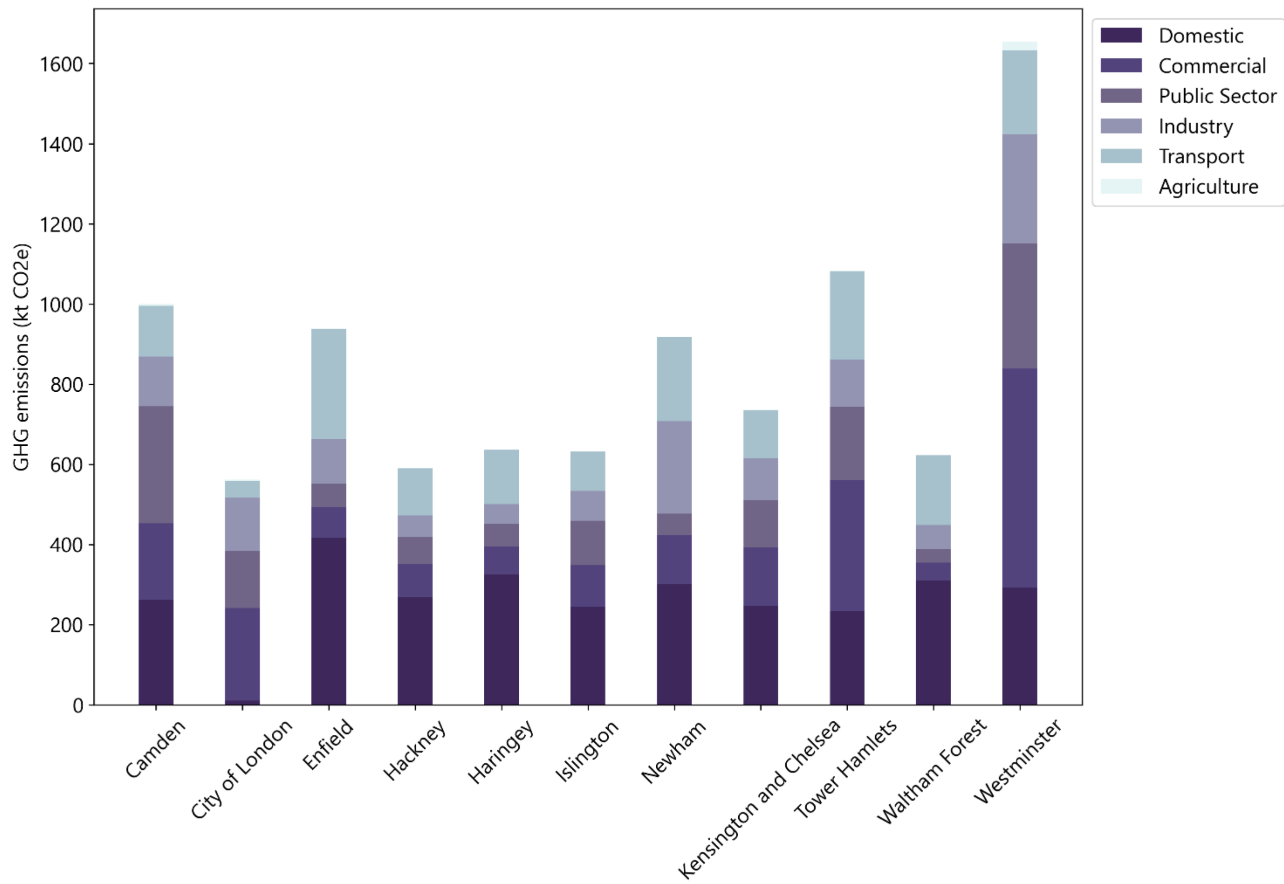

Figure 1—5 GHG emissions breakdown per Borough.

1.5 Reporting scales

The LAEP approach produces large volumes of detailed data, including every property in the subregion. A summary of the different scales of data used and considered in this report is provided in Figure 1—6.

Reporting at property level has challenges such as GDPR and commercial sensitivity but also, the volume of data can make it hard to form a strategy or prioritisation of actions. At borough level reporting headline values is useful but there is not enough detail for significantly sized project-based strategy, thereby further justifying reporting and analysis at subregional scale.

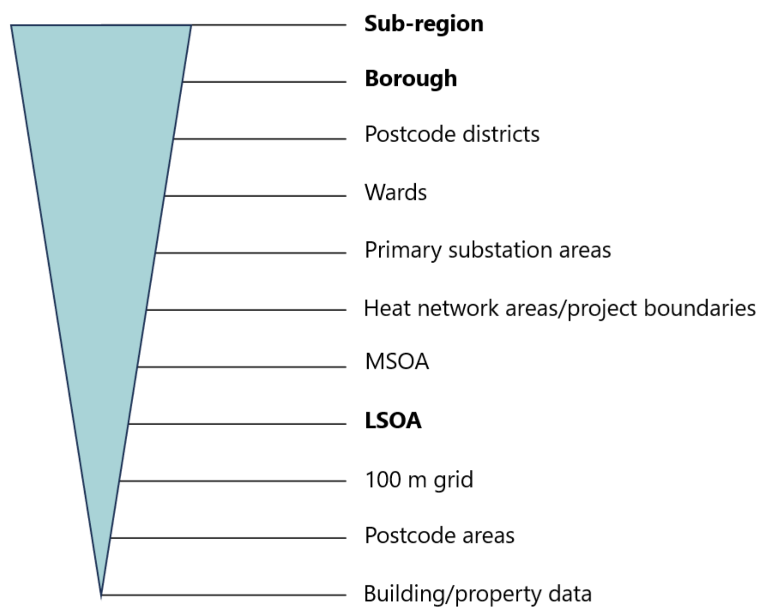

Figure 1—6 Overview of some data scales used; key reporting scales are marked in bold.

Given the scale of the subregional work presentation of data focuses and outputs is focused on the large scales. This means a subregional vision can be communicated.

The highest resolution of mapping and reporting is LSOA (Lower Layer Super Output Areas). This is a standard used in many LAEPs and aligns to census data. The LSOA boundaries and size are partly linked to population so vary in area, if they contain a large green space like a park or conversely contain much greater density of housing. The population in an LSOA does, however, still vary. In large rural LSOAs the population can be as low as 1000 whilst in the densest urban LSOAs it will be 3000. In the subregion for the Phase 1 LAEP the population of LSOAs varies between 2000 and 3000. It is worth noting that the LAEP DataHub will include some data down to building level.

In more detailed borough led LAEPs outputs would be expected to explore specific project boundaries and detailed resolutions like 100 m grids. This requires a preferred decarbonisation pathway and extensive local stakeholder engagement, which goes beyond the scope of the initial LAEP stages. At the end of this report suggestions are made to help standardise finer reporting scales, to streamline Phase 2 LAEPs and associated activity – such as funding applications.

1.6 LAEP DataHub

In parallel to the subregional LAEPs, the GLA is progressing a London-wide LAEP DataHub, to support collation of data relevant to local area energy planning and wider decarbonisation projects and strategies for access by London boroughs and key stakeholders. . The LAEP DataHub will draw on a variety of publicly available and GLA managed datasets. Figure 1—7 provides an overview of the GLA's future LAEP Datahub current and future interfaces for LAEP Phase 1 and 2 development.

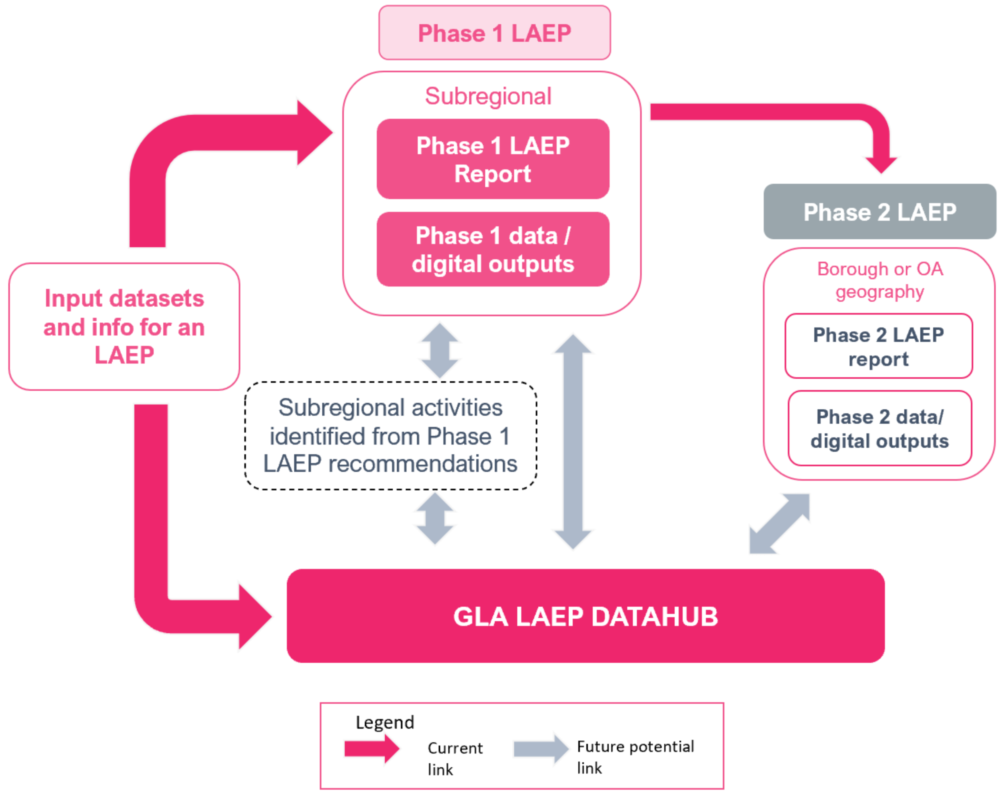

Figure 1—7 Proposed GLA DataHub interfaces for future LAEP development.

1.7 Report structure

The report is split into the following core chapters:

1. *Introduction* – this section
2. *Current picture:* summarising and interpreting baseline technical data collected and the current energy system. Consideration of social characteristics, stakeholders, the green economy and current plans.
3. *Future picture:* this provides an overview of the different decarbonisation pathways and scenarios tested. This includes the policy context behind the scenarios
4. *Decarbonisation opportunities:* summary of the decarbonisation opportunities identified and sector areas to prioritise.
5. *Next steps:* detailing the key next steps in progressing the LAEP beyond phase 1

2 Current picture

The CIEN London subregion is home to over 2.56 million people and is experiencing rapid growth, with the population growing by 5% between the 2011 and 2021 census. This is lower than the 6.6% for England overall. The subregion is mix of domestic buildings, commercial and other non-domestic development, particularly near the Thames and towards central London.

This section provides an overview of the CIEN London subregion's *current* energy system and factors relating to it. This is detailed in the following sub-sections:

1. Social indicators and climate resilience
2. Stakeholder mapping
3. Subregional net-zero plans and initiatives
4. The green economy
5. Subregional buildings stock
6. Transport systems and energy usage
7. Current energy networks
8. Low carbon technologies

2.1 Social indicators and climate resilience

Alongside technical factors, the LAEP also considers social indicators which can impact the energy plan. Social indicators have been considered throughout the Phase 1 LAEP analysis alongside the technical assessment of technology deployment to prioritise action where social indicators suggest a greater societal benefit. This is key as a just transition is at the core of many local policies and was noted on several occasions during borough 1-2-1 sessions.

In the context of energy, fuel poverty is one of the key societal factors to consider. Decarbonisation can present a path to more efficient energy systems which have the potential to lower fuel bills. However, there is also a danger with the higher cost of electricity compared to gas that low carbon technology could have an adverse impact on fuel poverty.

Fuel poverty is presented at LSOA level in Figure 2—1 which indicates the likelihood of fuel poverty across the boroughs from high (dark shading) to low (light shading). Fuel poverty is calculated from the energy efficiency of the homes, household income and energy prices.

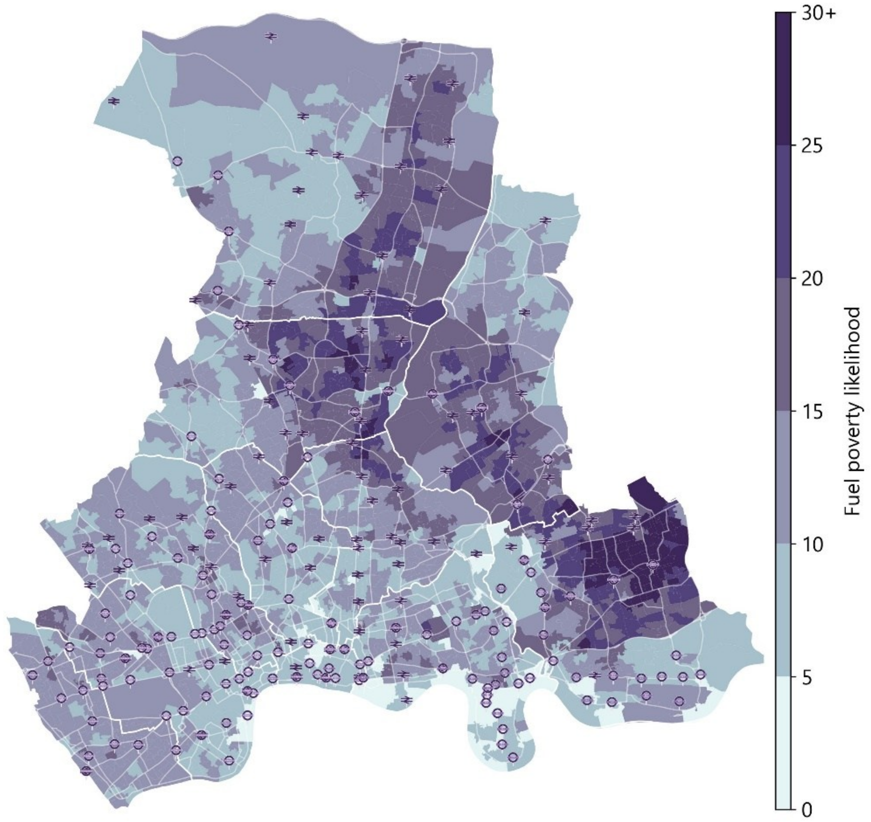

Figure 2—1 Percentage likelihood of being in fuel poverty by LSOA in 2022.

There are areas of fuel poverty across all boroughs in the subregion but with apparent lower concentrations in boroughs mostly adjoining the Thames and west Enfield. In contrast, there is a band of high fuel poverty likelihood which flows down from east Enfield down to Newham which has very clear large areas where fuel poverty is more prevalent.

Indices of Multiple Deprivation (IMD) provide a broader vision of society deprivation and ability to pay for energy than fuel poverty. The IMD score takes into account income, employment, education, health, crime, barriers to housing and services, and the living environment (both indoor and outdoor).

These IMD scores are presented in Figure 2—2. The IMD is often presented as a decile score at LSOA, with a decile of 1 meaning the LSOA is in the top 10% most deprived areas (darker shading), and 10 in the 10% least deprived areas (lighter shading).

Caption: IMD decile scores by LSOA. Description: A map displaying the Indices of Multiple Deprivation (IMD) decile scores by LSOA. Darker areas represent higher levels of deprivation. The map shows a strong correlation between high deprivation and high fuel poverty areas.

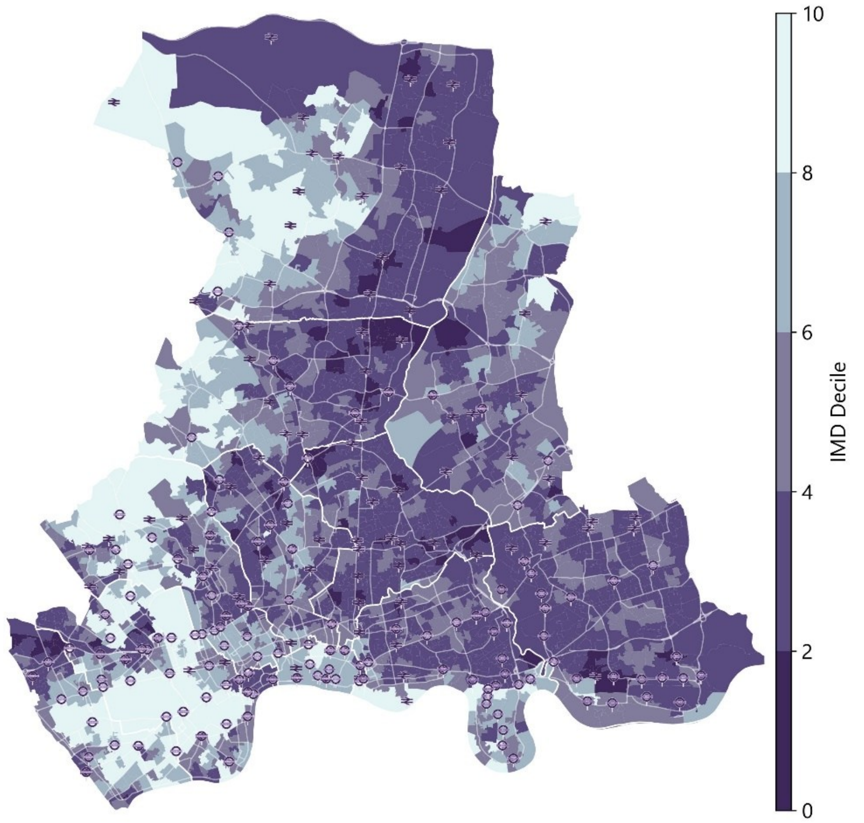

Figure 2—2 IMD decile scores by LSOA.

The relationship between fuel poverty and deprivation appears to be strongest in the band identified for fuel poverty. In general, the majority of CIEN shows low IMD scores indicating high levels of deprivation. Noticeable this reduces to the west of the subregion.

It is important to note that the transition to net zero can help improve many of the IMD measures, this includes:

- job creation through the green economy - this is discussed further in section 2.4.
- health benefits due to lower emissions - not only CO_2 but also many other gases like NO_X and carbon monoxide as well as particulates (PM2.5 and PM10).
- enhancement of the living environment – this is both inside the home with more efficiently and effectively heated buildings (e.g. comfort level and temperature gradient in living space) and the local environment due to lower levels of air pollution.

Climate resilience

Climate vulnerability, measuring the exposure of people to climate impacts from flooding and heat waves, has a strong link to social indicators. The London Climate Risk Mapping [8] and associated analysis demonstrates the distribution of areas across London with a higher risk of flooding, poor air quality, heat wave impacts and other environmental metrics while social indicators like deprivation are also part of the overall climate risk metric. Strong overlaps exist across the inner boroughs where the urban heat island effect is strongest with the exception of City of London and parts of Westminster and Camden presenting lowest deprivation. Parts of Haringey, Enfield and Waltham Forest also present lowest risk partly because of access to large open/green areas, which is also part of the risk metrics but also linked to lower deprivation index.

Building and heat decarbonisation plans need to account for such vulnerability and prioritise action for those affected the most. Building retrofit interventions are known to create unintended consequences such as poor indoor air quality and increased risk of overheating when appropriate ventilation is not designed in. Similarly, the impact of Air-Source Heat Pumps in local microclimates is only recently being explored. Both building retrofit and heating system electrification need to consider the appropriateness of the intervention based on the affected people's vulnerability as a whole.

2.2 Stakeholder mapping

Stakeholder engagement is a core component in the development of the LAEP, these at different levels for subregional and borough level LAEPs. For the subregional LAEP scale the focus is on larger stakeholders, such as central government, individual boroughs and utilities (such as network operators). In borough specific LAEPs the stakeholder engagement should be focused on more local stakeholders, such as key land owners, social housing providers and business improvement districts as more as more individuals within the borough councils.

Key aspects of the engagement included:

- Mapping stakeholders across the sub-region, both in the public and private sectors (see Appendix B)
- Facilitating and organising stakeholder group workshop sessions
- Formal 1:1 engagement meetings with primary stakeholders addressing:
  - Policy review in relation to local area energy planning
  - Data collection
  - Review of existing relevant studies, projects and plans across the energy system
  - Stakeholder mapping
  - Borough readiness to deliver the next stages of LAEP planning or project delivery (for those boroughs ahead in existing studies or having a borough-led LAEP already)
- Continued awareness raising through various events, e.g. initial launch event and result engagement day
- Providing opportunity for data owners to review and provide additional data and information

Relevant stakeholders were identified jointly with the GLA and the project team. These stakeholders were engaged to enable a better understanding of their current roles and responsibilities, existing decarbonisation targets and their objectives regarding the development of the sub-regional LAEP.

Following the initial engagement with the GLA, the primary and secondary stakeholders were confirmed. These are shown in Table 2-1.

The project management stakeholder group represented the GLA and lead boroughs from both CIEN and South subregions. All boroughs within each sub-region were identified as primary stakeholders. Key utility companies and public sector bodies also formed part of the primary stakeholder group.

Secondary stakeholders were engaged to enable additional data to be provided and to verify baseline and future assumptions.

To establish priorities, we held several stakeholder engagement sessions throughout the completion of the sub-regional LAEP. These sessions included focused 1-2-1 meetings with primary stakeholders to gather information and understand future objectives and initiatives.

Collaborative inter-stakeholder workshops were facilitated for broader discussions, which formed a basis to understand common challenges, collaboration opportunities, and potential actions.

Table 2-1 Stakeholder Mapping Summary

[8] Climate Risk Mapping - London Datastore

Primary stakeholders			
Project management group	GLA	Lead borough CIEN (Camden)	Lead boroughs South (Kingston, Merton, Southwark)
Non-lead boroughs		City of London, Enfield, Hackney, Haringey, Islington, Newham, Royal Borough of Kensington and Chelsea, Tower Hamlets, Waltham Forest, Westminster	Croydon, Royal Borough of Greenwich, Lambeth, Lewisham, Sutton
Non-boroughs - London	UK Power Networks, SSEN, Thames Water, TfL, Cadent, SGN, London Councils		
Non-boroughs - National	National Grid ESO, DESNZ		
Secondary stakeholders			
Environment Agency, Port of London, NHS, Met Police, London Fire Brigade, Industry groups (including TechUK), local stakeholders (the focus was identifying these in preparation for Phase 2 LAEPs			

Talk London Survey

Alongside the engagement carried out specifically for this project the project benefited from a survey of over 1000 Londoners, exploring their opinions on energy efficiency in homes[9]. The Talk London survey explored factors ranging from opinions on PV, heat networks, fabric improvement and smart meters. This is integrated into the modelling approach (with insights impacting the likelihood for different technology adoption) and is also used to help identify some next steps after the subregional LAEP.

2.3 Subregional net zero plans and initiatives

2.3.1 National Policy

In 2019 the UK government made a commitment through the UK Climate Change Act (2019) to achieve Net-Zero by 2050. Following the commitment, a series of legislations and strategies have been adopted across sectors.

The UK Net Zero Strategy released in October 2021 sets the target of fully decarbonising the UK power system by 2035, banning the sale of new gas boilers by 2035 (this was then reduced to an 80% reduction in installs) and introduces a new target of reducing the emissions of public sector buildings by 75% by 2037. In transport, there will be a ban on the sale of petrol and diesel cars after 2030 and all vehicles to be zero emission capable by 2035.

The UK Heat and Building Strategy was also released in October 2021, and outlines the strategy for decarbonising of domestic, public, industrial, and commercial buildings mainly through electrification of heat, utilising hydrogen gas whilst emphasising on energy efficiency.

Decarbonising Transport published in July 2021, outlines a plan to decarbonise the UK's transport system. It includes electrification of transport and development of nationwide charging infrastructure with the commitment that public transport will be zero-emissions by 2050.

The Energy Security Bill was introduced to Parliament on 6th July 2022. It introduces a regulatory framework for heat networks to facilitate heat network zoning and incentivising the use of low carbon fuels in transport.

The Energy Act 2023 introduced in 15 parts, provides a wide range of provisions for new energy activities, regulations, heat networks and energy performance of buildings. Following is a summary of relevant parts.

- Regulation of new technology including low carbon heat schemes, renewable transport fuel obligations and removal of greenhouse gases
- Regulation of heat networks: designating a regulator for heat networks and assigning heat network zones; creation of a Heat Network Zones Authority and zone coordinators; an enforcement powers and imposition of penalties.
- Energy performance of premises and energy savings opportunity schemes

The trickle-down impact on local and regional policy is clear, and adds weight to existing and emerging policy at sub-national level.

2.3.2 Regional Greater London Authority Policy

The Mayor of London has set a target for London to be net zero carbon by 2030 and based on previously completed research and analysis chosen a pathway named Accelerated Green[10].

A summary of the key required measures are as follows:

- ~40 per cent reduction in the total heat demand of our buildings, requiring significantly improved insulation for >2 million homes and >250,000 non-domestic buildings
- Installation of 2.2 million heat pumps in London by 2030
- 460,000 buildings connected to district heating networks by 2030
- A 27 per cent reduction in car vehicle km travelled by 2030
- Fossil fuel car and van sales ended by 2030 and enforced in line with Government's existing commitments.

A comparison of the national and regional policy is shown in Table 2-2. This indicates the more accelerated pathway approach by GLA.

[9] https://www.london.gov.uk/talk-london/topics/environment/more-energy-efficient-homes-london/surveys/1108#

[10] Pathways to Net Zero Carbon by 2030 | London City Hall

Table 2-2 Summary of National and Regional GLA Policy.

National	Regional / GLA
Net zero by 2050	**Net zero by 2030**
Key Policies	Key Policies
Legal commitment UK Climate Change Act (2019) • Sets legal targets for the UK to achieve Net Zero by 2050	**Buildings demand reduction** • 37% reduction in total heat demand of domestic buildings, 39% for non-domestic buildings by 2030 • Heat demand halved of non-domestic buildings halved by 2034
Power • Full decarbonisation of the power grid by 2035	**Retrofit** • 210,000 homes retrofitted each year between now and 2030 • 26,500 commercial/public buildings retrofitted each year between now and 2030
Buildings • No new gas boilers will be sold by 2035 • Install 600,000 heat pumps per year by 2028 • Tighten MEES so that landlords cannot let properties with EPC lower than E	**Heat source** • No new gas boilers from 2026 • 2.2M heat pumps by 2030
	Heat networks • 460,000 connections by 2030
Transport • End of sale of new petrol and diesel cars by 2030 • All cars must be fully zero emission capable by 2035	**Transport** • 27% of reduction in car km • End of ICE sales by 2030 • Bring forward MTS outcomes by 10y
	Rooftop PV • 3.9GW by 2050

2.3.3 Borough Policy

Each borough currently has differing net zero targets as indicated in Table 2-3 (and shown graphically in Figure 2—3). Some of the boroughs have separate council net zero targets, which relate to council operations, and borough-wide targets. Within this subregion Lambeth does not have a e net zero borough-wide target. Details of this have been shared in bespoke borough profiles included in Appendix D of the report. Each borough profile provides a visual summary of the 1-2-1 engagement carried out throughout the work. The table indicates the range in borough net zero targets from 2030 through to 2050. An intention of the sub-regional LAEP is to raise the visibility of regional and local targets and by modelling decarbonisation scenarios across the subregion develop a portfolio of strategic actions that delivered together by boroughs, the GLA and wider stakeholders can help us tackle the climate emergency and pursue our shared net zero goals.

Table 2-3 Council and Borough target summary.

Council/ Borough	Net zero borough target	Net zero policy - council
Tower Hamlets	2045	2025 (Council operations)
Camden	2030	Net zero carbon by 2030
Waltham Forest	2030	Net zero carbon by 2030
City of London	2040	Net zero carbon by 2027 (operations) Net zero by 2040 (council's full value chain) Net zero by 2040 in the Square Mile
Islington	2030	Official target is 2050 (2030 is ambition)
RBCK	2040	Net zero carbon by 2030 (operations)
Enfield	2040	Net zero carbon by 2040
Newham	2045	Carbon neutral by 2030 Net zero GHG emissions by 2050
Haringey	2041	Core council buildings net zero by 2027
Westminster	2040	Net zero by 2040
Hackney		Net zero council emissions - 2040

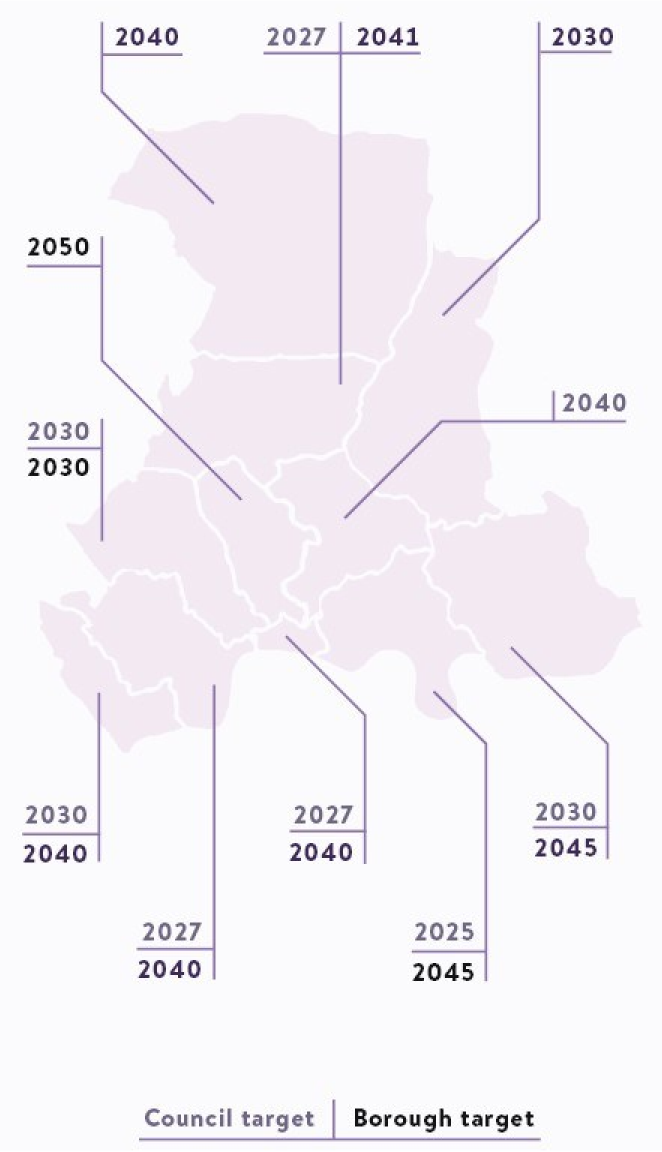

Figure 2—3 Borough net zero targets, source: Borough policy documents.

2.4 The Green Economy

There is no singularly agreed definition of *the green economy*, with various researchers using different approaches to develop a context dependent definition.

Recent examples include:

- the green occupations definition created by the GLA, drawing on research by O*NET and transferring it to a UK context [11];
- the mission-based approach taken by WPI Economics and Institute for Employment Studies in a recent report [12];
- industry-approach used by the ONS to generate experimental green jobs estimates [13];
- research into London's low carbon environmental goods and services (LCEGS) [14].

Taking account of the number of different methodologies, this sub-section subjectively analyses the green economy, rather than developing a definitive labour demand and supply balance and sector value.

2.4.1 Green Labour Demand

The recent report by WPI Economics and Institute of Employment Studies estimates the growth of green jobs in London across 11 sub-sectors from 2020 to 2030. The projected estimates do not go down to a sub-regional or local authority level; however, they provide useful insight into how the shape of the green economy in wider London may change in the future.

A summary of the green job growth estimates from 2020 to 2030 according to sector is provided in Table 2-4.

Table 2-4: London Green Job projections 2020-2030, Source: WPI Economic and Institute for Employment Studies, Green Jobs and Skills in London: Cross-London Report (2021).

Sector	Number of Jobs		Total % Change
	2020	2030	
Climate Adaption	2,500	3,900	56%
Climate Change Research and Development	3,700	9,900	168%
Climate Change Strategy, Policy, Monitoring and Planning	4,100	11,100	171%
Green and Blue Infrastructure	1,600	2,400	50%
Green Finance	50,700	137,600	171%
Home and Buildings	58,200	117,600	102%
Industrial Decarbonisation, Hydrogen and Carbon Capture	900	6,400	611%
Low Carbon Transport	13,700	69,200	405%
Power	82,900	126,600	53%
Reduce, Reuse, Recycle	14,500	18,100	25%
Reducing Localised Pollution	1,600	2,600	63%
Total	**234,400**	**505,400**	**116%**

Overall, green jobs are projected to grow by 271,000 (116%). Gains in green finance, home and buildings and low carbon transport represent the largest drivers of growth at the sector level (86,900, 59,400 and 55,500 jobs respectively), with the power sector also making a sizeable contribution (43,700 jobs). Sector definitions for these prominent areas for job growth are detailed in Table 2-5.

Table 2-5 Green Economy Sector Definitions

Sector	Sector Definition
Homes and Buildings	Retrofit, building new energy-efficient homes, heat pumps, smart devices and controls, heat networks and hydrogen boilers.
Low Carbon Transport	Low or zero emission vehicles, aviation and maritime, rail, public transport and walking or cycling.
Power	Includes renewables (such as wind, solar and hydropower), nuclear power, grid infrastructure, energy storage and smart systems technology.

Source: WPI Economics and Institute for Employment Studies, Green Jobs and Skills in London: Cross-London Report (2021)

The growth in homes and buildings, low carbon transport and power is highly pertinent within the context of interventions proposed as part of LAEPs. For example, homes and buildings includes the installation of heat networks, property retrofitting (fabric and technology replacement) and the construction of new energy efficient buildings.

The sub-regional LAEPs contain interventions which align with certain sector activities, thereby highlighting that importance of coordinated action from the LAEP to act as a driver for increasing green economy jobs.

It is important to note that some green jobs may not be net additional as some jobs may transition (e.g. gas boiler installers) as new technologies are adopted and the existing workforce retrains. An example being gas boiler installation and maintenance, which will in part be replaced with heat pump installation and maintenance.

2.4.2 Green Labour Supply

To gain an indication of how the future green jobs projected by WPI Economics and Institute of Employment Studies could be fulfilled, an analysis has been undertaken that looks at the resident supply of labour in each sub-regional Borough. This draws on Census 2021 population data and through conversion from 3-digit standard occupational classification 2020 (SOC 2020) [15] to 4-digit SOC 2010 level using ONS mapping [16]. This is then aggregated into O*NET green occupation groups using a crosswalk approach developed by the GLA [17]. It should be to note that results generated using this method represent upper-bound estimates as all jobs within an occupation are considered as 'green'. It is unlikely all jobs within each occupation will be green, considering that tasks and duties of people within the same occupation can differ (e.g., one software developer may use Python, whilst another specialises in using JavaScript), introducing the potential for some jobs within an occupation to not be green.

The definitions for the three O*NET green occupation groups are as follows:

- *"**Green Enhanced Skills:** the impact of green economy activities and technologies results in a significant change to the work and worker requirements of an existing O*NET-SOC occupation.*
- ***Green Increased Demand:** the impact of green economy activities and technologies results in an increase in employment demand but does not entail significant changes in the work and worker requirements of the occupation.*
- ***Green New and Emerging:** the impact of green economy activities and technologies is sufficient to create the need for unique work and worker requirements, which results in the generation of new occupations."* [18]

Taking account of these definitions, the green enhanced skills group can be considered to highlight roles where demand is likely to increase without a need to re-skill workers. Green increased demand group highlights roles where the requirements of the job may change significantly, resulting in a need to update the existing skillsets. Green new and emerging group highlights brand new roles created by the green economic transition.

According to the three O*NET definitions, Figure 2—4 shows the number and percentage of modelled residents in green occupation groups by borough within the sub-region in 2021. It shows the number of residents in each group as a total of all employed residents aged 16+ to highlight potential specialisation within the workforce of the boroughs.

[11] GLA Economics, (2022); Working Paper 99: Identifying Green Occupations in London
[12] WPI Economics and Institute for Employment Studies, (2021); Green Jobs and Skills in London: Cross-London Report
[13] ONS, (2024); Experimental Estimates of Green Jobs, UK: 2015 to 2022
[14] kMatrix Data Services Ltd (2024); London's Low Carbon Market Snapshot. https://www.london.gov.uk/media/105336/download
[15] ONS, (2021); Census
[16] ONS, (2022); SOC 2020 - SOC 2010 Relationship Tables 2021
[17] GLA, (2022); Identifying Green Occupations in London – US-to-UK Green Occupation Crosswalk
[18] https://www.onetcenter.org/dictionary/22.0/excel/green_occupations.html

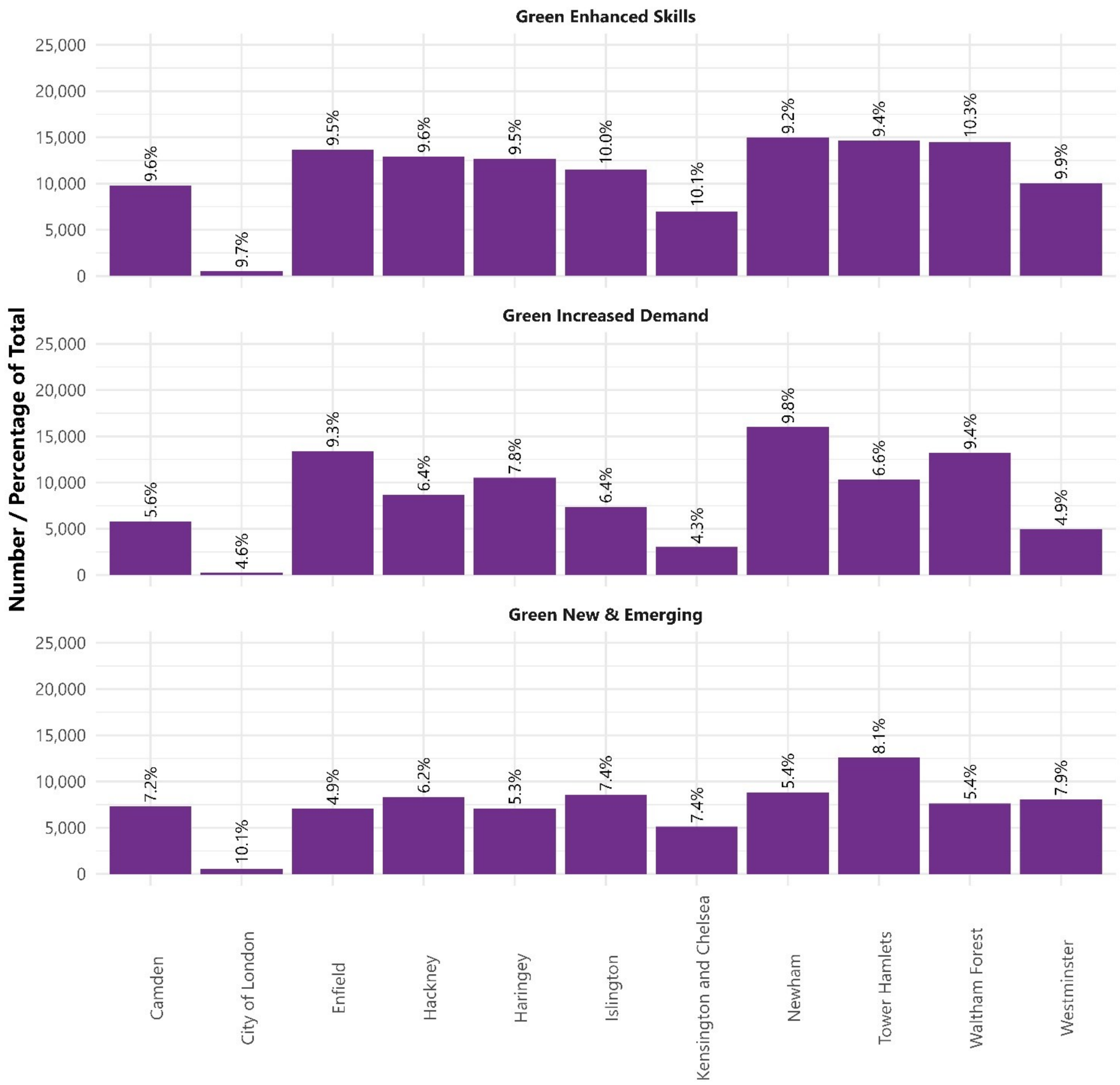

Figure 2—4 Residents Aged 16+ in Employment by Green Occupation Group (2021) (Source: ONS, GLA and Buro Happold analysis).

Figure 2—4 indicates that the local authorities in the sub-region have very similar proportions (%) of residents in occupations that may require re-skilling (green enhanced group). The proportions in the CIEN sub-region range from 9.7%-10.3%. In comparison, the concentration of the green increased demand group ranges more widely in the sub-region boroughs. The proportion of employed residents in this group ranges from 4.3% to 9.8%. Notably, the geographically central cluster of Kensington and Chelsea, Westminster and City of London all sit at the lower end of that range, whilst boroughs to the north and east such as Enfield, Waltham Forest and Newham focus on the higher-end of the range – indicating some level of geographical divergence in labour force characteristics.

The proportion of employed residents in the green new and emerging group varies in the CIEN sub-region. The sub-region ranges from 4.9%-10.1%. Local authorities closer to the CAZ are normally in the higher end of the range, suggesting a higher proportion of residents may be working in new roles created because of the green economic transition.

Overall, the capacity within the existing green resident workforce to move to potential jobs created by investments in new green schemes (like those created by green energy schemes) does not vary significantly across the boroughs. It should be noted that boroughs do not represent self-contained labour markets, with many residents normally commuting outside of the borough where they live to work, creating a geographically fluid labour supply. However, local training programmes and partnerships between educational institutions can help strengthen the supply of labour with the skills required available locally, supporting the transition to a green economy.

2.5 Subregional buildings stock

The building stock is the largest focus for decarbonisation in the LAEP analysis due to spend, demand and complexity of challenge. An overview of the count of domestic and non-domestic properties and associated energy demand and consumption is provided in Table 2-6. Total heat requirement is presented in column 'Head demand GWh', then broken down into electrical and gas consumption, including the heating system efficiencies. 'Other' categories refer to energy non-attributed to heating.

This subsection provides a summary of building energy relating to tenure, conservation areas and historic buildings, domestic versus non-domestic and council owned property.

Domestic properties dominate the subregion in terms of number of properties, although energy demand is higher for non-domestic overall aside gas consumption which is higher for domestic.

Table 2-6 Energy usage by building type, Source: GLA, London Building Stock Model v.2.

Borough	Typology	No of properties	Heat demand GWh	Electricity demand (heating) GWh	Gas consumption (Heating) GWh	Electricity demand (other) GWh	Gas consumption (other) GWh
Camden	Domestic	111,160	894	42	982	286	20
	Non-domestic	14,279	1,845	723	943	446	251
City of London	Domestic	7,386	36	15	14	13	0
	Non-domestic	3,750	1,227	704	567	918	72
Enfield	Domestic	124,413	1,255	75	1,360	359	28
	Non-domestic	8,635	673	253	454	248	36
Hackney	Domestic	117,418	831	41	909	282	19
	Non-domestic	11,313	499	253	260	263	48
Haringey	Domestic	109,049	1,008	32	1,125	299	23
	Non-domestic	8,695	531	264	300	143	30
Islington	Domestic	107,970	778	50	837	247	17
	Non-domestic	10,404	806	346	461	336	74
Kensington and Chelsea	Domestic	87,679	804	46	881	286	18
	Non-domestic	7,533	1,071	576	529	309	174
Newham	Domestic	118,848	954	49	1,026	303	21
	Non-domestic	7,216	1,388	604	827	341	90
Tower Hamlets	Domestic	138,412	904	118	907	302	19
	Non-domestic	16,320	992	494	519	1,512	85
Waltham Forest	Domestic	106,182	947	38	1,047	282	21
	Non-domestic	7,329	428	201	251	98	28
Westminster	Domestic	126,149	1,064	95	1,123	355	23
	Non-domestic	30,861	3,526	1,611	1,896	1,113	307

Total	**Domestic**	**1,154,666**	**9,475**	**601**	**10,211**	**3,014**	**209**
	Non-domestic	**126,335**	**12,986**	**6,029**	**7,007**	**5,727**	**1,195**

2.5.1 Building Tenure

One of the key items to consider in building stock is tenure. The public sector (including social housing) is generally easier to reach in terms of engagement and decarbonisation policy impact. In the context of heat networks, it is likely that a significant proportion of the public sector will be mandated for connection. Other sectors, such as private rented, have historically been hard to reach. Different tenures are shown at borough level in Figure 2—5 for domestic, and in Figure 2—6 for non-domestic, respectively.

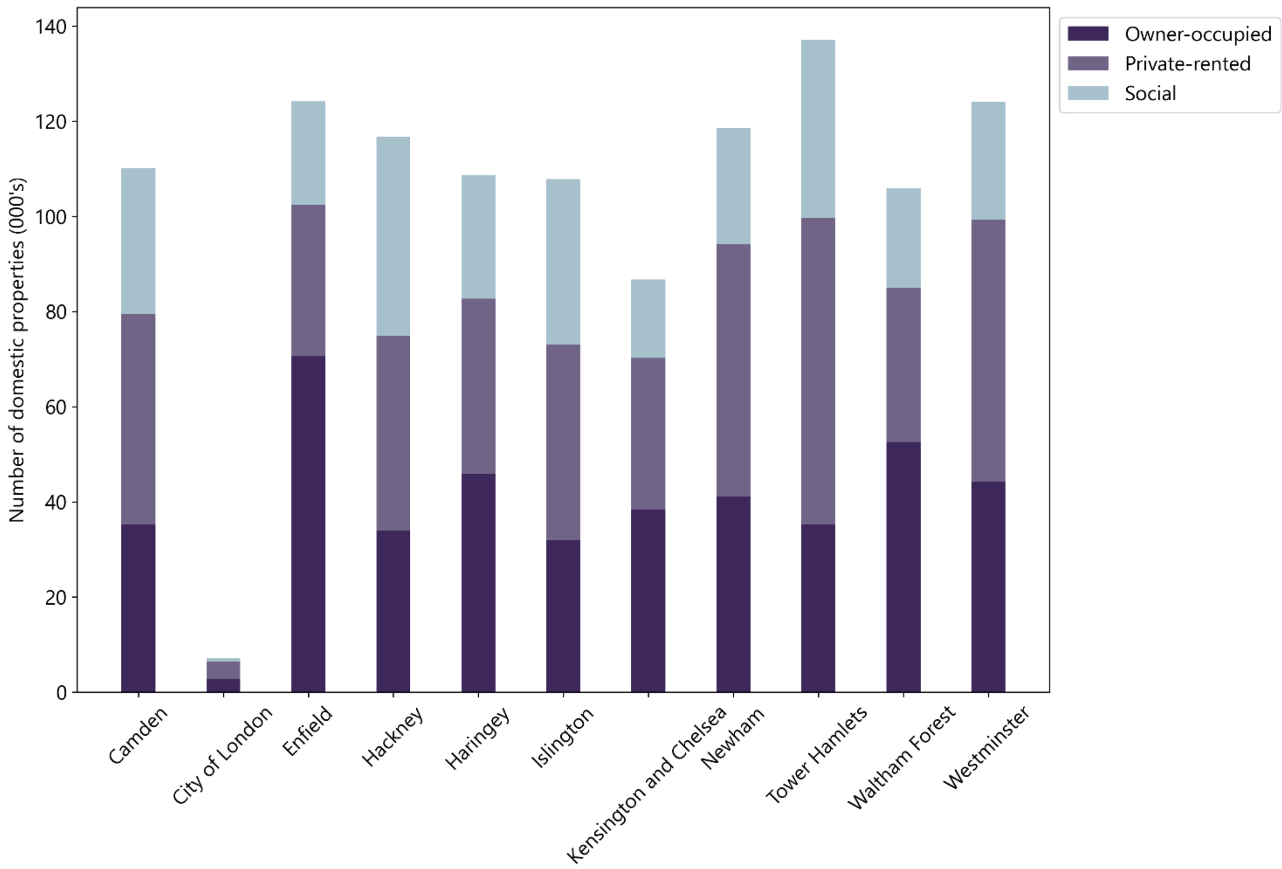

Figure 2—5 Number of properties of different tenure (domestic), Source: GLA, London Building Stock Model v.2.

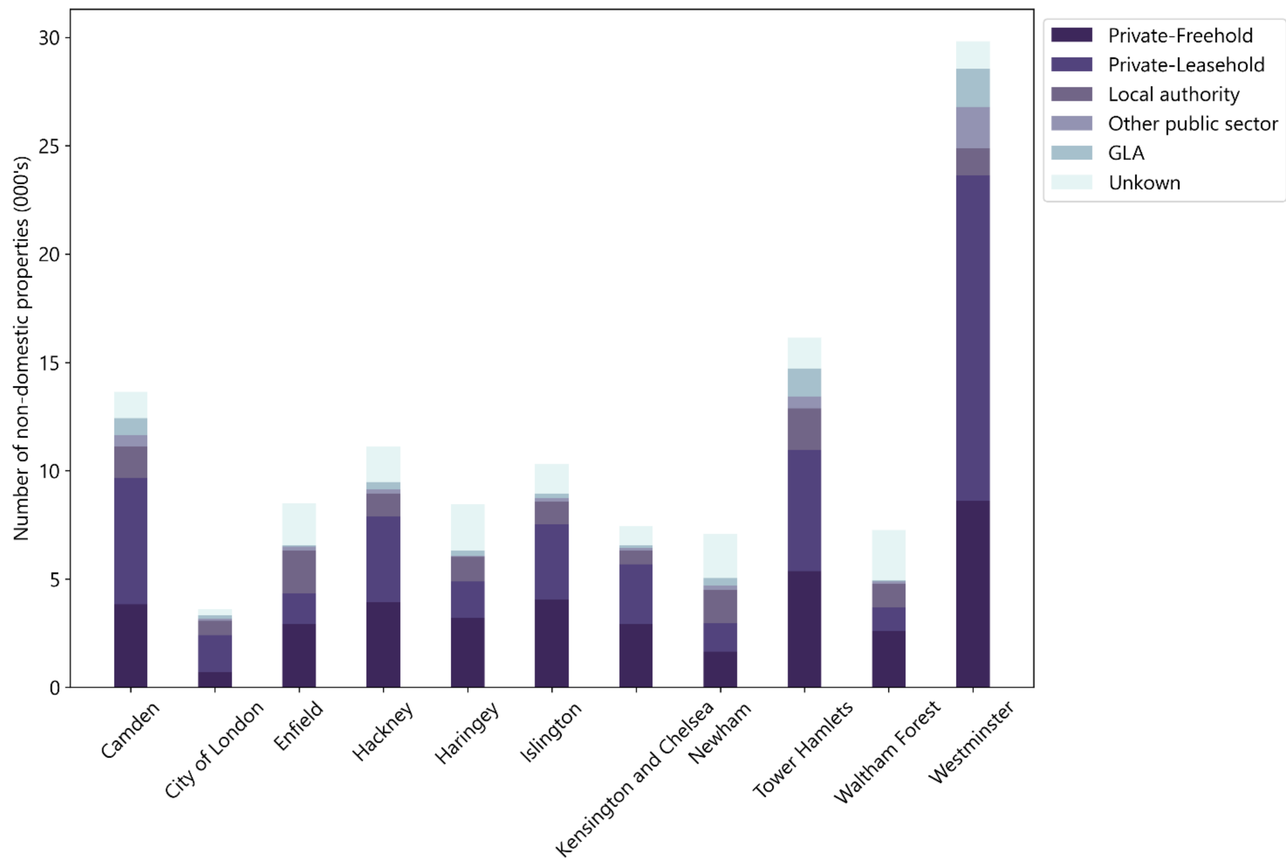

Figure 2—6 Number of properties of different ownership by borough (non-domestic), Source: building dataservices UCL, OS,HM Land Registry.

In terms of number of properties for domestic and non-domestic, owner occupied and private freehold respectively dominate the tenure overall for the region. Private rented and leasehold are also significant in terms of numbers of property. Social domestic housing is also significant across all boroughs apart from City of London which has very low levels of housing generally. This underlines the difficulty of effective engagement and policy development across the sub-region.

Westminster has a proportional low share of public sector stock, thus limiting the direct influence of the borough and to develop high impact heat network and decarbonisation projects directly. Other boroughs, such as Enfield and Newham have a higher share of public sector stock. This is particularly significant in these boroughs, as they have some of the highest levels of fuel poverty and deprivation. The influence of the public sector could help heat network adoption, where having a large number of high heat demands connect is key to driver for economic and commercial viability.

2.5.2 Conservation areas and historic buildings

Whilst historic buildings, and buildings within conservation areas, are often perceived as challenging and can incur some additional costs and considerations there are still decarbonisation pathways that are both practically and economically feasible[19]. The number of these buildings varies across the boroughs of the subregion, a summary is provided in Table 2-7.

Camden (20,137), Westminster (25,612) and Kensington and Chelsea (21,890) have a high number of listed buildings, whilst City of London (1,203), Newham (1,440) and Waltham Forest (1,783) have a lower value.

[19] Historic England often publish guidance document on this subject, the most recent being https://historicengland.org.uk/images-books/publications/adapting-historic-buildings-energy-carbon-efficiency-advice-note-18/heag321-adapting-historic-buildings-energy-carbon-efficiency/

Some of the challenges related to historic buildings including protection of aesthetic and visual aspects including windows, walls and internal services. These can often be challenging or expensive to replace with more thermally efficient alternatives and is a key area of consideration in the retrofit analysis.

Buildings within conservation areas, whilst having less planning retrofit restrictions than listed buildings, also will often require more bespoke and considered approaches. High numbers of buildings in conservation areas are found adjacent to the Thames to the west of the subregion.

Table 2-7 Summary of historic buildings by borough.

Borough	Number of buildings in conservation area	Number of listed buildings
Camden	20,137	539
City of London	1,203	63[20]
Enfield	3,691	34
Hackney	10,562	172
Haringey	16,237	79
Islington	15,871	398
Kensington and Chelsea	21,890	331
Newham	1,440	20
Tower Hamlets	10,330	240
Waltham Forest	1,783	21
Westminster	25,612	1,312
Total	**128,756**	**3,209**

An indication of the concentration of listed buildings is shown in Figure 2—7 whilst conservation areas across the subregion are shown in Figure 2—8.

The boroughs closest to the river have the highest proportion of historic buildings and conservation areas but there are clusters across all the boroughs. Generally, the more stringent (from a planning perspective listed buildings are concentrated in conservation areas.

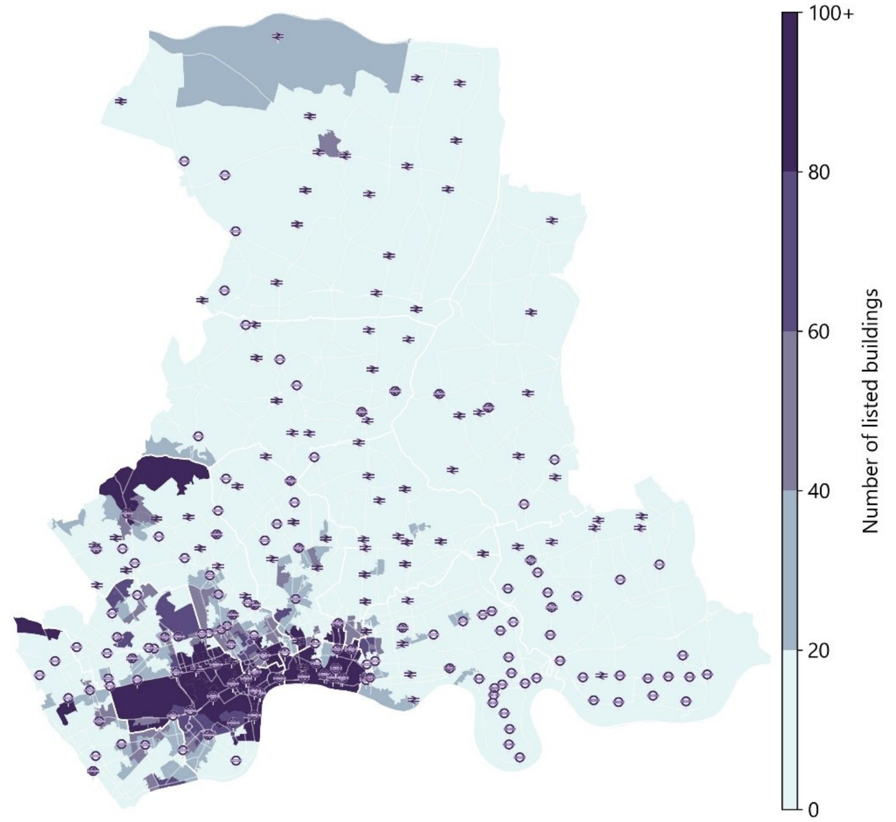

Figure 2—7 Number of listed buildings in subregion by LSOA (2024), Source: Historic England, Mar 24.

[20] It should be noted that there is a potential issue with London Building Stock Model here, with the Historic England dataset flagging 600.

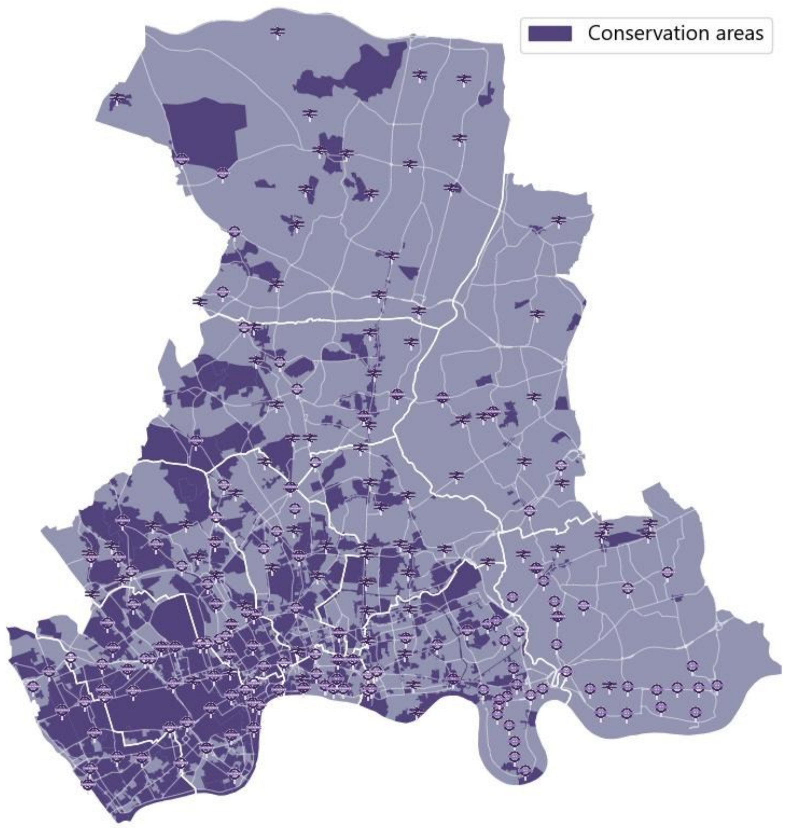

Figure 2—8 Conservation areas in subregion (2024), Source: Historic England, Mar 24.

2.5.3 Domestic

Within the CIEN London subregion there are nearly 1.15 million domestic properties.

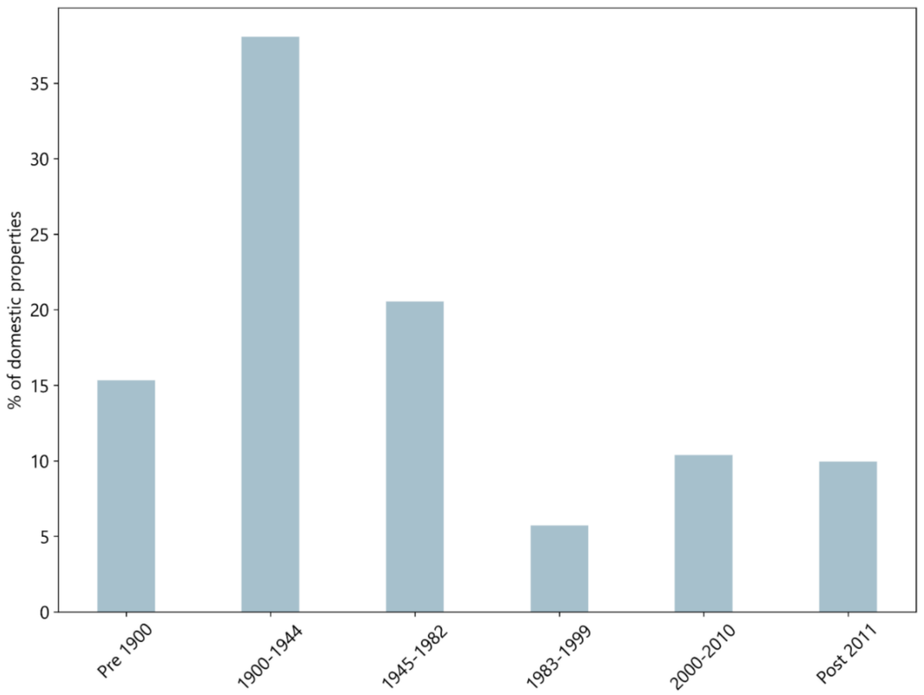

Figure 2—9 Age distribution among domestic properties in the CIEN London subregion, Source: GLA, London Building Stock Model v.2.

The housing stock in the CIEN subregion is relatively old, with over half of the properties built pre-1944. Pre 1900 properties will almost exclusively be of a solid wall construction whilst 1900-1944 are a mixture of solid wall and cavity. Beyond 1944 cavity walls became a common construction approach for buildings. This construction type as well as the level of insulation in the wall is a key item to consider for retrofit analysis. Increasingly, if a wall is challenging to insulate suitable low carbon technologies will become available to overcome the high cost and practical constraints where other interventions are more feasible For example, a modern heat pump with large radiators can often overcome the need for intrusive and expensive internal or external wall insulation.

The distribution of different property ages at LSOA is displayed in Figure 2—10. This shows that the oldest bands are the most frequent. Pockets of newer developments are also seen in every borough. North Enfield shows high concentration of post war housing and development potentially indicating the expansion of London during this period.

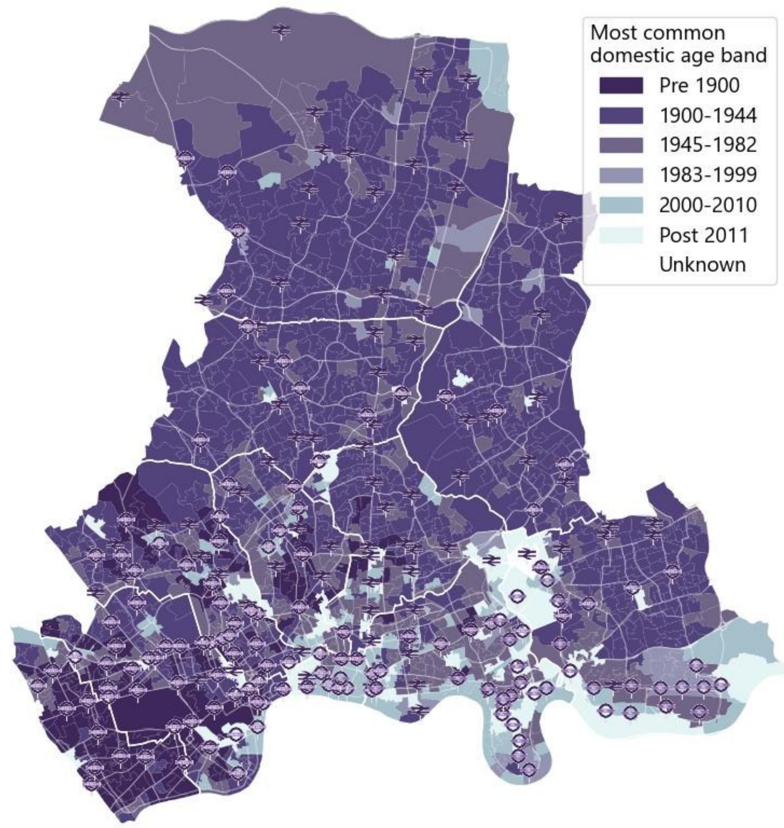

Figure 2—10 Most common age band by LSOA in the subregion, Source: GLA, London Building Stock Model v.2.

Figure 2—11 shows the distribution of domestic stock type in the subregion. Across the 11 boroughs, flats are the most dominant property type, accounting for around three-quarters of the building stock. The least dominant property type is detached houses, making up less than 5% of the building stock.

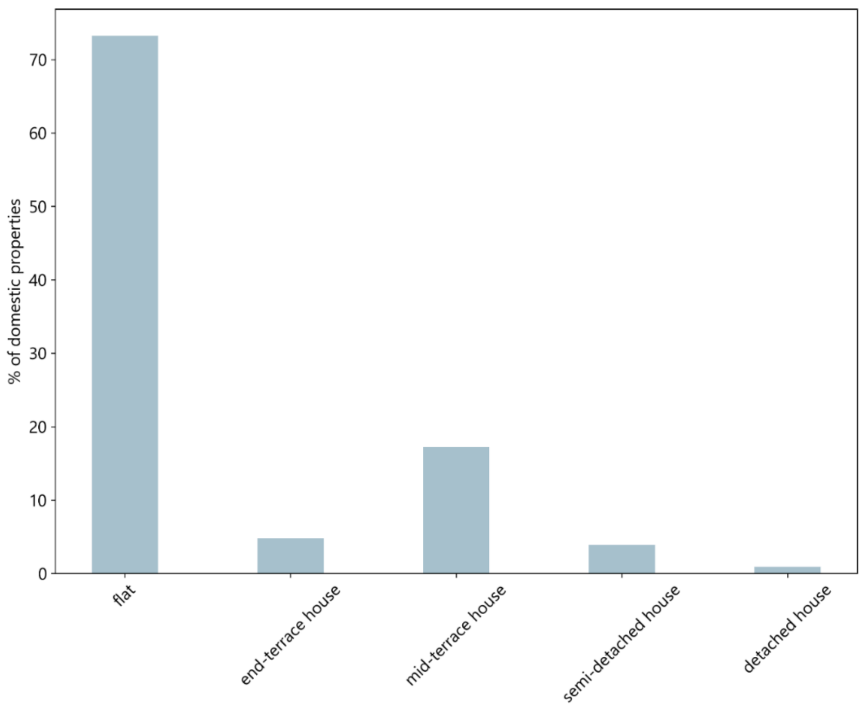

Figure 2—11 Proportion of domestic property type distribution in the CIEN London subregion, Source: GLA, London Building Stock Model v.2.

A more detailed breakdown by borough is provided in Table 2-8 and Figure 2—12.

The dominance of flats is greatest in the more central boroughs with terraced properties also being common in these areas. Detached and semi-detached houses are more frequent in outer boroughs which correlate with a lower density of building and housing generally. An example of this is Enfield which has only ~40% flats compared to Camden which is over 88% flats.

Table 2-8 Property type by borough.

Borough	Type	No. of properties	Percentage (%)
Camden	Detached/semi-detached	2,846	2.6
	Terraced	9,587	8.6
	Flat	98,726	88.8
City of London	Detached/semi-detached	23	0.3
	Terraced	62	0.8
	Flat	7,301	98.8
Enfield	Detached/semi-detached	26,491	21.3
	Terraced	47,273	38.0
	Flat	50,648	40.7
Hackney	Detached/semi-detached	1,409	1.2
	Terraced	17,875	15.2
	Flat	98,114	83.6
Haringey	Detached/semi-detached	6,146	5.6
	Terraced	34,413	31.6
	Flat	68,487	62.8
Islington	Detached/semi-detached	1,178	1.1
	Terraced	14,440	13.4
	Flat	92,343	85.5
Kensington and Chelsea	Detached/semi-detached	1,216	1.4
	Terraced	11,562	13.2
	Flat	74,899	85.4
Newham	Detached/semi-detached	3,265	2.7
	Terraced	50,587	42.6
	Flat	64,996	54.7
Tower Hamlets	Detached/semi-detached	937	0.7
	Terraced	13,337	9.6
	Flat	124,138	89.7
Waltham Forest	Detached/semi-detached	10,800	10.2
	Terraced	45,081	42.5
	Flat	50,291	47.4
Westminster	Detached/semi-detached	1,118	0.9
	Terraced	9,534	7.6
	Flat	115,491	91.6
Total	**Detached/semi-detached**	**55,429**	**4.80**
	Terraced	**253,751**	**21.98**
	Flat	**845,434**	**73.22**

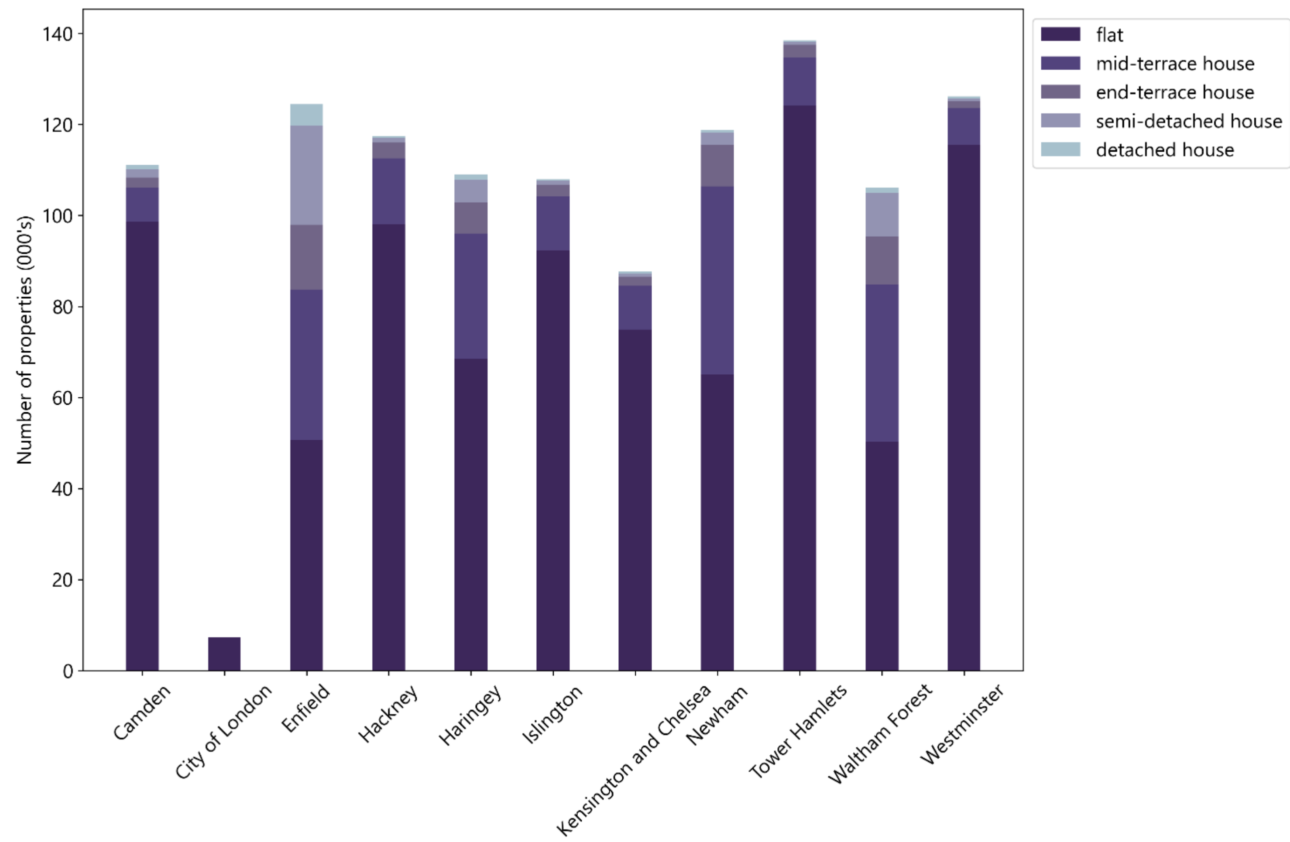

Figure 2—12 No. of domestic housing typology for each borough, Source: GLA, London Building Stock Model v.2.

In relation to decarbonisation pathways, semi-detached or detached domestic properties are more suited to heat pump installation due to spatial requirements. Heat pumps are also viable for flats, however, for large blocks of flats a centralised communal heat pump or connection to a wider heat network is preferred. This is particularly the case for listed buildings or conservation areas, where mounting a heat pump per property for flats can be challenging given planning and spatial restrictions.

Alongside property type the energy efficiency of properties is one of the main characters to understand how suitable a property is for low carbon technology. Energy Performance Certificates (EPCs) give an overall indication of energy efficiency and used extensively in the LAEP analysis.

The most common domestic EPC scores across the subregion are shown in Figure 2—13, whilst the overall proportional spread across the subregion is shown in Figure 2—14.

Generally, higher EPC scores are associated with newer property and concentrations of A-B are shown in pockets of new building development. The most common EPC ratings overall are D (over 30%) and C (over 40%). Higher efficiency buildings represent approximately 10% of the overall domestic building stock.

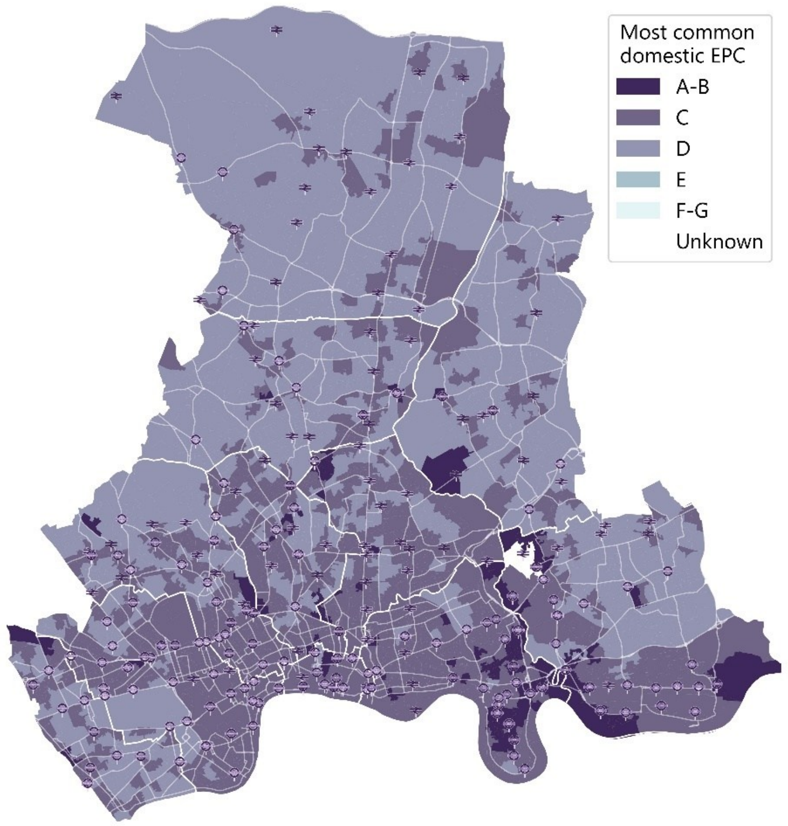

Figure 2—13 Most common domestic Energy Performance Certificate rating by LSOA in the subregion, Source: GLA, London Building Stock Model v.2.

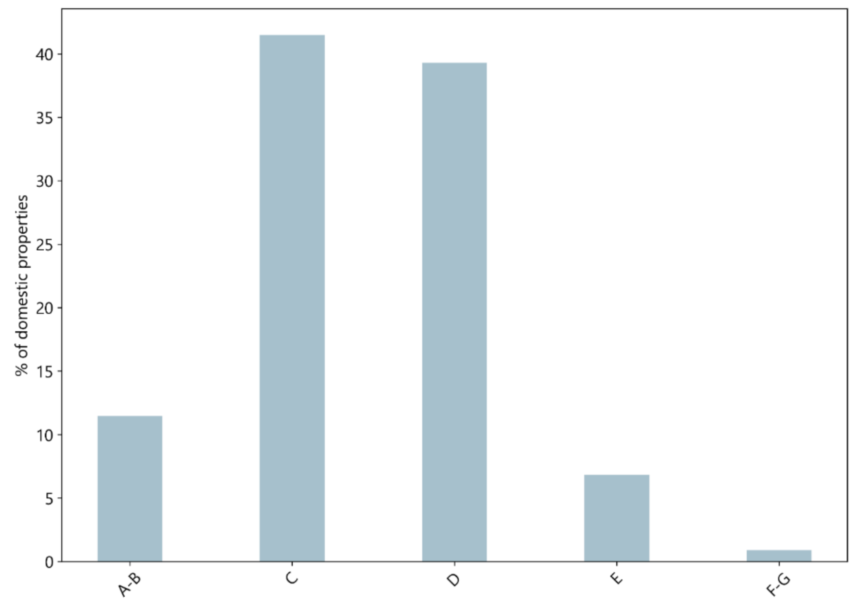

Figure 2—14 Distribution of Energy Efficiency Performance ratings in domestic properties across the CIEN London Subregion, Source: GLA, London Building Stock Model v.2.

The most efficient properties, EPCs A and B and generally C, are likely to have good fabric performance efficiency and thus be well suited to low carbon heating technologies. EPC D will often need only minor fabric improvements to make them suitable whilst E-G properties represent a greater need for fabric improvement.

It is important to note that domestic EPCs include consideration of occupier bills. This means direct electric systems often score poorly in terms of EPC rating, as the price difference between gas and electricity makes these systems very expensive to run. From a carbon perspective these direct electric systems are already net zero ready (grid decarbonisation will naturally reduce their carbon footprint). However, from a fuel poverty perspective it can be important to consider low operational cost approaches. This is done within the decarbonisation pathways explored in this piece of work, with the main constraint related to switching being property size and type.

The geographic distribution of EPC grades is provided in Figure 2—15. This focuses on EPC grades of D and below, as these are the properties that will need the greatest interventions to decarbonise. Conversely areas with a low share of these properties indicates areas where properties are ready for low carbon heating systems with little need for building fabric improvement. This figure shows higher concentrations of low EPC scores to the north of the region which correlates with older domestic property.

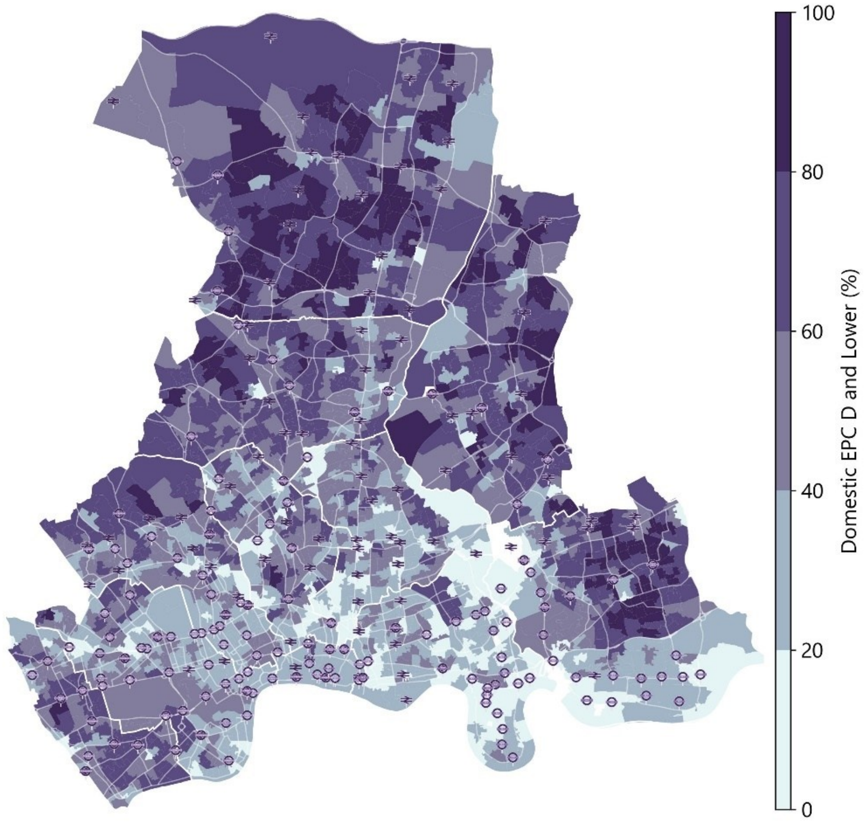

Figure 2—15 Domestic EPC rating D and below by LSOA in the subregion, Source: GLA, London Building Stock Model v.2.

The last element of the domestic stock that is characterised in this sub-section is the current heating system of the properties. An inherent main focus of the LAEP is to identify low carbon solutions, thereby focusing on properties which use gas, or other fossil fuels, rather than electricity.

A summary of the different heat demands and fuel consumption for different heating technologies at borough level is provided in Table 2-9. This highlights the dominance of individual domestic gas boilers. It should be noted electric boilers and communal systems do exist but have a very small proportion.

There is an obvious direct correlation with the number of communal systems and flats for each borough. Equally, there are correlations with the building age and type with the heating system due to building design trends and regulations at the time of building. Some areas of London have seen the development of heat networks progress at a greater speed due to new development, commercial viability and strong stakeholder engagement.

Table 2-9 Summary of different heating system types for domestic properties across the subregion.

Borough	Heating system type	No. of properties	Heat demand GWh	Gas consumption GWh	Electricity (heat) consumption GWh
Camden	Boiler	77,188	700	813	6
	communal	20,474	127	155	2
	heat pump	400	4	-	1
	heat network	6,014	31	32	2
	Room/storage heaters	6,408	29	1	28
	No heating system	204	-	-	-
	Other	472	3	2	2
City of London	Boiler	2,137	14	14	2
	communal	201	1	1	-
	heat pump	63	-	-	-
	heat network	3,295	14	-	6
	Room/storage heaters	1,458	6	-	6
	No heating system	32	-	-	-
	Other	200	1	-	1
Enfield	Boiler	106,139	1,159	1,361	2
	communal	3,062	14	14	2
	heat pump	186	2	-	1
	heat network	790	5	6	-
	Room/storage heaters	13,525	72	4	68
	No heating system	347	-	-	-
	Other	364	3	2	1
Hackney	Boiler	92,190	709	830	3
	communal	14,449	77	91	2
	heat pump	460	4	-	1
	heat network	1,387	6	6	1
	Room/storage heaters	8,405	34	1	33
	No heating system	265	-	-	-
	Other	262	1	1	1
Haringey	Boiler	94,235	928	1,089	2
	communal	8,036	46	55	1
	heat pump	317	3	-	1
	heat network	-	-	-	-
	Room/storage heaters	6,122	30	3	27
	No heating system	258	-	-	-
	Other	81	1	1	0
Islington	Boiler	84,243	663	773	6
	communal	11,120	62	75	3
	heat pump	465	3	-	1
	heat network	3,810	13	5	3
	Room/storage heaters	7,561	34	1	33
	No heating system	176	-	-	-
	Other	595	3	-	3
Kensington and Chelsea	Boiler	64,815	652	759	7
	communal	15,769	114	137	3
	heat pump	179	2	-	1
	heat network	-	-	-	-
	Room/storage heaters	5,622	27	1	26
	No heating system	245	-	-	-
	Other	1,049	8	2	9
Newham	Boiler	93,756	829	971	3
	communal	9,474	59	63	1

Borough	Heating system type	No. of properties	Heat demand GWh	Gas consumption GWh	Electricity (heat) consumption GWh
	heat pump	123	1	-	-
	heat network	6,202	22	9	6
	Room/storage heaters	8,742	41	2	39
	No heating system	205	-	-	-
	Other	346	1	1	1
Tower Hamlets	Boiler	75,370	566	653	10
	communal	30,366	179	203	7
	heat pump	552	4	-	1
	heat network	8,926	57	69	-
	Room/storage heaters	20,974	90	1	89
	No heating system	175	0	-	-
	Other	2,049	8	1	10
Waltham Forest	Boiler	92,427	874	1,027	1
	communal	4,618	23	26	1
	heat pump	255	2	-	1
	heat network	1,620	10	12	-
	Room/storage heaters	6,497	36	4	32
	No heating system	269	-	-	-
	Other	496	3	-	4
Westminster	Boiler	79,183	744	850	17
	communal	25,709	199	239	5
	heat pump	703	8	-	3
	heat network	6,472	44	51	1
	Room/storage heaters	10,886	52	1	51
	No heating system	403	-	-	-
	Other	2,793	18	4	18
Total	**Boiler**	**861,683**	**7,838**	**9,140**	**59**
	communal	**143,278**	**901**	**1,059**	**27**
	heat pump	**3,703**	**33**	**-**	**11**
	heat network	**38,516**	**202**	**190**	**19**
	Room/storage heaters	**96,200**	**451**	**19**	**432**
	No heating system	**2,579**	**-**	**-**	**-**
	Other	**8,707**	**50**	**14**	**50**

2.5.4 Non-domestic

The non-domestic data available is less detailed and complete than the domestic sector for the CIEN region, so the same depth of baseline cannot be provided. However, broad characteristics such as energy demand and typology are available whilst other characteristics can only be explored in properties that have an EPC or DEC[21]. Graphs rather than maps are used to characterise the non-domestic stock, as many of the LSOAs have no or very few non-domestic data available.

Age is one of the characteristics that is available for all non-domestic properties across the subregion. This is provided in Figure 2—16.

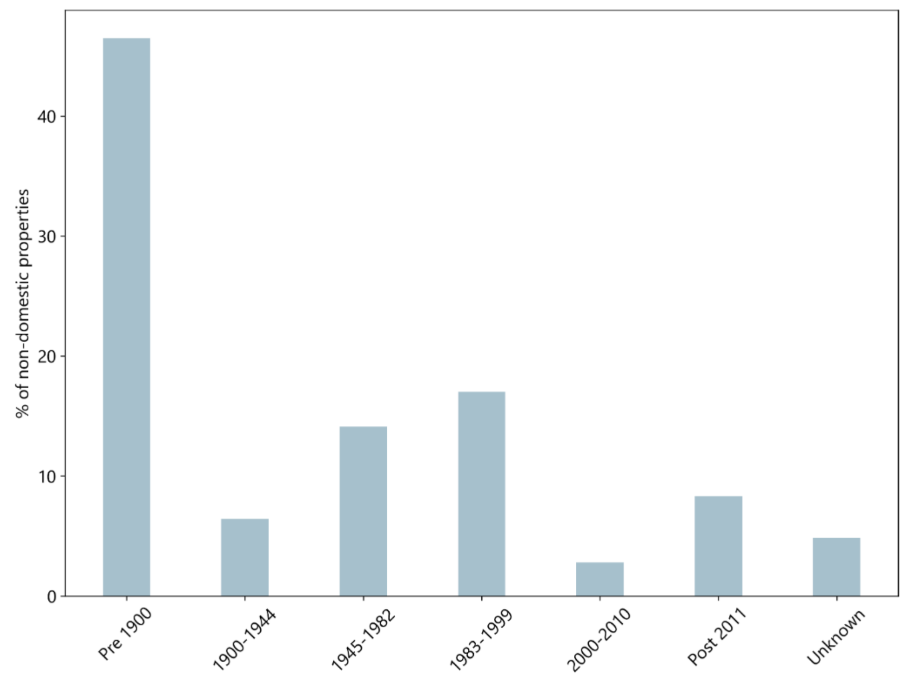

Figure 2—16 Age distribution among non-domestic properties across the CIEN London subregion, Source: building dataservices UCL, OS.

The non-domestic building stock in this region is relatively old, with over 40% of properties built pre-1900. This is a larger share of the oldest age band than the domestic sector. This relates to the age banding being greater, but the more common trend for particularly historic non-domestic buildings to be maintained and protected from demolishment or major redevelopment.

Figure 2—17 shows the distribution of non-domestic typologies across the CIEN London subregion. Retail is the most prominent typology accounting for nearly 40% of the building stock, with offices also prevalent (~35%). Other typologies are less prevalent but in some instances more likely to be much larger properties with high heat demands and reliance on fossil fuel heating systems.

[21] Display Energy Certificate – which is an advanced version of an EPC for public sector buildings. It still includes the A-G rating system.

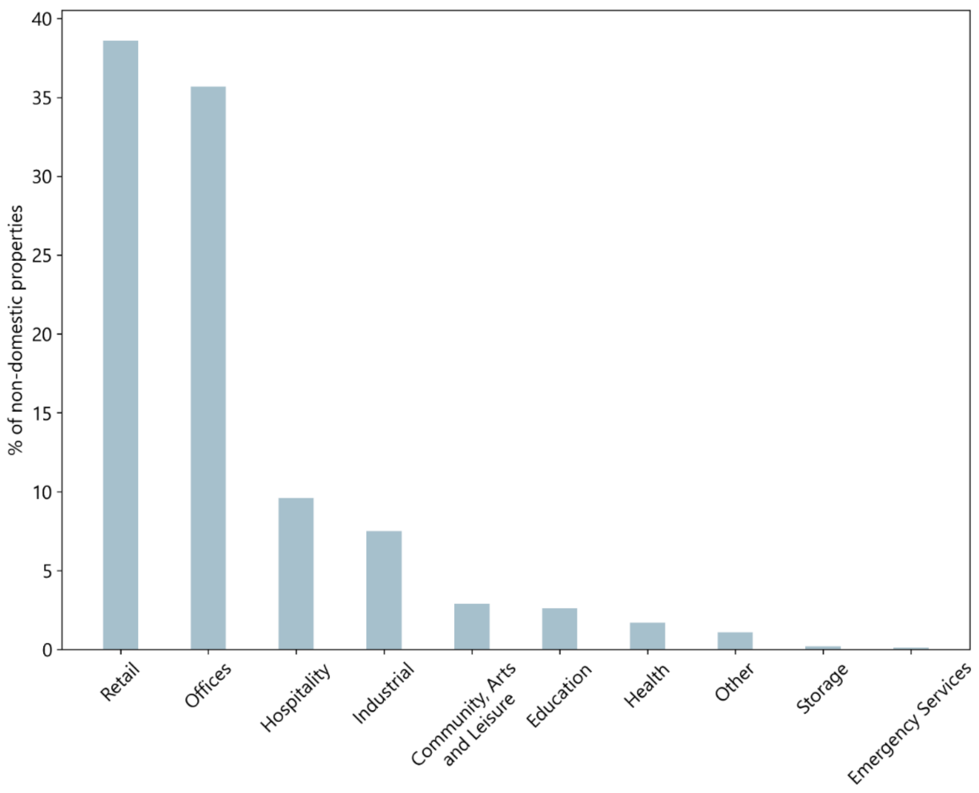

Figure 2—17 Distribution of non-domestic typologies across the CEIN London subregion, Source: building dataservices UCL, OS.

The energy demand for the different non-domestic typologies is summarised in Figure 2—18. This shows the energy demand dominance of some larger non-domestic buildings such as offices, hospitality and retail which characterise the commercial activity in many boroughs.

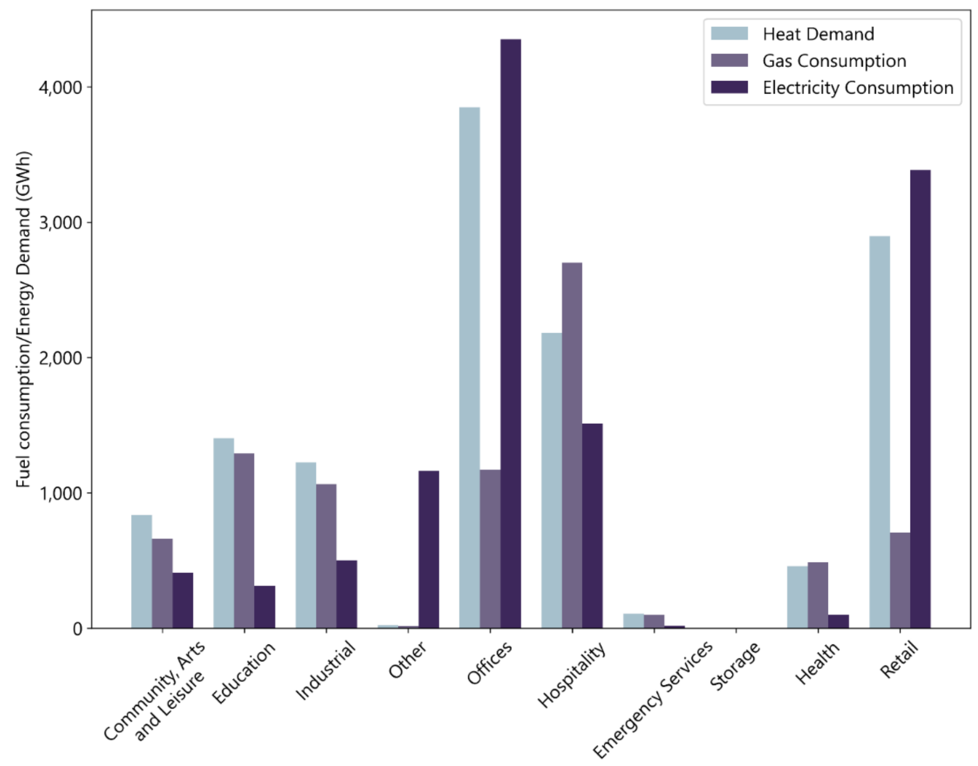

Figure 2—18 Summary of energy consumption by non-domestic typologyacross the CIEN London subregion, Source: building dataservices UCL, OS.

Gas has a large share of energy consumption across all typologies. This is not always used for space or hot water, in the hospitality sector in particular a larger share of gas consumption can come from cooking. This is not suited to heat pump decarbonisation and whilst in the domestic sector electric ovens are an easy alternative there can be challenges with this for some applications in commercial kitchens. Electricity use is higher in the non-domestic sector generally due to concentration of small power, higher lighting, occupancy and electric cooling, and in some instances heating too.

The industry in the CIEN sub-region is generally light and thus relatively easy to decarbonise. In more industrialised areas heavy industry can often be a draw for hydrogen in decarbonisation analysis.

Figure 2—19 shows the available Energy Efficiency Performance (EPC) ratings among the non-domestic building stock in the CIEN London subregion.

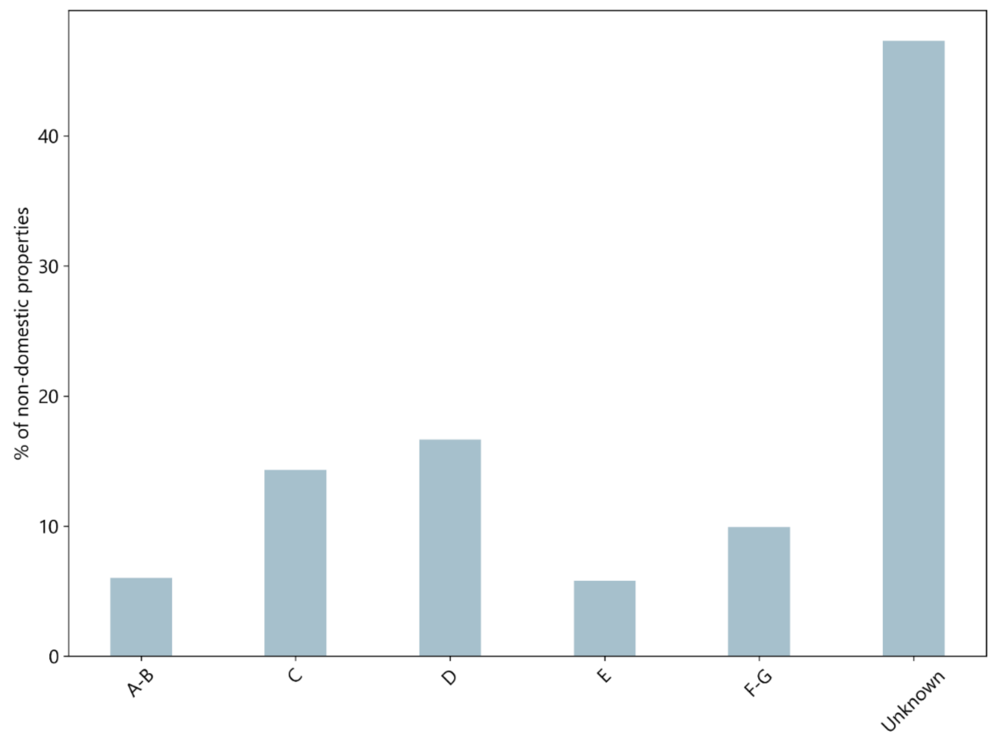

Figure 2—19 Distribution of energy efficiency performance ratings in non-domestic properties across the CIEN London subregion, Source: building dataservices UCL, OS.

The most dominant EPC rating is D, with over 15% of properties falling within that category. However, over 40% of the non-domestic properties in the CIEN subregion do not have a valid EPC score. This limits the depth of conclusion that can be drawn from EPC certificates. As such they are not relied upon heavily to inform decarbonisation pathways. The exception to this is public sector buildings that have a greater requirement for providing DECs and EPCs and thus have a consistent level of information to rely upon.

2.5.5 Summary of council stock around the subregion

The public sector can have a greater influence on early decarbonisation due to the ease of stakeholder engagement and coordination. The borough's own stock is examined in Table 2-10.

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Table 2-10 Council owned stock.

Borough	Typology	No of properties	EPC % A-C	EPC % D	Elec. demand (Heating) GWh	Gas demand (Heating) GWh	Elec. demand (Other) GWh
Camden	Domestic	19,971	58.4	36.4	1	156	39
	Non-domestic	1,469	16.1	17.9	86	163	35
City of London	Domestic	581	43.0	50.6	0	3	1
	Non-domestic	683	15.8	17.0	162	115	184
Enfield	Domestic	8,944	64.9	27.1	10	53	18
	Non-domestic	2,029	9.7	14.3	22	67	37
Hackney	Domestic	21,230	72.4	22.4	2	154	44
	Non-domestic	1,124	15.6	14.6	33	94	43
Haringey	Domestic	14,404	64.6	30.4	1	119	32
	Non-domestic	1,131	11.8	19.7	22	73	28
Islington	Domestic	21,269	65.5	30.4	3	151	42
	Non-domestic	1,059	17.4	9.7	46	83	25
Kensington and Chelsea	Domestic	6,412	71.0	25.6	1	45	12
	Non-domestic	629	14.9	13.5	125	82	19
Newham	Domestic	12,452	67.8	29.6	2	101	27
	Non-domestic	1,536	20.6	20.9	116	117	81
Tower Hamlets	Domestic	13,731	68.3	27.6	2	109	27
	Non-domestic	1,925	19.5	15.3	49	111	58
Waltham Forest	Domestic	9,365	70.2	26.5	4	73	20
	Non-domestic	1,109	10.1	18.1	24	75	22
Westminster	Domestic	12,466	75.3	21.2	4	86	23
	Non-domestic	1,269	37.9	26.3	67	186	39
Total	**Domestic**	**140,825**	**67.2**	**28.3**	**30**	**1,050**	**287**
	Non-domestic	**13,963**	**17.3**	**17.2**	**751**	**1,165**	**570**

The borough owned stock performs substantially better than the general subregional stock. This shows that boroughs are generally progressing further towards their own targets. These are frequently more challenging than the timeframes presented for whole borough decarbonisation.

2.6 Transport systems and energy usage

From a transport perspective London is one of the best suited areas for decarbonisation, with a very strong public transport network and short journeys that are well suited to active travel. However, not all areas of the subregion have the same character.

The broad characteristics across are explored in Figure 2—20, this is done by assigning one of five different typologies at an LSOA level. These typologies are:

- Connectivity Realisation Areas: low car ownership - high public transport uptake.
- Modal Choice Areas: high car ownership - high public transport uptake.
- Modal Shift Areas: high car ownership - low public transport uptake. These are the main target areas for transport decarbonisation in the subregion, often through a focus on electric vehicle uptake but increased public transport access should also be considered.
- Connectivity Opportunity: Areas with low car ownership and low public transport uptake. In central London this is often characterised by a very large uptake of active travel.
- Transport Poverty: These are areas with low car ownership and low public transport usage. These can be linked with broader deprivation but this relationship is somewhat complex in central boroughs due to the high level of active travel.

PTAL[22] 1a & 1b areas are also examined in Figure 2—20; these are the lowest rankings in public transport access and connectivity (overlaid on areas with low public transport uptake).

[22] Public Transport Accessibility Level – these are defined by TfL.

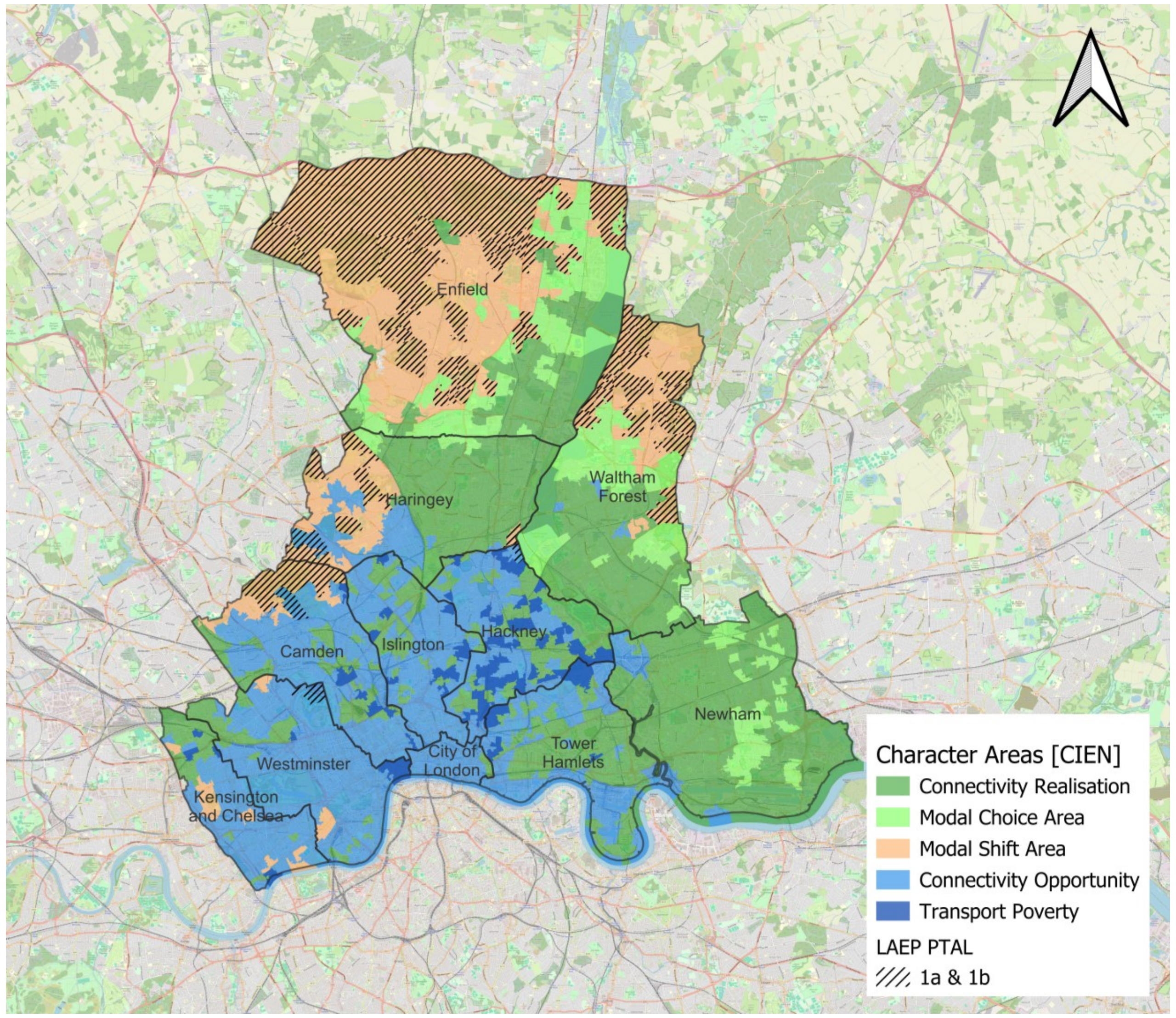

Figure 2—20 Indication of dominant transport character across the CIEN London subregion, Source: TfL (2024) [23], Buro Happold Analysis.

The modelling approach used to characterise the subregion had to be adapted from a national modelling approach. This is due to the unique character and high level of access to public transport in London.

The analysis shows that for residents the focus for electrification of cars will be in the outer boroughs, aligning to low PTAL scores. Higher levels of transport poverty are seen in Hackney in particular, reflecting low car ownership and lack of London Underground connectivity, but this may partly be due to underestimating the impact of active travel, something which has been a focus of borough policy.

Trains and trams are not considered in the transport analysis beyond access to them as a means for enabling model shift. This is because they are already electrified and require a larger regional and national funding approach for any significant change. However, large transport hubs such as bus and coach depots, large emergency service sites as well as areas with a large number of HGVs are significant to the subregional decarbonisation strategy. These services need to be decarbonised either through electrification or hydrogen. The distribution of these largest transport hubs is provided in Figure 2—21.

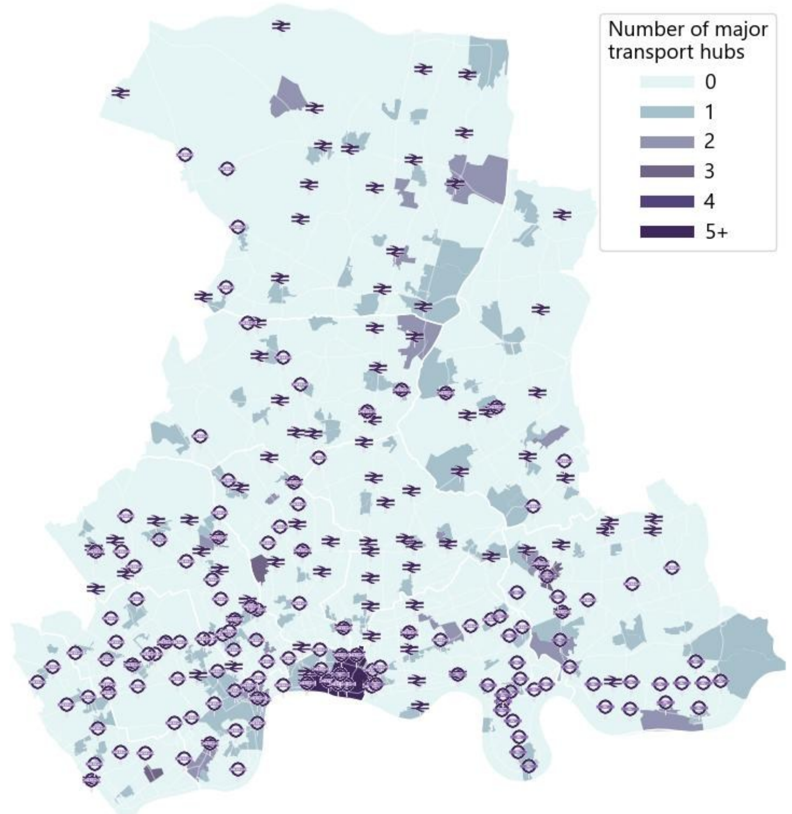

Figure 2—21 Count of major transport hubs by LSOA

There are a high number of transport hubs identified across the subregion, according to the following:

- police stations
- ambulance depots
- hospital sites
- fire stations
- bus/coach depots
- major industrial estates
- TfL fleet sites

Alongside these transport hubs large car parks are another focus for centralised charging of electric vehicles. The location of these is provided in Figure 2—22.

[23] Public Transport Accessibility Tool (PTAL)

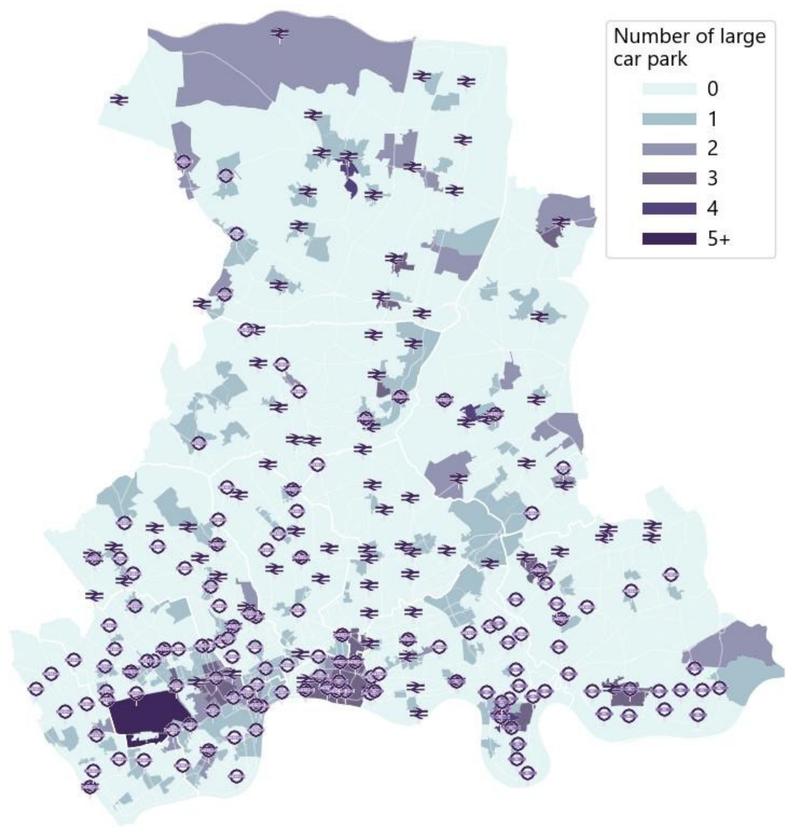

Figure 2—22 Counts of large car parks by LSOA, Source: Department for Transport (2016), Google Maps (2024).

Many of these car parks already have some EV charging infrastructure installed. This alongside on street chargers make up the publicly available EV chargers. In areas with limited off-street parking these public chargers are key for enabling EV deployment for residents. For visitors and enabling wider national decarbonisation these public EV chargers are also significant. The number of these public chargers by LSOA is provided in Figure 2—23.

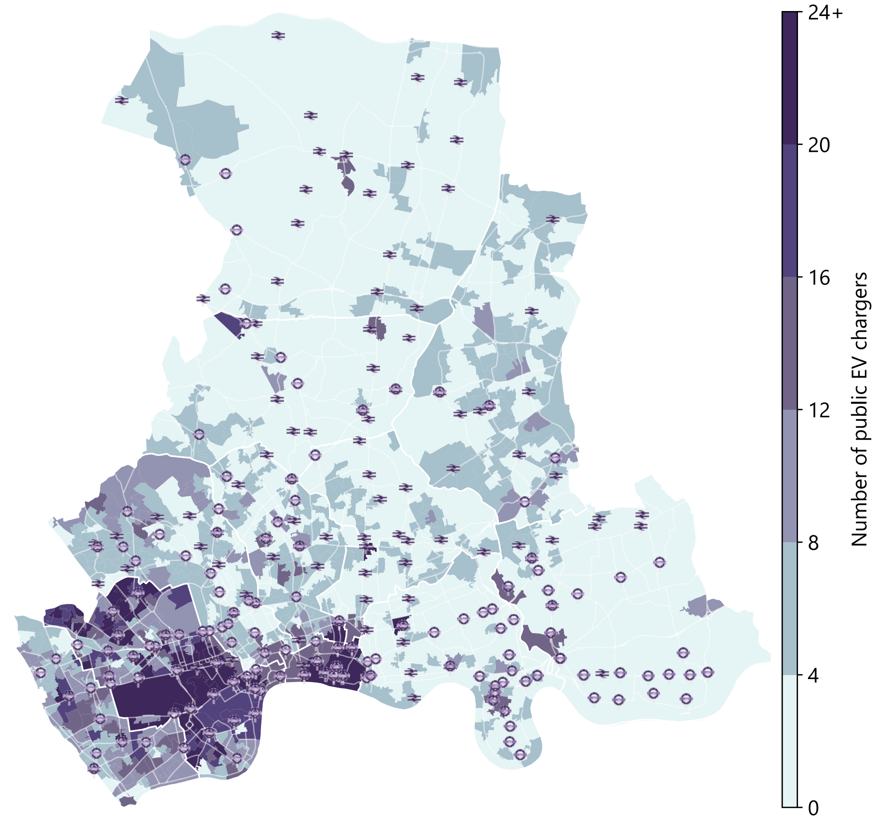

Figure 2—23 Number of publicly available EV chargers per LSOA Source: National chargepoint registry (May 24).

From borough engagement it was found that the transport departments were generally progressing well with public available EV chargers. It was flagged that the commercial sector is also progressing well developing public EV charge points, particularly along major transport routes.

The proportion of different types of vehicles is important to understand, as these present different requirements for decarbonisation. The makeup of the transport types does not vary significantly across the boroughs, this is shown in Figure 2—24 with cars dominating the region, with relatively small numbers of motorcycles, light good vehicles and buses and coaches. The proportional breakdown is similar for total miles travelled as shown in Figure 2—25, although the prevalence of heavy goods vehicles is now more evident. This is in part due to the relatively low number of HGVs but also potentially due to registration of ownership which may be outside the boroughs.

Just to underline the impact of non-EV vehicles on the total carbon emissions, Figure 2—26 indicates the very low current emissions associated with EVs. As the grid is decarbonising, carbon emissions will reduce accordingly with the proposed significant shift to EVs.

In summary, as cars dominate across the region this will represent the most significant focus area for decarbonisation.

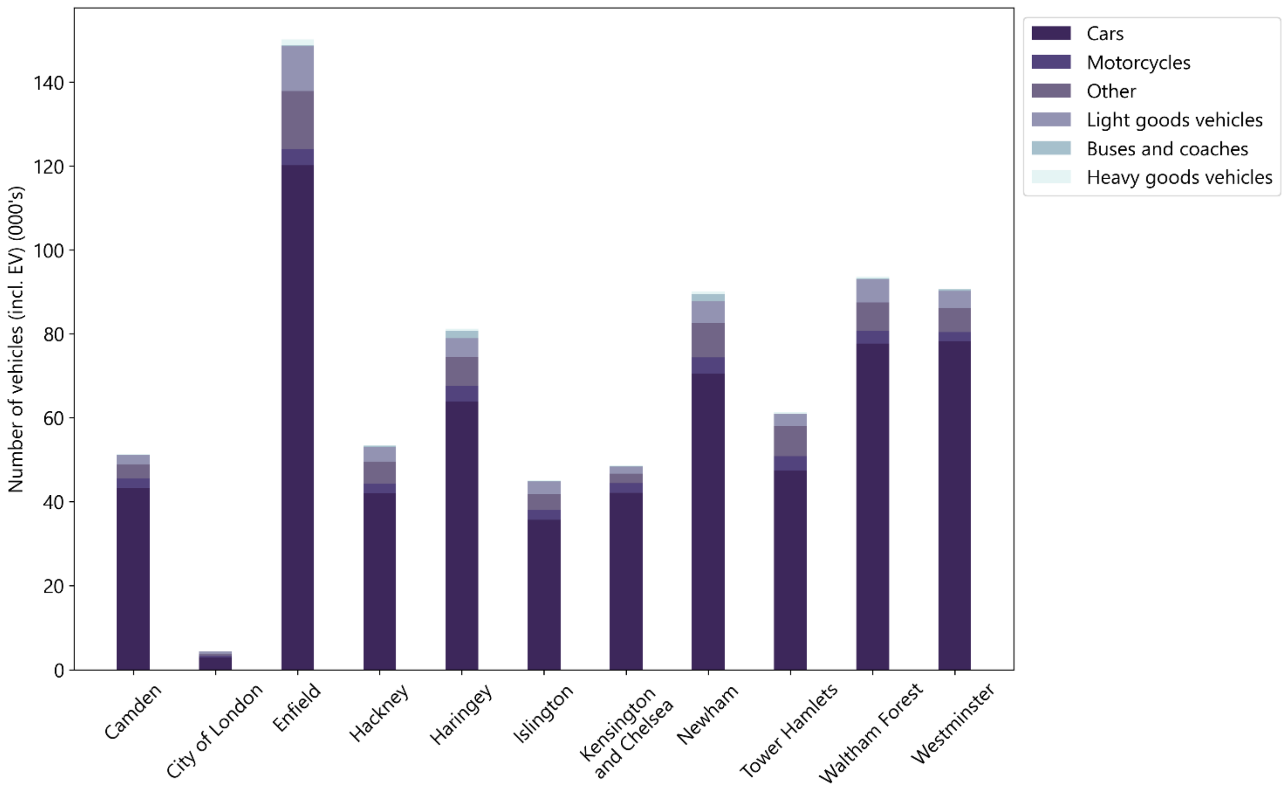

Figure 2—24 Numbers of different vehicle types per borough, Source: Department for Transport (2024).

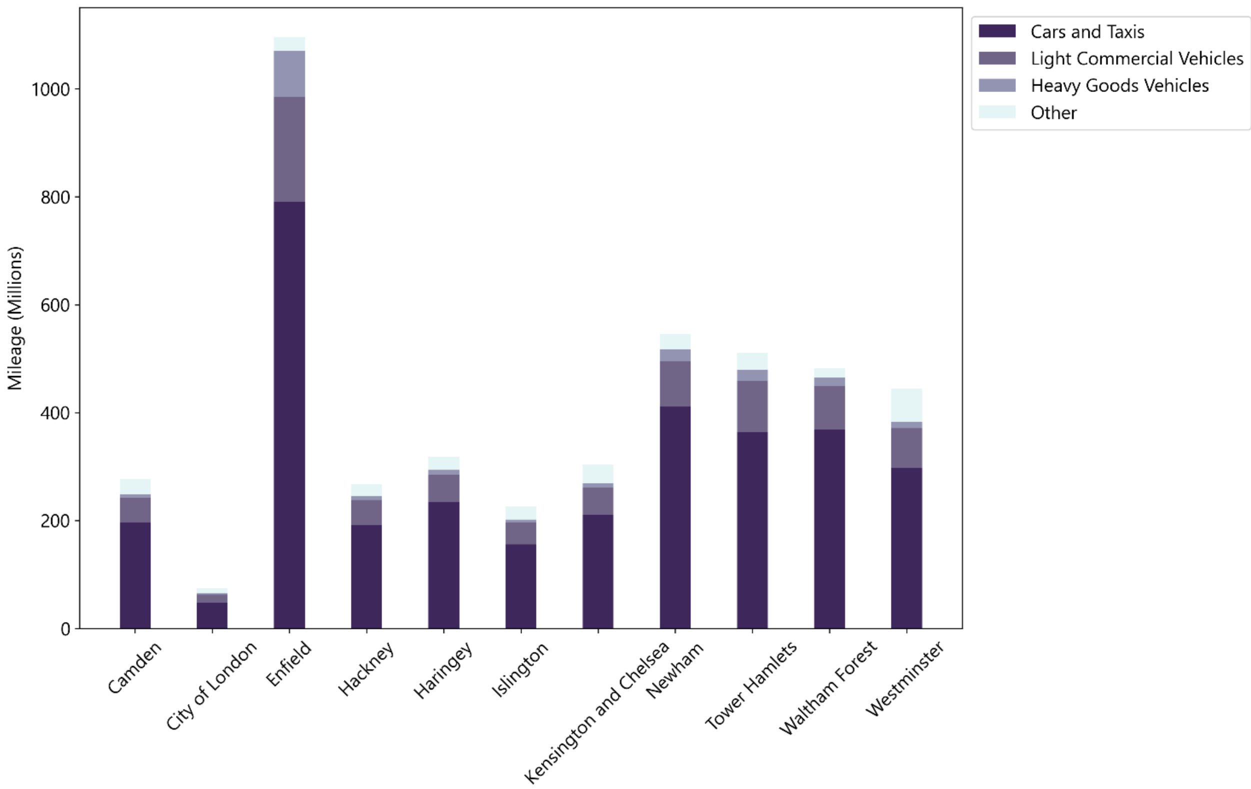

Figure 2—25 Mileage by vehicle type per borough, Source: Department for Transport (2024).

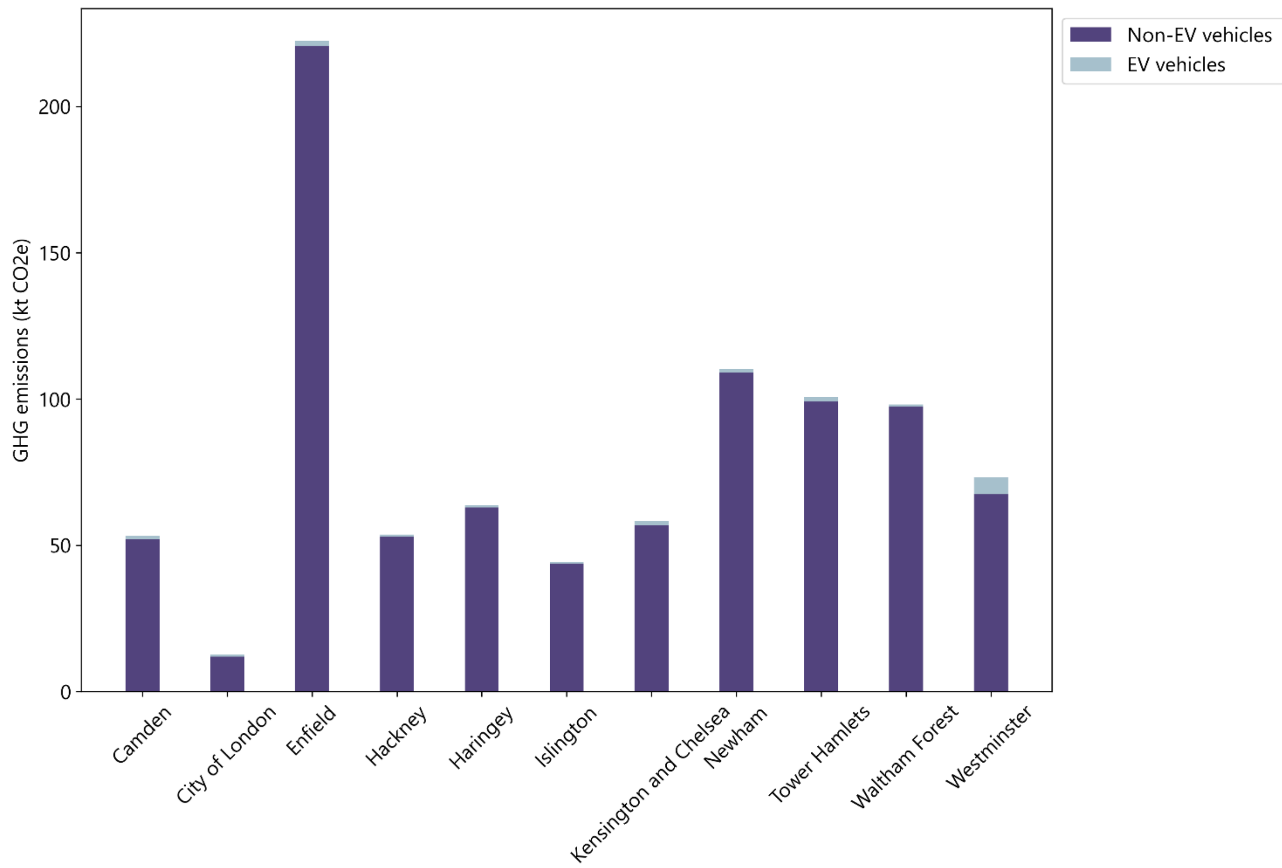

Figure 2—26 Mileage by vehicle type per borough, Source: Department for Transport (2024).

2.7 Current energy systems

A key enabler of decarbonisation is the energy networks. One of the main elements of LAEPs is to aid the visibility energy utilities to enable a more coordinated approach. Because of this the energy networks have a very significant role in future area decarbonisation. This is particularly the case when hydrogen is not considered. This promotes electrification and heat network solutions as key means to decarbonise heat and transport. Electricity and heat networks are generally linked, as the main source of heat for most decarbonised heat networks will come from centralised electric heat pumps, although with some limited waste heat opportunities across London.

This section explores the existing energy networks; namely, electricity, gas and heat.

2.7.1 Electricity networks

Electricity networks are complex, with multiple different voltages to consider, with the transmission and distribution networks being the two key differentiations. In England the transmission network is owned and maintained by National Grid, and operated by the NESO (the National Energy System Operator) whilst the distribution network (which forms the majority of the network) is operated in the subregion by UK Power Networks (the distribution network operator or DNO). An overview of the voltage levels and interfaces of the electricity network and the data availability is shown in Figure 2—27.

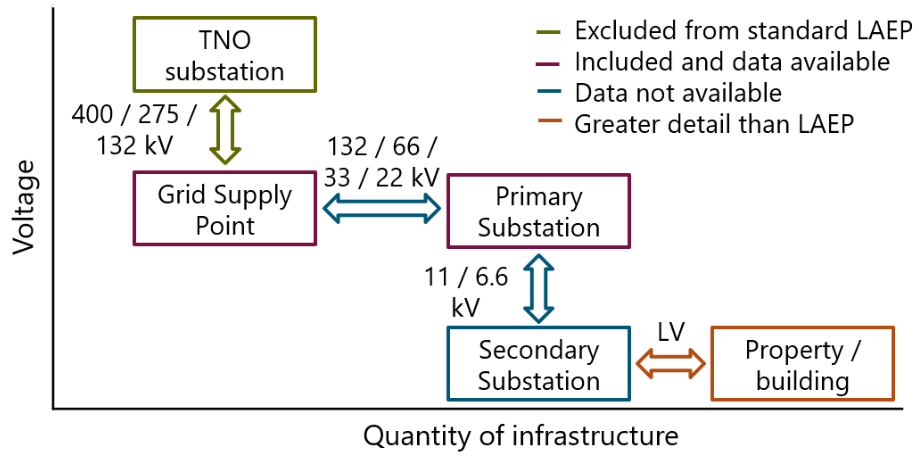

Figure 2—27 Overview of elements of the UK electricity network.

Whilst it is unusual for a TNO to be involved in LAEPs, as they focus on national and regional strategy, the aggregated demand for all the borough involved in the subregional work means they are an important stakeholder to engage. The additional electrical demands with the scale of electrification required is likely to trigger regional transmission investment as well as upgrades to the more local distribution networks.

As Figure 2—27 shows there were some data limitations in this work. The main elements being a lack of information relating to length and capacity on network cables and a lack of information about headroom on secondary substations. However, UK Power Networks have been heavily engaged with this process and will be running analysis on the scenarios tested to give deeper insight of the impact on the networks. Additionally, since the analysis was undertaken more data relating to secondary substations has been published.

It is important to note that by being primarily focused on distribution network level system elements some key concerns fall outside of the LAEP. An increasingly important draw on the energy networks are new data centres. These would tend to have their own substation and sometimes their own 132 kV connection and also being new do not have the same focus as decarbonising existing assets. However, they can have a large impact on capacity within the network. This can be mitigated through early liaison with the electricity companies to ensure there is sufficient headroom and also through early conversations in planning asking the developer to make clear the impact of the proposed electricity demand on the network as highlighted in the recommendations.

A key reason for the switch to increased electrification for decarbonisation is the rapid decarbonisation of the UK electricity grid. This is projected to continue, in UK Government figures with the Labour Government aiming for a zero-carbon electricity grid by 2030 and the UK Green Book also showing sharp emissions decline. The latter projections are presented in Figure 2—28.

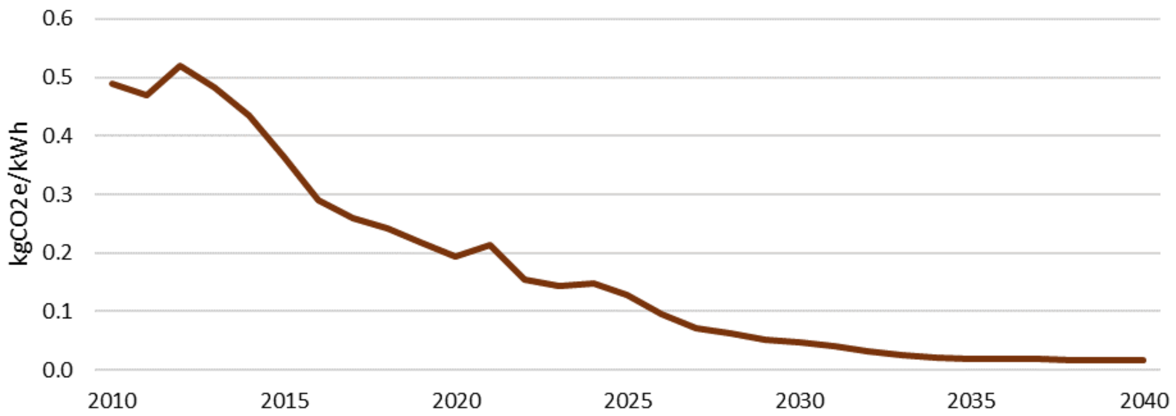

Figure 2—28 Historic and projected carbon content of the UK electricity grid, based on UK Green Book data.

Information is available for primary substations, which help to transform and distribute large volumes of electricity to lower voltage networks across the subregion. Primary substation boundaries and their currently available capacity for the CIEN London subregion can be seen in Figure 2—29. Primary substation boundaries and political boundaries do not align and therefore, a borough will be served by multiple primary substations and conversely, a primary substation will serve more than one borough. When assessing the suitability of the boroughs and substations for the deployment of low carbon technologies these boundary misalignments must be considered.

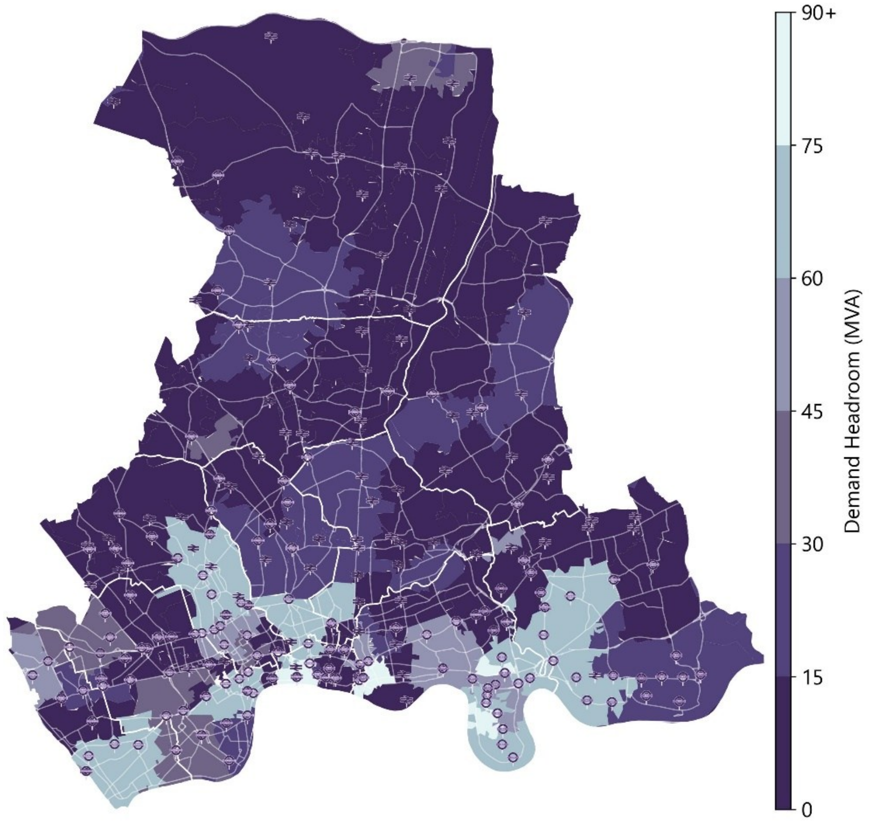

Figure 2—29 Current headroom for different primary substation areas – based on UK Power Networks primary substation data, Source UK Power Networks Open Portal (Mar 24).

The majority of substations towards the Thames currently have apparent notable headroom capacity. This indicates that these substations may be suitable for the connection of additional loads such as heat pumps or EVs. However, the cables at 11 kV from primary substations and LV cables from secondary substations may not have capacity so this is not guaranteed without further localised reinforcement. As network evolves at a fast pace, it is always recommended to engage the UK Power Networks early to ensure there is sufficient network capacity to facilitate low carbon technologies deployment at subregion. Recommendations can be made on the areas most suitable for immediate electrification however, constraints to the 11kV and low voltage networks will need to be assessed before deployment.

Smart meters are key to the ability of consumers to participate in flexibility, allowing more active engagement with the electricity network. A note detailing current information relating to smart meters and their potential in enabling Phase 2 LAEPs and monitoring progress is appended to this report (Appendix C). However, for context the penetration of smart meters to domestic properties is provided in Figure 2—30.

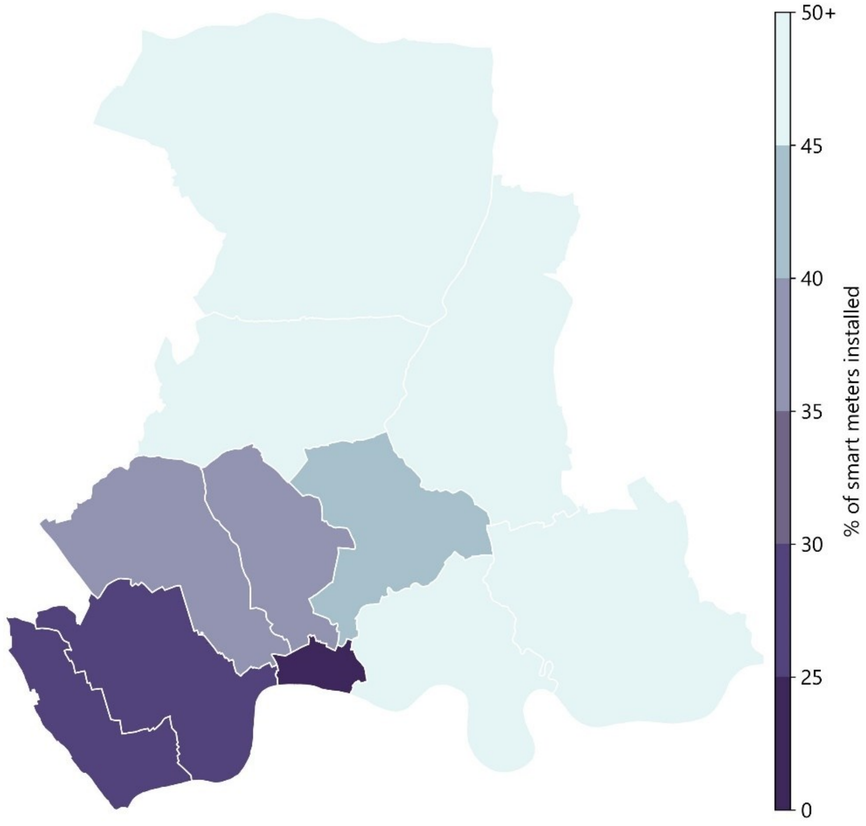

Figure 2—30 Percentage of smart meters installed per borough, Source: Smart DCC.

This shows that the less central boroughs have a higher penetration of smart meters. This is to be expected as smart meter penetration is generally lower in flats. From a flexibility perspective it is houses rather than flats that can have the largest impact at a property level on the network. Consequently, this distribution of smart meters is positive from an immediate flexibility opportunity perspective.

This does not mean that smart meters are not beneficial in flats. Active participation with networks (enabled by smart meters), including access to variable tariffs can create substantial energy savings. In flats, which have the highest number of direct electric heating systems, this can be important to help minimize the risk of fuel poverty.

Some substations in the region are already constrained with available capacity's near to or below 0MVA. It is likely that these substations will not be able to absorb additional load without intervention, either through flexibility or reinforcement. Planned reinforcement and network upgrades are displayed in Figure 2—31. This figure shows that in the near to medium term some of the immediate areas of constraint are being tackled to the south of the subregion.

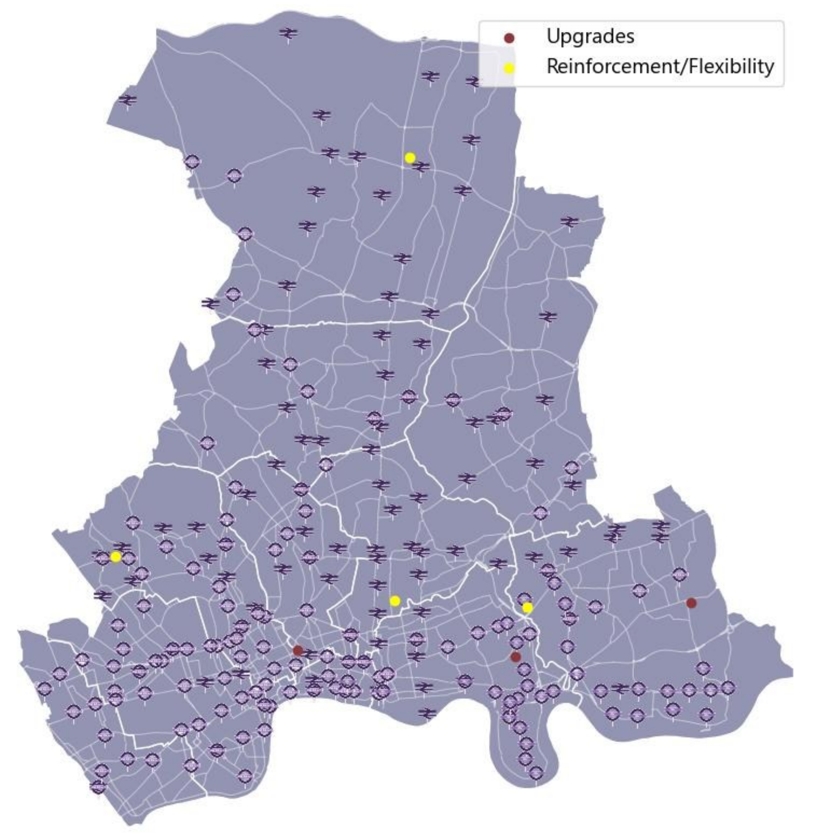

Figure 2—31 Location of UK Power Networks planned reinforcement and infrastructure upgrades, Source UK Power Networks Open Portal (Mar 24).

Timing of constraint is important as different low carbon technologies will have different impacts on the electricity network at different times of year. Figure 2—32 displays the seasonal constraint for the primary substations.

Several primary substations within the CIEN subregion currently have negative demand headroom. The primary substations with negative headroom and the boroughs they serve are as below:

- Hendon Way Primary, Newham
- Cockfosters Primary, Enfield
- East Enfield Primary, Enfield
- Nelson St, Newham
- Whiston Rd, Hackney and Tower Hamlets

The Long Term Development Statement (LTDS) of UK Power Networks provides forecasted loads on the network over a 0 – 5 year period. By 27/28 several primary substations are forecasted to have negative demand headroom. These substations and the boroughs they serve are as below:

- Cockfosters Primary, Enfield
- Hendon Way Primary, Camden
- Nelson St, Newham
- Lithos Rd A, Camden
- Bow, Tower Hamlets and Newham
- South Chingford Primary, Waltham Forest and Enfield

Kimberley Rd, Camden, Westminster, Kensington and Chelsea

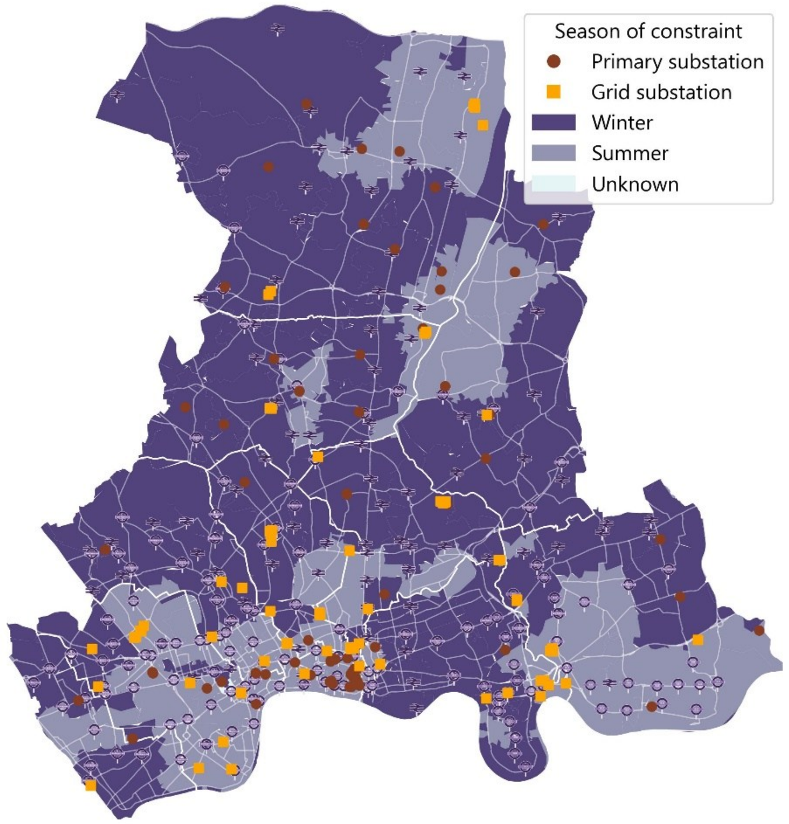

Figure 2—32 Primary substation season of constraint across the CIEN London subregion, Source UK Power Networks Open Portal (Oct 24).

The majority of the primary substations experience their highest loads during the winter months however, a few substations experience higher loads during the summer. Summer constraints often indicate that an area has high levels of air conditioning, and with climate change, it is expected that the loads associated with air conditioning will increase. Peak summer loads offer an opportunity to supplement some of the demand with solar PV, and with the additional use of private wire networks the impact to the grid in these areas could be reduced. This could free up capacity and allow for the installation of other low carbon technologies, such as heat pumps and electric vehicle charging points.

High winter peaks will be challenging with electrification of heat as it will cause increased demand at these times – which are already most challenging for the electricity network.

Data centres are becoming increasingly common across the UK. In urban areas without heavy industry they are often the single largest electricity consumers on the network. Their energy demands are very large, with 100 MVA connections not being uncommon and recent data centre planning applications including single sites with electricity demand of over 300 MVA. For context, 100 MVA equates to over 30,000 small domestic heat pumps.

The locations of data centres in the subregion are provided in Figure 2—33.

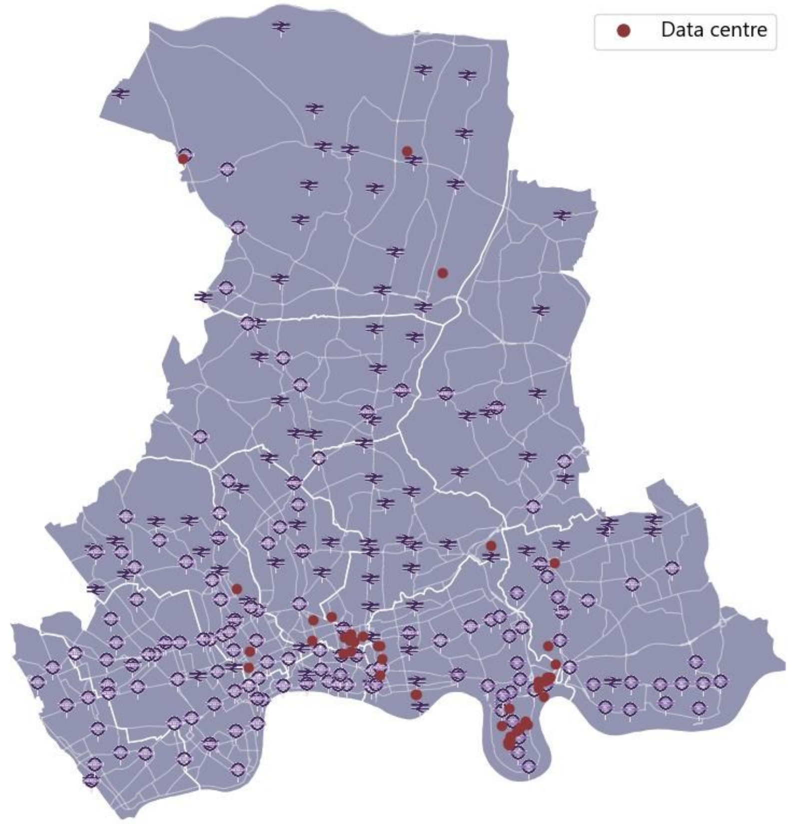

Figure 2—33 Data centre locations, Source: London Heat Map (Aug 24)[24].

The high number of data centres near to the City of London and Tower Hamlets appear to be linked to the network reinforcement in the area. This highlights some of the network challenges associated with data centres. As previously discussed this is not a focus of the LAEP work, but boroughs should actively consider the wider impact of data centres in their decarbonisation pathway, particularly in regard to how removal of network capacity could slow electrification in other areas. Whilst data centres do impact network headroom, they also present an opportunity. The most important opportunity being a potential source of waste heat for heat networks. This waste heat source is important as the data centres tend to be in areas where other large waste heat sources are not plentiful.

2.7.2 Gas networks

Natural gas is currently the single biggest source of energy in the CIEN London subregion. The network in the area is operated by Cadent. Whilst it does not form a component of the decarbonised energy system considered in this pathways analysis, understanding the system to an extent is important context for the baseline and direction of travel for the pathways.

Gas is particularly dominant for heating in the domestic sector. The percentage of different primary heat sources for domestic and non-domestic properties is provided in Figure 2—34 and Figure 2—35 respectively. For non-domestic, electricity is apparently more dominant for heating, potentially reflecting direct electric, and variations of combined heating and power plant.

[24] Based on London Heat Map data which includes information from Tech UK, DCByte and Colo-X.

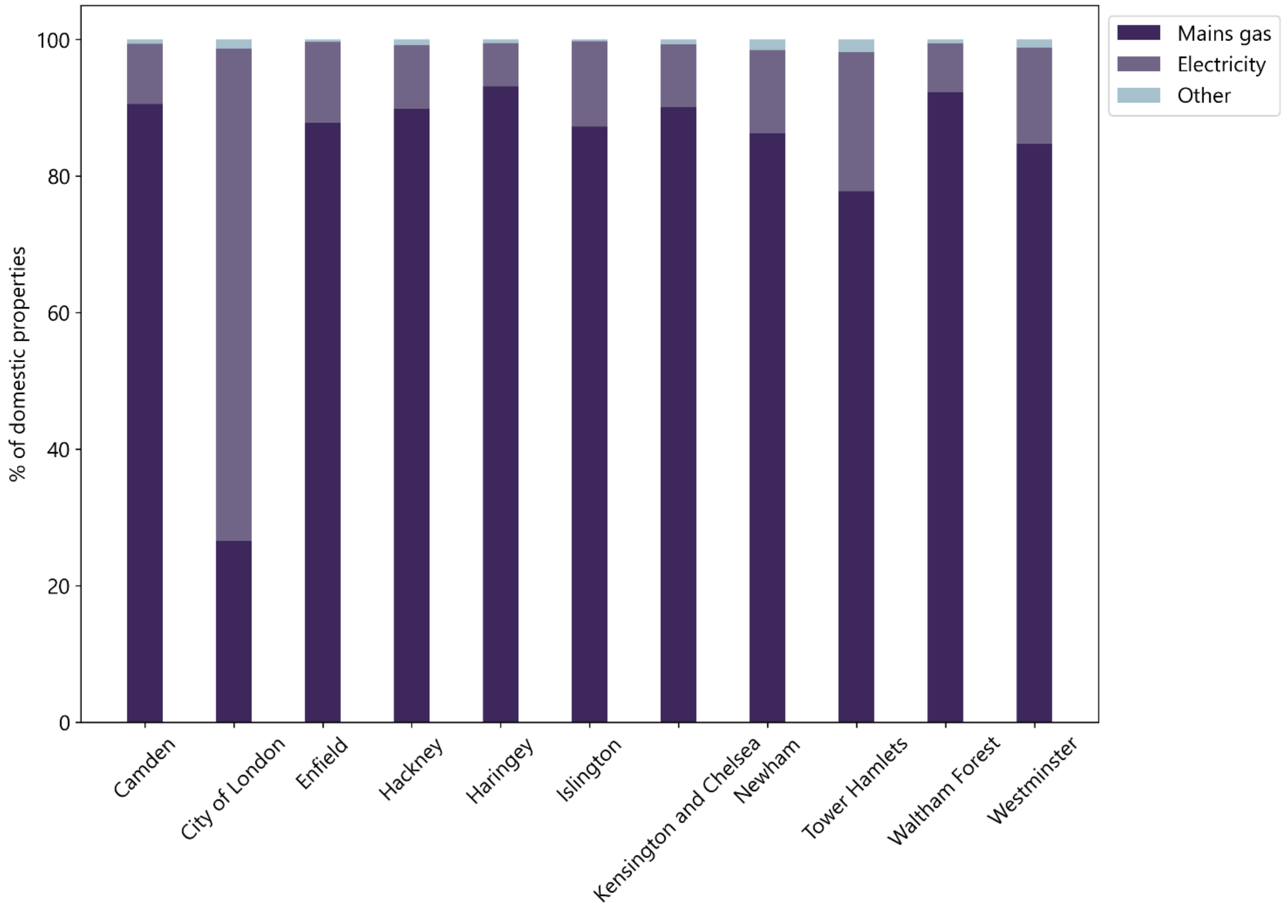

Figure 2—34 Primary source of heat as a percentage share of the domestic building stock, Source: GLA, London Building Stock Model v.2.

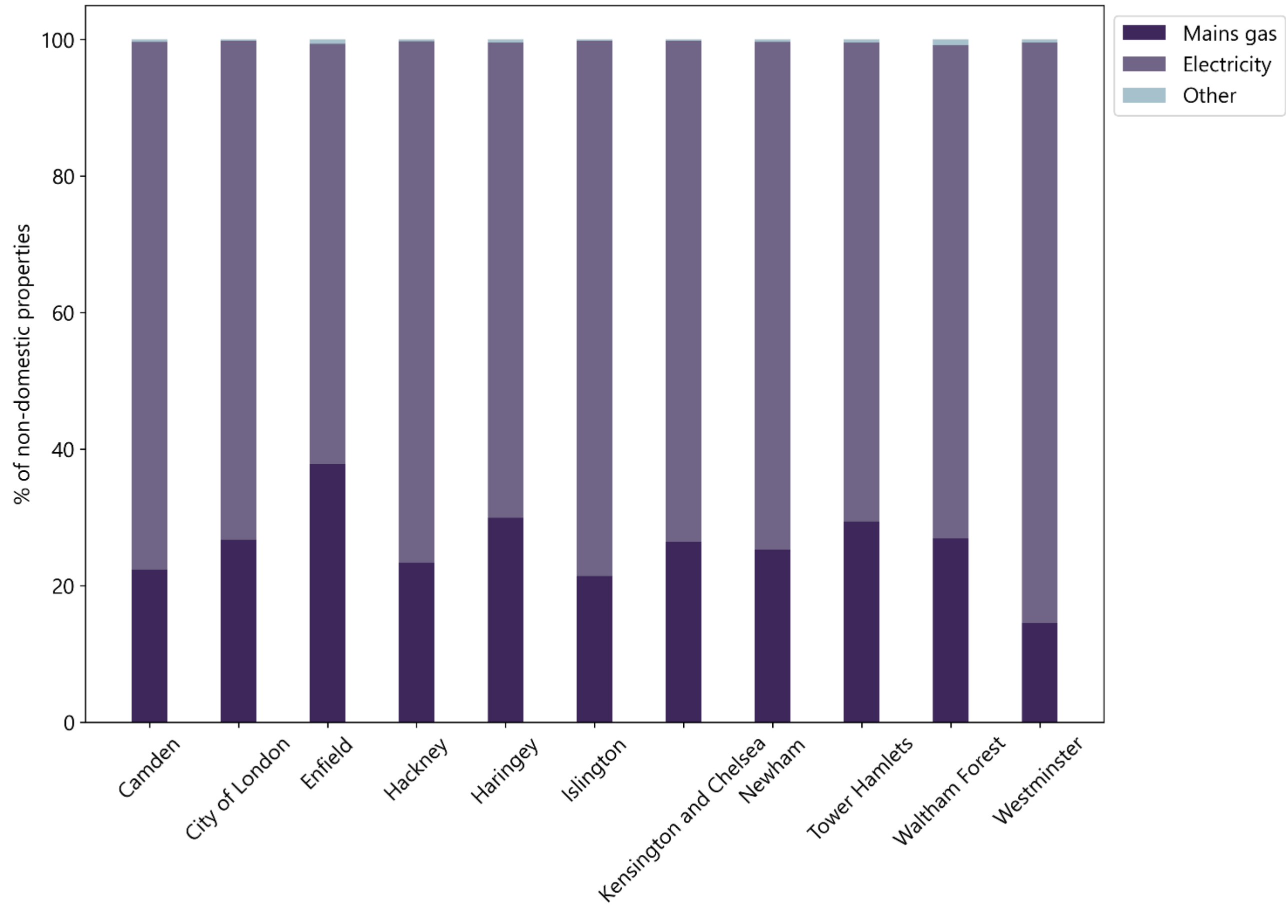

Figure 2—35 Primary source of heat as a percentage share of non-domestic building stock, Source: building dataservices UCL, OS.

The lack of heavy industry in the subregion makes the gas demand relatively suitable for electrification or connection to heat networks. This is one of the reasons that the subregion is not considered to have large scale deployment of hydrogen in any of the decarbonisation scenarios analysed.

2.7.3 Heat networks

Heat networks are the last major network type considered. Historically, in the UK these have been relatively small isolated networks. In other countries, particularly in Scandinavia, they are much more similar to gas and electricity networks with large transmission and distribution pipes providing heat across city scale networks.

In the CIEN London subregion operational heat networks are focused in the denser areas, this is illustrated in Figure 2—36.

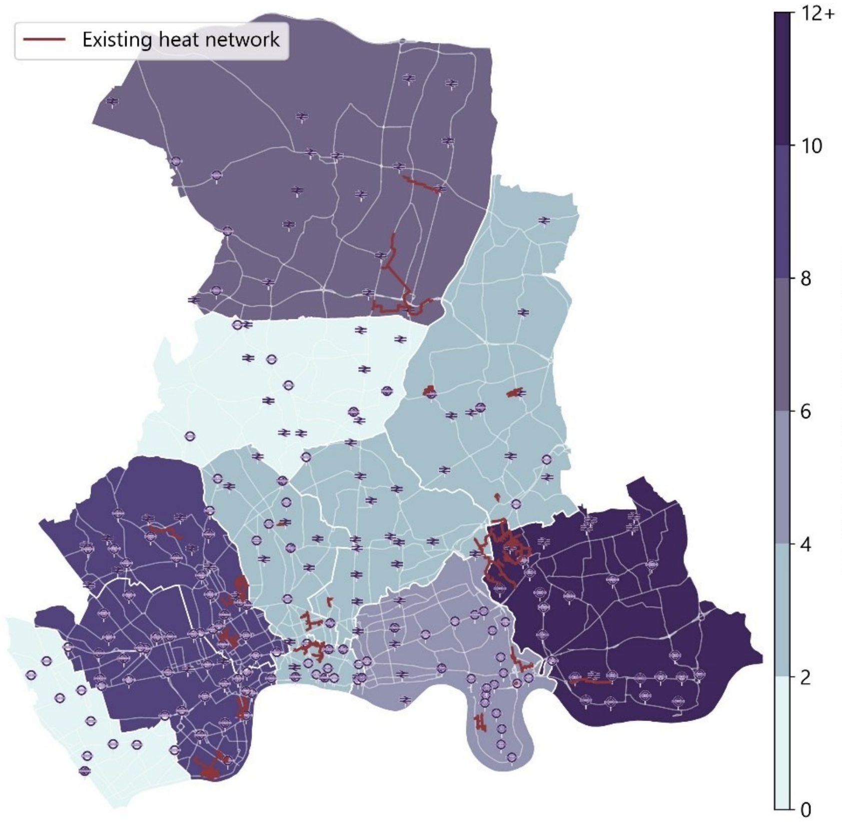

Figure 2—36 Existing heat networks across the CIEN subregion, length by borough, Source: London Heat Map (Aug 24).

There are, however, plans to expand and deploy new heat networks in the subregion. The location and extent of these networks are provided in Figure 2—37. These proposed networks are concentrated in the boroughs along the Thames.

It should be noted that communal systems are not captured in the map above but are included in the data relating to heating systems. This is also the case for useful insights relating to large communal systems provided in 1-2-1 engagement sessions.

Also, of note is Westminster, Islington, City of London and the London Legacy Development Corporation are being supported in their assessment of heat networks through the Advanced Zoning Programme. This support will help prioritise heat network deployment in the short to medium term in the borough.

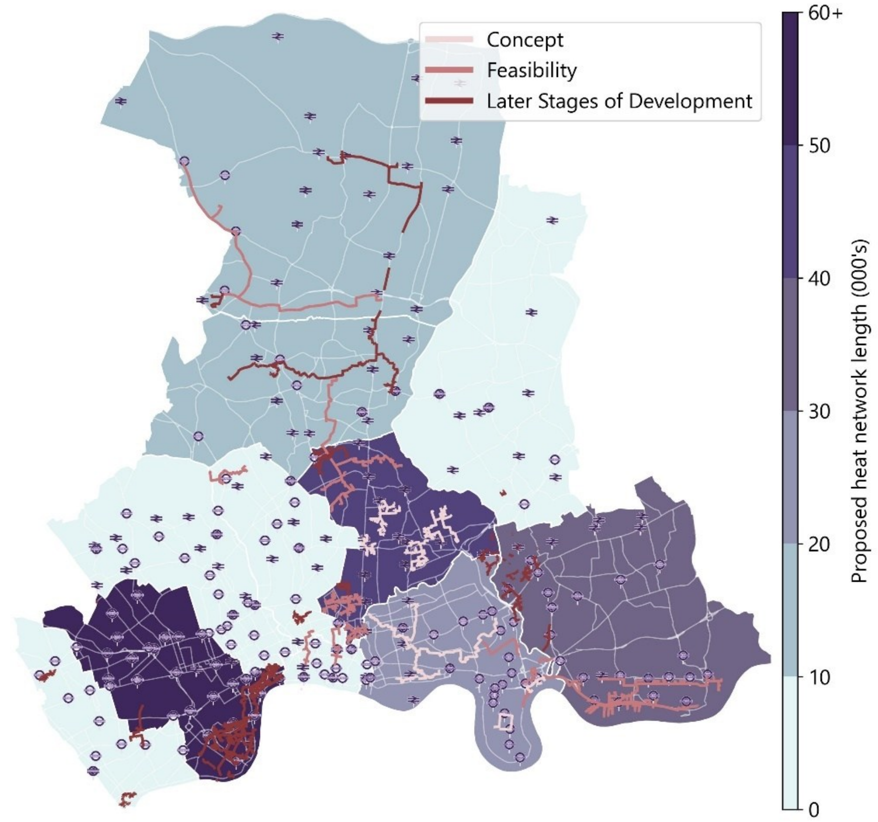

Figure 2—37 Proposed heat networks in stages of maturity and length, Source: London Heat Map (Aug 24) and Buro Happold maturity assessment based on project knowledge and borough engagement.

As well as large scale district heat networks, presented above, there are smaller communal systems. These are within building heat networks, where one centralised heating system provides heat to all properties in the building. This makes these systems attractive for early decarbonisation as it means change of one centralised heat source decarbonises multiple properties. It is often hard to distinguish these communal systems from wider heat networks due to lack of data.

To overcome this uncertainty the two are combined and presented in Figure 2—38. It shows more widespread deployment than is captured in the London Heat Map.

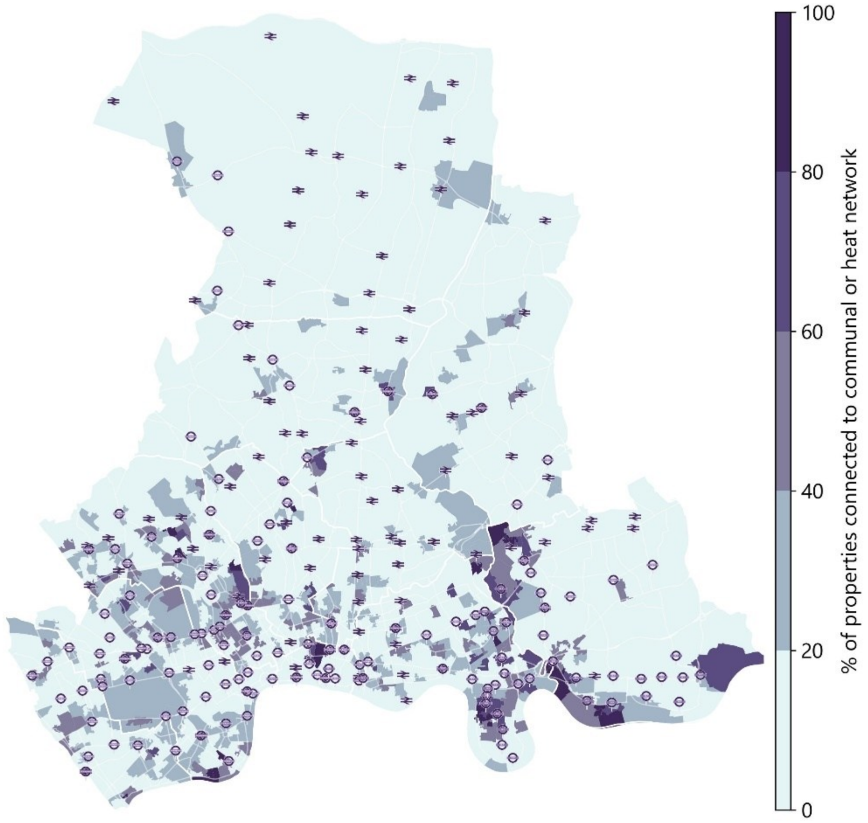

Figure 2—38 Heat map of number of heat network or communal heating systems across the CIEN subregion, London Heat Map, GLA, London Building Stock Model v.2.

2.8 Low-carbon technologies

Large scale low carbon technology sites are not common in London, generally being confined to combustion technologies like energy from waste. Figure 2—39 indicates the location and size of low carbon technologies exceeding 150kW in the CIEN subregion, as recorded in the renewable energy planning database. The sites are either operational, under construction, awaiting construction or awaiting planning permission[25].

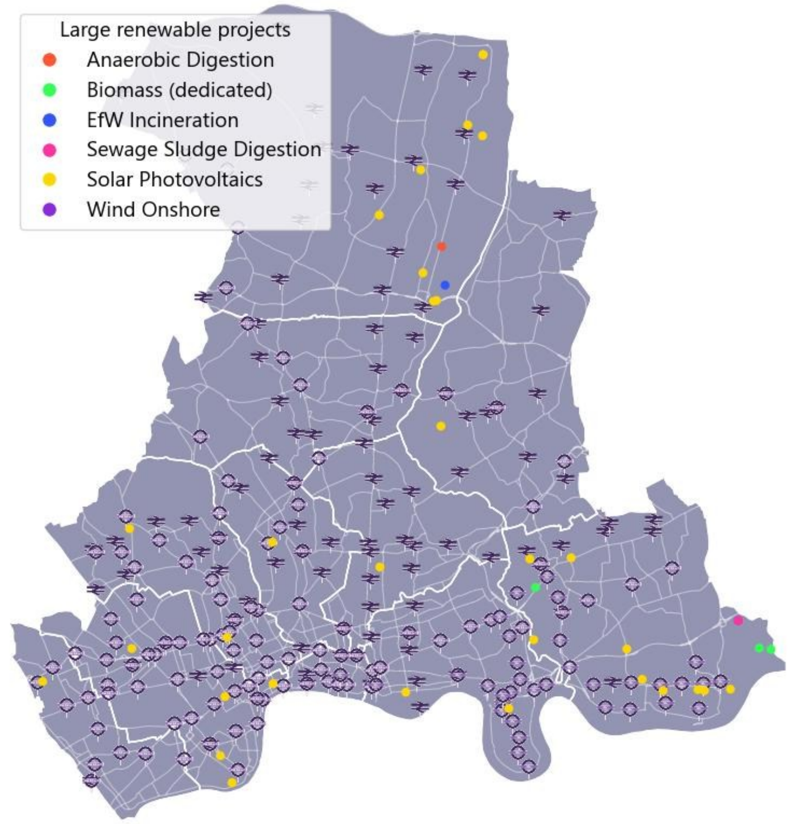

Figure 2—39 Renewable energy projects exceeding 150kW, installed, under construction, awaiting construction or awaiting planning permission in the CIEN London subregion.

The majority of the low carbon technology sites in the CIEN region are small scale rooftop PV sites. The installed PV capacity is provided in Figure 2—40

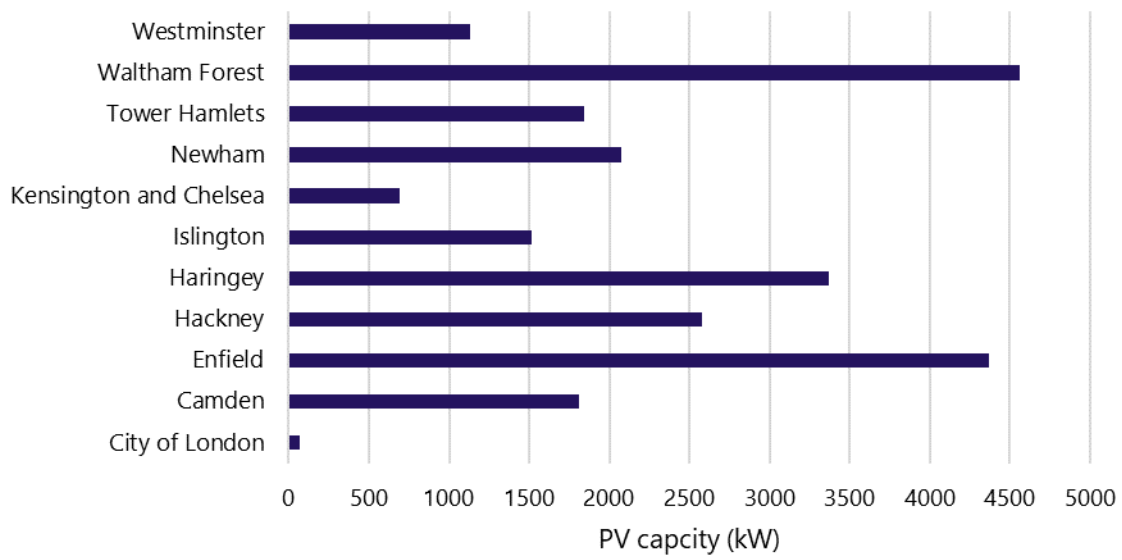

Figure 2—40 Installed PV capacity by borough. Data source: UKPN DFES and adjusted with some local insights

[25] Note that PV currently is being installed on the roof of the London Stadium and was not included in the data.

Alongside small scale solar there are larger PV sites as well as other renewable energy installation, those that are either progressed in the planning system or operational are displayed, including a small number of biomass and anaerobic digestion and a single EfW plant in Enfield.

Community energy groups are playing an increasingly active role in bringing forward low carbon projects. Locations of these are indicated in Figure 2—41. The currently limited distribution of these projects shows a strong focus in the more central boroughs, although with Westminster and City of London with no projects currently visible.

As progress to net zero is made and more projects are delivered it is anticipated that more community projects will be delivered. Community groups are a key set of stakeholders in the subregion. In Phase 2 LAEPs they are considered to be even more important partners and are well suited to bringing forward projects that may not be best led by boroughs. The GLA are already working in partnership with community groups to best understand how they can help unlock and deliver a pipeline of low carbon projects.

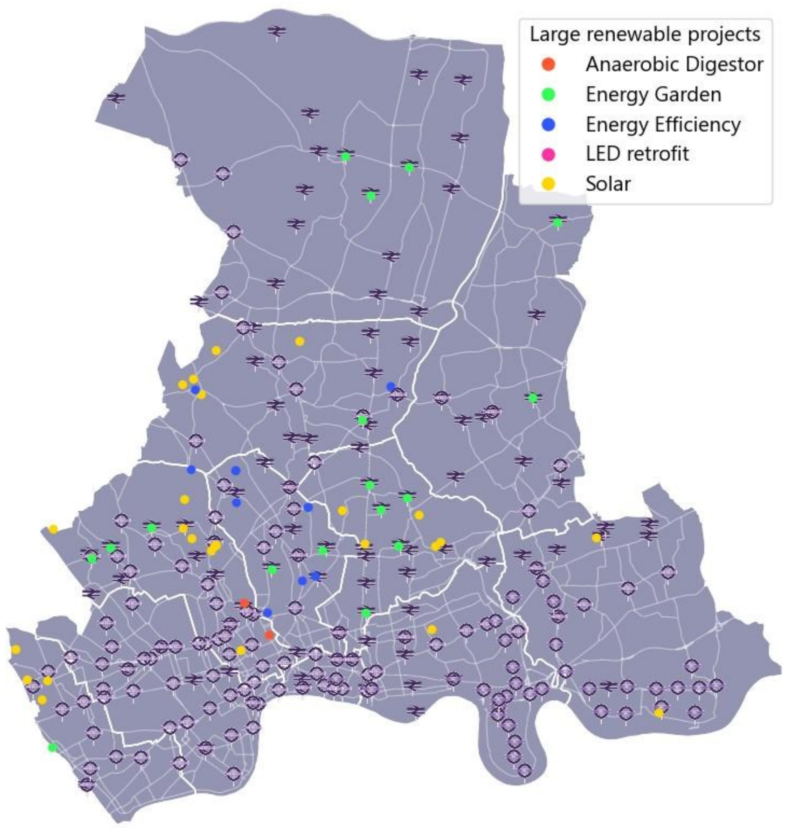

Figure 2—41 Location of community energy projects in the CIEN London Subregion, by Community Energy London.

The projects include energy gardens, these integrate renewable generation as well as wide environmental benefits like planting to improve diversity. The energy yield is low but there are significant wider benefits, more details are available online[26].

[26] https://www.energygarden.org.uk/

3 Future picture

3.1 Subregional decarbonisation context

There are multiple pathways to decarbonise the energy system, with variations in technology and timing being considered. Policy, legislation and targets are a key part of this on a local, regional and national level.

3.1.1 Integrating policy into modelling

National, regional and local policies, as outlined in section 2.3, are key to the modelling approach. They are the basis of key assumptions over timings of decarbonisation pathways, with a variety of net zero target years analysed. One of the key regional policy elements, broadly supported by borough feedback, was the stance on hydrogen. This is detailed in section 3.2.

3.2 The role of green and/or blue hydrogen

The regional position on Hydrogen is that it has a strategic role to play in our future flexible low carbon energy system. It is a high value energy vector that will be in limited supply and is best deployed to support the decarbonisation of high-emitting and hard-to-decarbonise sectors, such as industrial and heavy transport, as well as having a potential role in heat networks through the supply of strategic energy centres that are able to generate both clean heat and power. So, this position along with the positions of the majority of the participating boroughs meant that the decision was taken to exclude considering the full substitution of fossil gas with hydrogen as an option for space heating and hot water, although blending of hydrogen and biomethane is considered. The decision was also informed by the following two challenges around the viability and timelines around largescale deployment of hydrogen in the London gas network:

- Green and/or Blue Hydrogen is **not deployed at scale in the UK** with the UK Government still focusing on research [27] and as is stated in the 'Pathways to Net Zero Carbon by 2030' report that the times lines do not allow for it to make a significant contribution to London's net zero 2030 target. This raises questions also about deliverability throughout the 2030s and to the additional 2040 timeframe for many of the decarbonisation scenarios developed in response to many of the borough-wide targets that London boroughs have set. The blending of up to 20% green and/or blue hydrogen and biomethane into the gas grid to help reduce the carbon emissions in the short term is reliant on availability of product along with a decision by central government with the consultation having closed in autumn of 2023 [28]. However, this will only provide a small reduction in carbon emissions of around 7%, whilst potentially important in the short term, does not enable anything near full decarbonisation.
- It also **requires a decision on its role and subsequent national strategy and guidance** – this will not be until 2026 [29], when a decision will be made on hydrogen heating.

Additionally, two large trial projects for hydrogen heating deployment in Whitby and Redcar were recently cancelled – showing the challenges for large scale hydrogen adoption (including public opposition). There is, however, a trial in Fife being explored (H100). There is also the broader national context of the National Infrastructure Commission recommending that "government should not support the rollout of hydrogen heating" [30] as well as over 50 independent studies not presenting compelling evidence for large scale use of hydrogen for heating [31]. These factors mean hydrogen has a very high level of uncertainty, which is particularly challenging given the timescales for decarbonisation aimed for in this analysis.

Both Cadent (the gas DNO north of the Thames) and SGN (the gas DNO south of the Thames) were involved as stakeholders in the 'Pathways to Net Zero Carbon by 2030' report to ensure that their ideas around the role that Hydrogen could play was represented and helped to inform the various pathways including the chosen 'Accelerated Green' pathway in the final document. Cadent and SGN have produced a number of studies examining the potential role of hydrogen in London, most notably the Capital Hydrogen Programme [32]. The Programme focuses on bringing hydrogen into London from the east. This means there would be a delay in connection for the subregion, even under a hydrogen scenario. This is partly due to the lack of large industrial demands often a key pull for hydrogen decarbonisation pathways.

Enfield has some large industry but has completed a full LAEP which did not consider hydrogen. Newham also has some industrial loads and is part of the later stage of a potential project being examined by Cadent looking at bringing hydrogen from the east. In both instances, this could be useful for hydrogen being a future fuel for heat networks, particularly in Enfield, where energy from waste may eventually be phased out. Consequently, hydrogen could play a role in the longer term and assist delivery of scenarios that are heat network rather than hydrogen led. It is, however, excluded from use in buildings in the scenario modelling for the CIEN subregion – due to the lack of industry in the non-domestic sector. For transport it is considered for large scale road transport, namely coaches and HGVs.

3.3 Decarbonisation scenario context – Accelerated Green 2030 Pathway

The Mayor set a 2030 Net Zero Target in 2021 and the GLA commissioned a London wide study [33] examining four different pathways to net zero by 2030. The report shows that under all pathways it is possible to accelerate action and radically reduce carbon emissions with the right ambition, leadership, powers and funding. The Accelerated Green 2030 pathway was chosen as the preferred pathway for meeting London's 2030 Net Zero target as it balanced ambition with deliverability. The scenario represents the rapid decarbonisation activity that is required to meet the 2030 Net Zero target, which is a 78% reduction on 1990 levels. There are important discussions to be had around regional, sub-regional and local infrastructure needs that will ensure that London balances the rate of decarbonisation against the cost of decarbonisation . The type and scale of actions that will be needed across London include things such as:

- **Retrofit** of 210,000 homes and 26,500 non-domestic buildings each year to 2030.
- Installation of 2.2 million **heat pumps** by 2030.
- 27% reduction in **car mileage**.
- 460,000 new **heat network** connections by 2030.
- 3.9 GW of **rooftop PV** by 2050.

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[27] Department of Energy Security and Net Zero, 2023: Hydrogen Strategy Update to the Market: August 2023. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1179651/hydrogen-strategy-update-to-the-market-august-2023.pdf

[28] Department of Energy Security and Net Zero, 2023: Hydrogen Blending into GB Gas Distribution Networks. https://assets.publishing.service.gov.uk/media/650057d81886eb00139771f8/hydrogen-blending-into-gb-gas-distribution-networks-consultation.pdf

[29] Department of Energy Security and Net Zero, 2023: UK hydrogen strategy. https://www.gov.uk/government/publications/uk-hydrogen-strategy

[30] National Infrastructure Commission, 2023: Technical Annex: hydrogen heating. https://nic.org.uk/app/uploads/NIA-2-Technical-annex-hydrogen-heating-Final-18-October-2023.pdf

[31] Rosenow, A meta-review of 54 studies on hydrogen heating, Cell Reports Sustainability (2023), https://doi.org/10.1016/j.crsus.2023.100010. https://northeastbylines.co.uk/wp-content/uploads/2023/12/PIIS2949790623000101.pdf

[32] Capital Hydrogen https://www.capitalhydrogen.co.uk/

[33] Element Energy for the Greater London Authority, 2022: Analysis of a Net Zero 2030 Target for Greater London. https://www.london.gov.uk/sites/default/files/nz2030_element_energy_final.pdf

These are ambitious targets and account for a carbon emissions reduction from buildings and transport of 63% between 2020 and 2030. Progress towards this target is indicated in Figure 3—1.

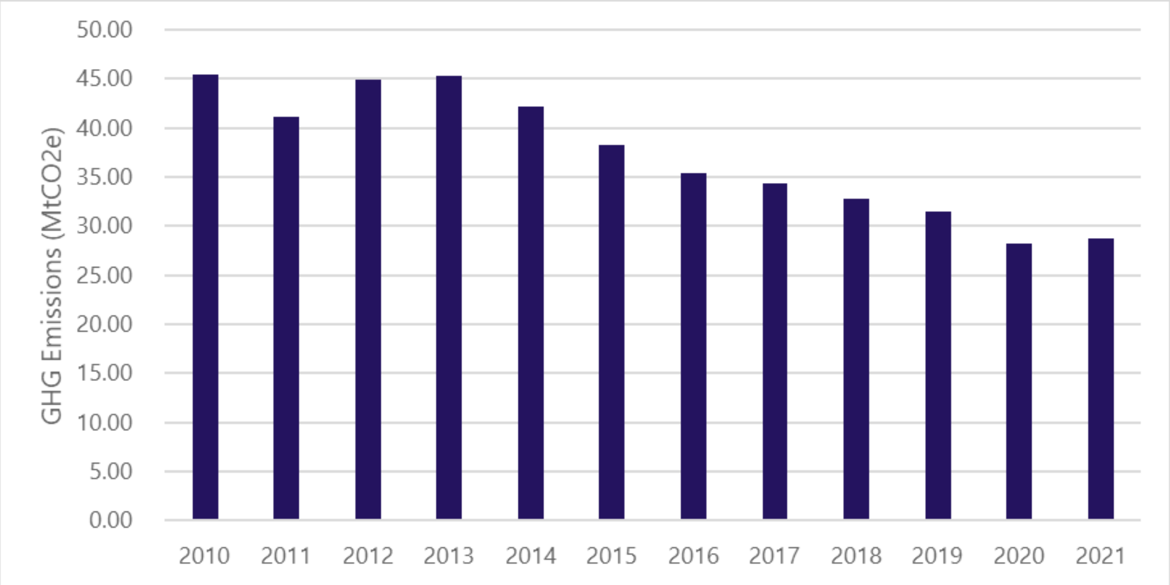


Figure 3—1 Carbon emissions for London over the last 10 years for which data is available[34].

Although it only covers two years it should be noted that there is no discernible change between the 2020 baseline and 2022. This is in part due to a post COVID rebound in energy consumption after 2020 but demonstrates the scale of challenge. However, the ambition of Accelerated Green 2030 and the technology mix and decarbonisation choices it presents form a basis for different scenarios to test.

3.4 Accelerated Green – 2030 Mayoral Target

The 2030 target aims to reduce emissions by 78% of their 1990 levels by 2030[35] and have a 90% phase-out of natural gas as a heating source by the mid-2030s. This requires substantially faster deployment of low carbon technologies than other scenarios and also does not always align to borough specific targets, borough level targets range from 2030 to 2050.

To meet this target, a number of technical and non-technical considerations must be addressed; these are summarised below.

Technical
- Rapid step-change in deployment of low carbon heat networks across the subregion
- Substantial increase in heat pump and shallow fabric retrofit than has currently been achieved in the UK
- Widespread installation and high penetration of on-street and off-street electric vehicle charging (including associated electric vehicle replacement)
- Significant reinforcement and upgrades to electrical networks

Non-technical
- National, regional and local policy and regulatory support requiring alignment and
- Multi-stakeholder engagement and agreement (public and private sector)
- Shift in skills and workforce capability and capacity
- Fuel poverty considerations due to current funding models of different approaches and current electricity pricing versus gas

Requirements for the scenario in terms of heating system deployment, fabric retrofit, PV, transport and the electrical network are explored below. This quantifies some of the challenges, with some additional consideration to these being given in the practical installation and policy and regulation subsections.

3.4.1 Heating

By 2030, all existing heat networks and communal systems need to be decarbonised in this scenario; this accounts for 43,000 properties. Alongside this around half of the properties in the subregion need to have a complete change of heating system by 2030. How this is split by property level solutions, communal systems and heat networks is displayed in Figure 3—2. For context, 2035 is included, which represents the switch for all existing properties.

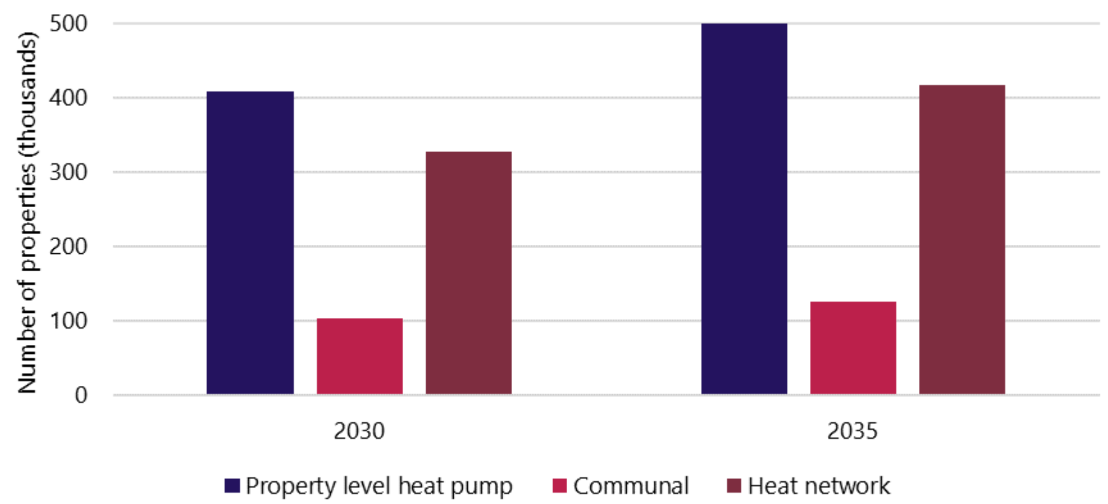


Figure 3—2 Number of properties requiring transition to property level heat pump, communal system retrofit or heat network connection.

Heat pumps are the most common solution across the majority of London's building stock; however, heat networks are also anticipated to play a major role in denser parts of London. Heat networks take longer to procure and install and tend to serve larger non-domestic properties and domestic apartment blocks and as such are responsible for increased decarbonisation by 2035.

[34] Data taken Department for Energy Security and Net Zero, 2024: UK local authority and regional greenhouse gas emissions statistics, 2005 to 2022. https://www.gov.uk/government/statistics/uk-local-authority-and-regional-greenhouse-gas-emissions-statistics-2005-to-2022.

[35] The residual 22% would need to be offset to be counted as a net zero scenario.

For context, 55,000 heat pumps were installed in 2022 in the UK as a whole, with a national target of 600,000 to be installed annually by 2028[36]. Assuming linear growth of heat pump installations between the 55,000 and 600,000 this means by 2030, the subregion would have had 12.2% of total UK heat pumps installed (despite only having 3.8% of the population).

The rapid large scale introduction of heat networks presents both practical and cost considerations. Large scale transmission heat networks are a key element of the decarbonisation pathway identified for the subregion. The long lead time for such projects, and given the current status of heat network zoning across the subregion, would indicate that this would require a significant step-change in deployment to achieve the 2030 timeframe. For comparison twice the number of properties connected to heat networks currently would need to be connected every year to 2030 to hit the required deployment trajectory.

To ramp up deployment of heat networks at this scale further government funding and legislation will be required. Alongside this resourcing for developing the required skills and resource capacity in this sector will be required. Without this support the sector is not equipped to achieve the required rates of deployment.

It is important to note that the impact of the new heating systems installed by 2030 becomes greater as the electricity system decarbonises. With the carbon content of grid electricity in 2035 is forecasted to be 41% of its value in 2030. The new Labour Government is committed to faster grid decarbonisation, however, these values are not yet included in the Green Book – which forms the basis of carbon assumptions for this work.

The low carbon heating systems are supported by fabric retrofit. Over 600,000 homes in the subregion need some form of fabric improvement (mostly shallow) by 2030, with a cumulative total of over 800,000 by 2035. This is explored further in Figure 3—3.

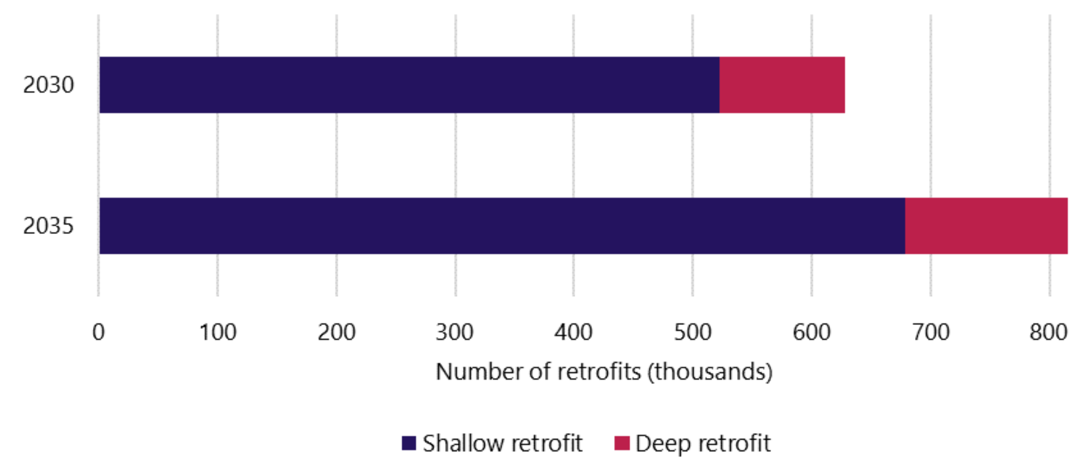


Figure 3—3 Number of properties requiring different levels of retrofit.

3.4.2 Fabric retrofit and PV deployment

The majority of fabric improvement required is shallow. This reflects the improvement in heat pump technology in recent years, meaning less invasive improvement is needed for the technology to function at effective temperatures to heat the building. Shallow retrofit enables the faster adoption of heat pumps, as less initial work is required. The number of new low carbon heating technologies being higher than the fabric improvement indicates that many properties already have sufficient levels of fabric efficiency for low carbon technology.

PV deployment is also high for the Mayoral Target, although this in line with other high deployment scenarios explored in more detail later. The total PV deployment across the subregion is 401 MW by 2030.

3.4.3 Transport and electric vehicle charging

To enable substantial savings from transport a large number of EV chargers are required, with the total requirements provided in Figure 3—4.

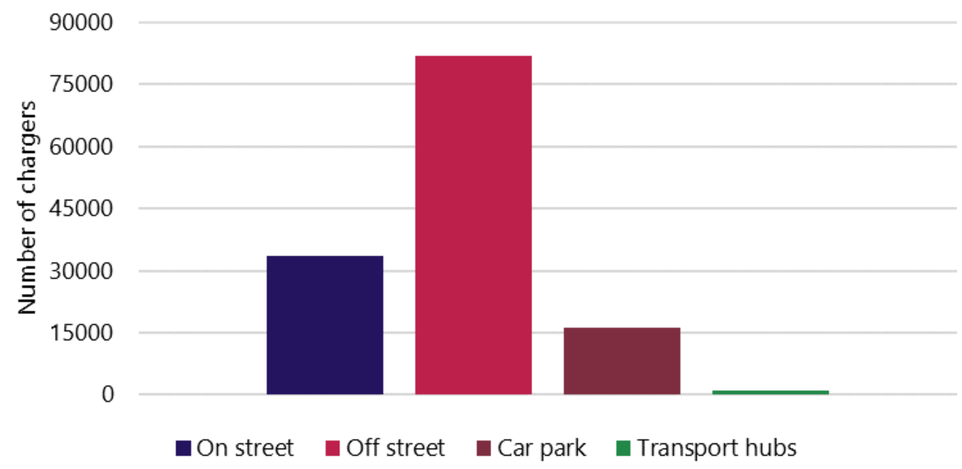


Figure 3—4 EV charger requirements for 2030.

Off-street chargers are the most frequent charger, in a large part due to outer boroughs having higher car ownership and more driveways due to lower density housing. Inner boroughs require a higher percentage share of on-street parking, due to the lack of private or public off-street parking for home-based off-street charging.

Car parks have an increased role in terms of installed capacity even though the total numbers are relatively low. The car park-based chargers modelled are often at least three times a standard off-street charge in terms of capacity. The rapid and fast chargers at these sites can present difficulties for securing capacity on the electricity networks. With transport hubs this difference becomes even larger, with chargers often being ten to thirty times the capacity of a home-based EV charger.

Alongside EV charging, and associated elevated electric vehicle uptake, a key element for early decarbonisation to meet the 2030 target is reducing car mileage. This is achieved through behavioural shift, such as greater levels of active travel and public transport. This is in a large part responsible for a 27% overall reduction in car mileage across the subregion included in scenario. This does not represent a reduction in car ownership but rather a reduction in usage, although in reality this likely to be a combination of the two.. Finally, while Accelerated Green 2030 references pay-er-mile road user charging as a potential means for driving mileage reduction, the mayor has ruled out this approach.

3.4.4 Electricity networks

The high levels of electrification across heat and transport will bring forward the need for network upgrades which will require street works that need to be coordinated effectively in the near term to minimise disruption. The upgrades are likely to cost in the order of £3.2 billion in the subregion although accurate costing is hard as such rapid large-scale upgrade is hard to benchmark[37]. These costs are borne largely by consumers via utility bills and connections charges, socialising the costs outside of the specific reinforcement areas. The speed of investment would be a substantial change from how Ofgem allow for network operators to make investment and will require reopening of current business plans to

[36] https://www.nao.org.uk/press-releases/low-heat-pump-uptake-slowing-progress-on-decarbonising-home-heating/#:~:text=The%20government%20wants%20to%20see,heat%20pumps%20being%20installed%20annually.

[37] With the level of network detail provided this was based on other studies of a similar scale that have associated upgrade costs with an overall increase in MVA. This includes a report investigating network impacts of London boroughs provided through stakeholder engagement as well as costs from national models under previous BuroHappold work. However, lack of cable and secondary substation detail during the modelling means there is a large degree of uncertainty with this figure.

unlock new investment, and rapid planning over coming years. To justify such substantial near-term investment the level of confidence would have to be very high, with a strong confirmed pipeline of projects being developed to investment-grade to respond to London's 2030 target and similar targets for London boroughs as set out earlier in the report..

3.4.5 Policy and regulation

From a deliverability perspective, a range of additional policy and regulatory levers need to be put in place by central government to enable and support London's aspirations and ambitions to tackle the climate emergency. A key consideration is the medium-term need for re-balancing of levies on gas and electricity to bring prices closer together and now reflect the lower carbon intensity of the electricity network compared to the gas network. In the short-term there needs to be incentives for heat pumps to offset the difference between gas and electricity prices (this could include regulatory/fiscal changes to reduce the price paid by consumers per unit of electricity). This was a significant concern for boroughs, particularly where fuel poverty is a large issue. In addition, the government is pursuing a major framework for heat network deployment through Heat Network Zoning and the Advanced Zoning Programme. Whilst this is ambitious, the timescales do not mean that these will all be built out across London by 2030 but London Government is coming together to help ensure that progress around heat network development is significantly accelerated in response to our ambitions around net zero. It is too soon to tell how the new government policy or regulation might change in this area. Across all aspects of energy system decarbonisation, if we are to meet the 2030 target, it will require significant increases in funding and resources from government to help build the skills and capacity within the sector to a scale where it is consistent with the scale of the challenge.

In the interest of exploring a number of additional scenarios, other trajectories, which consider investment costs, market readiness and London borough targets beyond 2030, have also been considered in this report with dates of 2040 for London borough targets and the UK's 2050 timescales. This allows for the same technology choices and activities to be considered as are considered in the Mayor's 2030 Accelerated Green pathway mayoral trajectory, but these are just spread out over a longer timescale. This allows low and no regret actions to be identified for delivery first which will support a 2030 scenario but will also continue to reduce the residual emissions that will be remaining in 2030 and that will need to be reduced over a longer time frame. The clear and continuing need for stronger national policy and support (or more devolved powers and funding to London), which was always required to deliver London's 2030 net zero target, is common to all scenarios explored. However, the more pressing timeframe of the 2030 target means that these considerations are even more time critical in order to minimise the level of residual emissions remaining in 2030.

3.5 Post 2030 scenario definitions

Four additional scenarios are examined alongside the Mayor's Accelerated Green 2030 pathway, an overview of these is provided in Figure 3—5. The scale of change needed means there is a shift in focus from 2030 to 2040 or 2050 for these. However, interim targets are still crucial to creating actions and will be included in reporting.

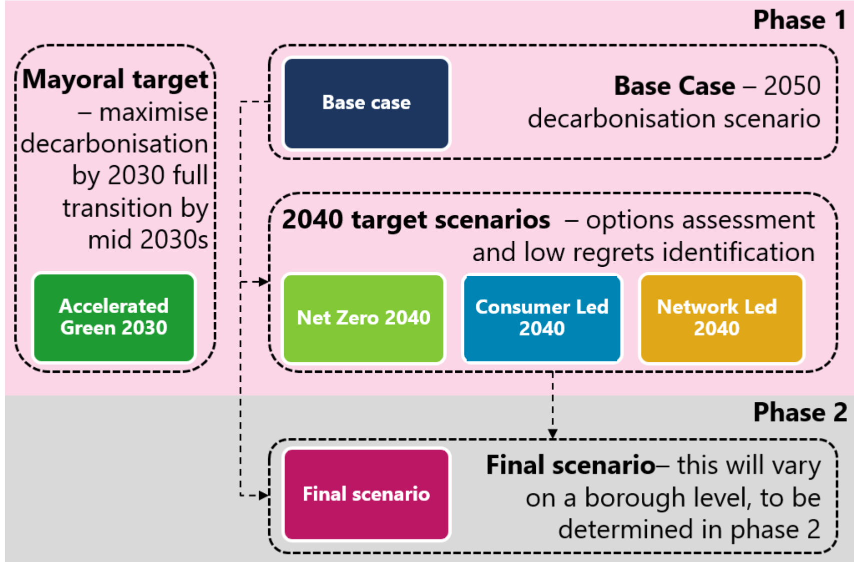


Figure 3—5 Summary of timings for different scenarios.

In summary, the four scenarios explored beyond the Mayoral Target are:

1. Base Case 2050
2. Net Zero 2040
3. Consumer Led 2040
4. Network Led 2040

Details of the characteristics of these scenarios are provided in 3.5.1 to 3.5.4It should be noted that a final scenario will not be selected at the subregional level, as this will depend on the choices of different boroughs. While all scenarios are similar, the focus of different actions and priorities shift.

3.5.1 Base Case 2050

Although this scenario is the slowest decarbonisation option, it still presents an ambitious scenario, aligning with national targets for decarbonisation in 2050. This reflects the timings of power network strategies through the FES and DFES.

As with all scenarios, heat networks, communal systems and heat pumps are considered. In all cases only certain areas are considered for heat networks, this is based on reaching specific heat densities. For the Base Case 2050, Net Zero 2040 and Consumer Led 2040 this is based on linear heat density analysis carried out specifically for this project (see Appendix A for more details). This identifies areas of high heat density and connects these (when viable) to each other and heat sources through heat transmission pipes.

Heat network connections are only considered in these areas. Properties can have different decarbonisation technologies within these heat network areas, unless they are considered mandatable[38] under DESNZ guidance (in which case they are connected). Outside of these heat network areas communal or heat pump solutions are considered, with communal requiring multiple properties in a building to be considered (for more details see Appendix A).

3.5.2 Net Zero 2040

This follows a similar technology route to the Accelerated Green 2030 pathway outlined in section 3.3 and referred to elsewhere as the Accelerated Green 2030 or Mayoral target. The difference is a slower uptake rate for technologies, reflecting more of what is possible with the current supply chain. However, as with all the 2040 target scenarios this is still highly ambitious.

[38] A heat demand of over 100 MWh/yr or public sector buildings.

A key change in the scenario is the impact of some of the measures. The most notable being the savings from retrofit. This is a result of published figures on the impact of retrofit. As an indication of scale, the maximum saving from deep retrofit in domestic properties in this analysis is 12.4% of current heat demand compared to 37% in the London wide assessment. This is further reduced as deep retrofit is not often required for low carbon heating technology (such as heat pumps) to function effectively and efficiently. So, whilst the number of retrofits is similar the impact and carbon savings are substantially reduced from the original Accelerated Green 2030 scenario – when considered without the low carbon heating system they enable.

Net Zero 2040 is the fastest decarbonisation scenario considered. This is due to the mix of both centralised and property level solutions. This means it requires the greatest coordination between government (central, regional and local), network operators, commercial and industrial energy users, as well as building owners and residents.

3.5.3 Consumer Led 2040

The Consumer Led 2040 scenario is very similar to the Net Zero 2040 scenario, with the main difference being an elevated level of heat pump deployment and, conversely, fewer heat network connections.

To offset some of the impact of this on the electricity network, flexibility and demand side management are key. This also allows more electrification to take place before network upgrades are undertaken. As with the Net Zero 2040 scenarios this also has a high level of solar deployment, relying less on imported zero carbon electricity.

3.5.4 Network Led 2040

This scenario relies most heavily on centralised infrastructure supporting decarbonisation. This is characterised by less embedded flexibility and diversity in the electricity modelling, representing lower levels of behaviour change or active engagement with the energy systems. Consequently, it is more reliant on the electricity network operators to carry out upgrades for the same level of heat pump or electric vehicle deployment as the Consumer Led 2040 or Net Zero 2040 scenarios.

The centralised approach to Network Led means rather than relying on heat network areas generated in this analysis areas determined by an interim run of the DESNZ heat network zoning tool. This is meant as an indicative scenario rather than a finalised pathway, representing what the most detailed national view available at the time would mean for heat network deployment. This national model is being updated and, like the other scenarios, would require local review, either through the Advanced Zoning Programme or a Phase 2 LAEP.

The reliance on upgrading the electricity networks and deployment of new heat networks results in a slower decarbonisation trajectory than Net Zero 2040 or the Consumer Led 2040 scenarios. The centralised nature of the scenario means a greater responsibility sits with government (with an increase in central and regional due to the cross-borough nature of heat networks) and network operators (such as UK Power Networks and potential partners to deploy extensive heat networks).

3.5.5 Summary of scenario variations

A summary of the main assumptions for different scenarios is provided in Table 3—1. It is important to reiterate that these scenarios are to test different decarbonisation considerations and a final scenario should be selected by boroughs. There is a generally high level of commonality between various scenarios, this is in part due to the exclusion of hydrogen which limits the technology choices available.

Table 3—1 Summary of key elements of different scenarios.

Theme	Accelerated Green 2030	Base Case 2050	Net Zero 2040	Consumer Led 2040	Network Led 2040
Heat networks	High level of heat network connections. Supported by identification and deployment in heat network zones. Aims for 460,000 connections across London by 2030.	Longer period for decarbonisation gives more opportunity for heat network connection. Larger heat demands more likely to connect. Heat network areas are based on zones identified in this analysis.	Larger heat demands more likely to connect. Heat network areas are based on zones identified in this analysis. Centralised push to heat networks encourages early uptake.	Focus on large heat demands. Houses and small flats having an increased likelihood of pursing individual heat pumps compared to Net Zero 2040. Heat network areas are based on zones identified in this analysis.	Follows DESNZ zoning and focus on large demands. Means heat networks are focused on where they are the most economic solution (including gas) not necessarily when it is the most cost effective or easiest to deploy decarbonisation option.
Building and property level heat pumps	Very high early uptake – with 2.2 million across London in 2030. At the time of setting the targets equated to fastest possible deployment without scrappage	High level of uptake. Heat pumps are still selected in properties in heat network areas. This includes a focus on communal systems (due to the long lead time for heat networks).	High adoption particularly in the domestic sector, more emphasis towards heat networks in the non-domestic sector than Consumer Led.	High level of adoption in most areas, this includes heat network areas due to higher drive of individuals (domestic and non-domestic) to decarbonise early.	Heating technology outside of DESNZ zones and for buildings with below 100 MWh/yr heat demand in zones. Outside of DESNZ zones flats and non-domestic buildings with multiple properties will generally adopt communal technology.
Retrofit	Very high level of retrofit. Much of this is deep retrofit to achieve the very high levels of heat demand reduction targeted (37% for domestic and 39% for non-domestic by 2030).	Incremental retrofit occurs (from consumer choice) more than other scenarios – due to extended period for decarbonisation. Slightly lower drive for retrofit (compared to other scenarios) but still a high level of adoption.	High levels of retrofit improvement to allow for early decarbonisation. This provides some interim decarbonisation for properties that will connect at a later time to heat networks.	High levels of uptake based on consumer choice, this is initially based on those able to pay. Or where grants are available. Often combined directly with other measures such as heat pumps adoption.	Relatively lower push for retrofit (but still high), with a focus on minimal requirements for low carbon heating technologies to function effectively.
Transport	27% reduction in car mileage and high EV uptake – supported by public charging infrastructure.	Follows the most ambitious national scenario for EV adoption and has a 23% reduction in total car mileage by 2050.	27% reduction in mileage occurs quickly from behavioural change. High adoption of electric vehicles by 2040 – slightly exceeding most optimistic national scenarios.	27% reduction in mileage occurs quickly from behavioural change. High adoption of electric vehicles by 2040 – slightly exceeding most optimistic national scenarios.	Slower behavioural change than Net Zero 2040 and Consumer Led 2040 scenarios but high adoption of electric vehicles by 2040. Marginally less overall mileage than Net Zero 2040 or Consumer Led 2040 (25%)
Renewables	High level of uptake in line with mayoral target (1 GW across London) in 2030 and 3.9 GW by 2050.	In line with Mayoral targets – this is lower at scenario end point than Net Zero 2040 and Consumer Led 2040.	High levels of renewable deployment. Focusing on hitting the 3.9 GW 2050 Accelerated Green solar target by 2040. This is to maximise carbon and operational savings.	High levels of renewable deployment. Focusing on hitting the 3.9 GW 2050 Accelerated Green solar target by 2040. This is to maximise carbon and operational savings.	In line with Mayoral targets – this is lower at scenario end point than Net Zero 2040 and Consumer Led 2040.
Electricity networks	High levels of demand side	Lower levels of behavioural	High level of flexibility from greater	High level of flexibility from greater	Lower levels of behavioural change

and flexibility	response and flexibility, helping to reduce near term electricity network upgrades.	change reduce the impact of flexibility.	engagement with the energy system.	engagement with the energy system.	reduce the impact of flexibility.

3.6 Non-2030 Scenario outputs

This section presents an overview of the different scenarios. More geographically tied items are presented in section 4, with next steps and actions.

The numbers presented for Net Zero 2040 in this section are generally true for the 2030 or Net Zero 2040. They values presented focus strongly on a scenario end point so the technology choices remain the same but the speed of deployment changes.

Heating systems represent one of the largest changes for energy system decarbonisation. The deployment pathway modelled for the Net Zero 2040 scenario is provided in Table 3—2. To view this in the context of the Mayoral 2030 scenario the 2035 values need to be achieved in 2030 and the 2040 in 2035.

Table 3—2 Number of major heating system changes for the Net Zero 2040 scenario for three different periods in the scenario.

Technology	2030 cumulative new installs	2035 cumulative new installs	2040 cumulative new installs
Low carbon heat network	213,000	367,000	711,000
Low carbon communal	49,000	109,000	196,000
Property level heat pumps	281,000	407,000	833,000

The deployment represents a build up of support and strategy in the years to 2030 but still with substantial deployment. Key elements of this strategic work are network based, ensuring the electrical network is in place to support electrification, and alongside this heat networks are progressing through feasibility to ensure a constant pipeline of deployment. This provides the foundations for continued ramp up through the 2030s, which is relatively constant to hit 2040 (in line with heating systems reaching the end of their functional life and avoiding scrappage).

One of the core differences between scenarios is the uptake of different heating technologies, these are presented in Figure 3—6 and Figure 3—7.

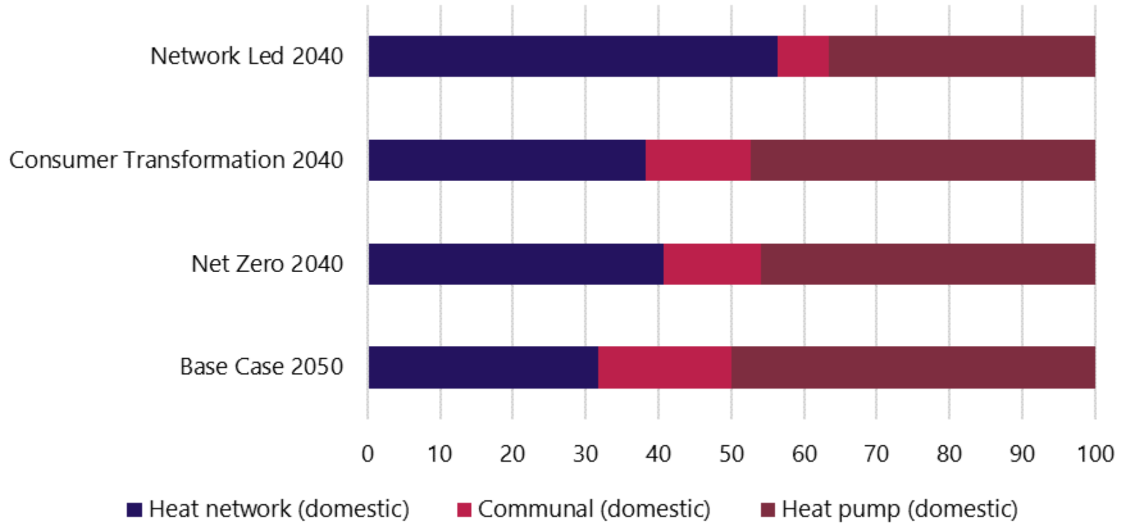


Figure 3—6 Percentage share of domestic properties switching to different low carbon technologies.

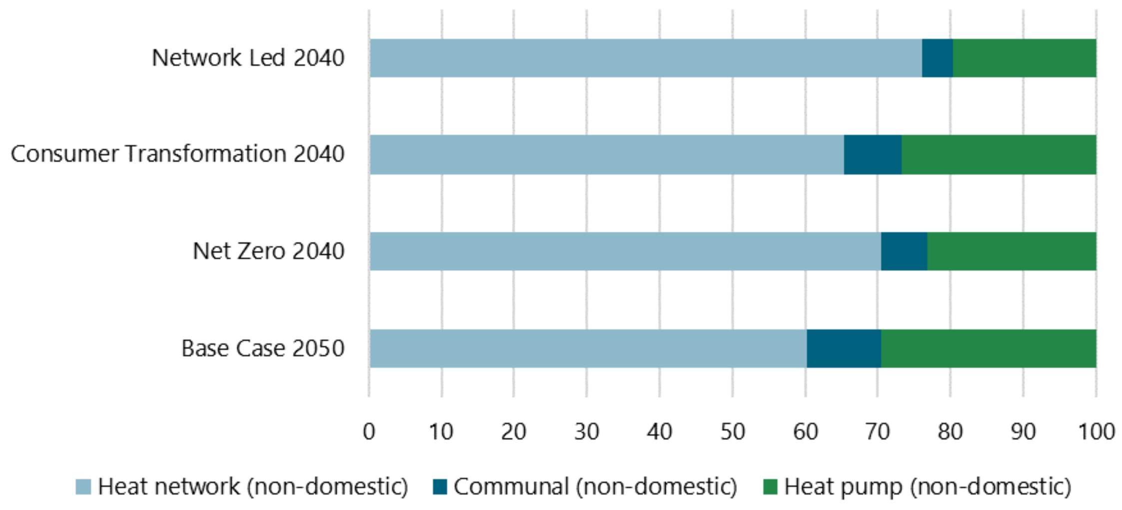


Figure 3—7 Percentage share of non-domestic properties switching to different low carbon technologies.

Heat networks dominate the non-domestic sector in all scenarios. This is driven by the high heat density and number of non-domestic properties in inner boroughs. The high number of flats in the subregion mean communal or heat network systems are the selected low carbon heat source in over 50% of the domestic properties in all scenarios as well. However, apart from in the Network Led scenario heat pumps have the highest total property counts.

Linked to the heating system are changes in building fabric efficiency. This is presented in Figure 3—8.

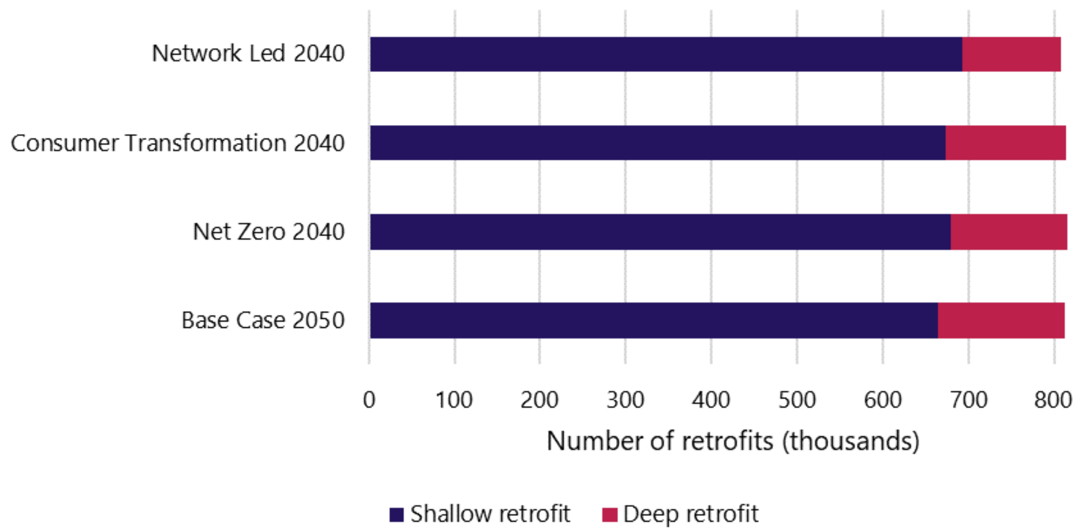


Figure 3—8 Number of domestic retrofits for the different scenarios.

All scenarios have a similar high level of shallow retrofit, with Network Led the highest and Base case the lowest, reflecting that with the introduction of district heating many properties will not significantly need or benefit from retrofitting.

In the Baseline scenario fabric retrofit allows for some earlier decarbonisation before low carbon heating systems are adopted in place of gas boilers. This is an example of a low regrets action as it will create savings regardless of which low carbon heating system is selected. Whilst the modelling identifies a high number of deep fabric retrofits this may not be preferable as in many instances a shallow retrofit will be sufficient. This is likely to become increasingly the case as technologies continue to improve.

Both the Net Zero 2040 and Consumer Led 2040 scenarios have a high number of shallow retrofits but low levels of deep retrofit. This reflects that shallow fabric improvements often represent the best return on investment and are frequently suitable to allow for low carbon heating technology.

The poor availability of EPC data, and the lack of detail about the specific building element condition for the non-domestic sector means the number of shallow and deep retrofits are very similar across all scenarios, with 115,500 shallow and 1,400 deeper retrofits identified. Insights form the Westminster Phase 2 LAEP indicate higher levels of fabric retrofit are required in the borough due to the large presence of historic buildings, this is captured in the retrofit costs later.

The transport elements of the scenario testing are very similar across all scenarios, aligning to the highest ambition national scenarios in terms of car number reduction. The main difference being the timings of EV uptake which are more visible in the carbon emissions (section 3.6.1). Final charger numbers for standard vehicles are presented in Figure 3—9 and Figure 3—10 for car parks and the split between on and off-street parking respectively.

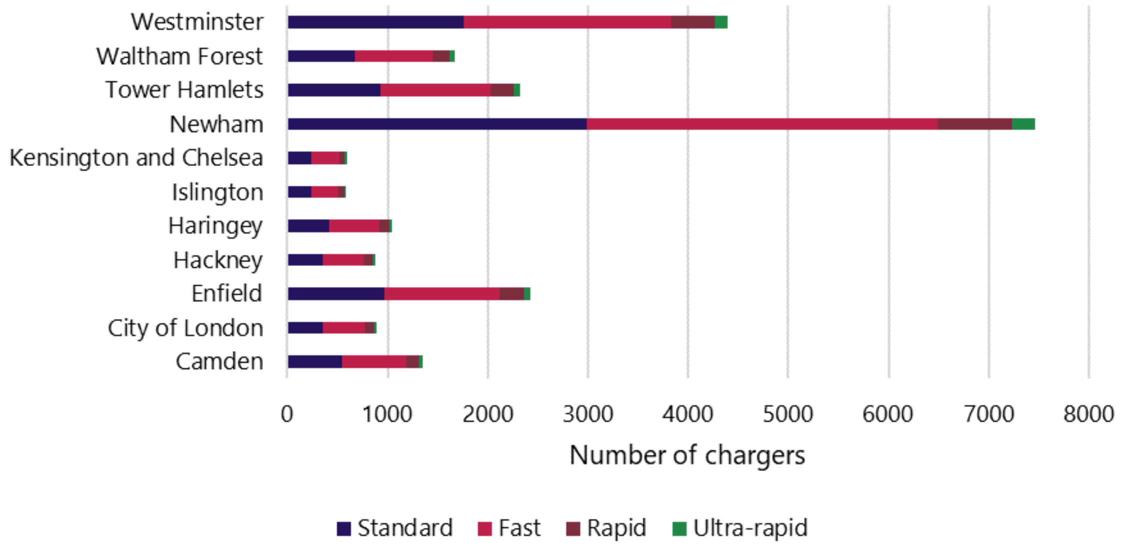


Figure 3—9 Car park chargers by borough under the Net Zero 2040 scenario.

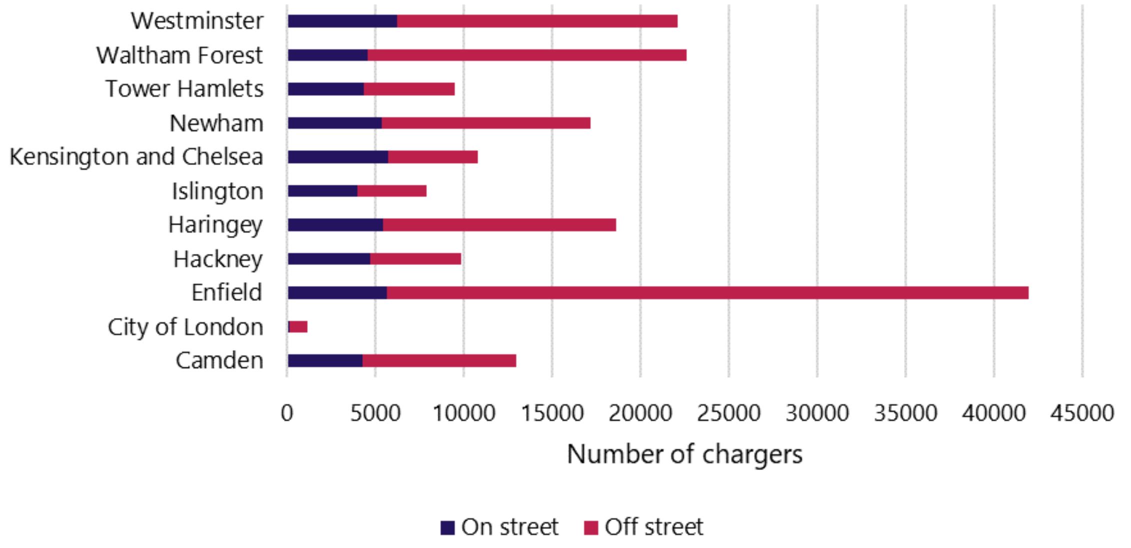


Figure 3—10 On and off street charger numbers by borough under the Net Zero 2040 scenario.

Off-street charger numbers are determined by the presence of driveways alongside car ownership values. The lower cost of charging at home being a determining factor. These off-street chargers are most prevalent in the less urban boroughs, which makes on street chargers most important in the more urban areas. This highlights the importance, particularly in inner boroughs, of making EV charge points publicly available.

The large number of car park based EV chargers in Newham is in a large part due to City Airport parking. It highlights the need for a specific strategy in the area as this is likely to be a significant drain on the local grid, with one site having more car park chargers than the majority of boroughs.

Chargers at car parks will represent a significant local power draw. With a fast charger representing the power draw of at least three standard home based off street chargers.

Renewable capacity is the last item summarised. Deployment follows one of two scenarios with Net Zero 2040 and Consumer Led 2040 having the highest levels of PV deployment. As with transport this, is presented at a borough level, with attention given to the different sizes of the scheme. Figure 3—11 and Figure 3—12 provide details of how the PV capacity is split across the subregion. The top graph relating to baseline scenario, and the lower for network led.

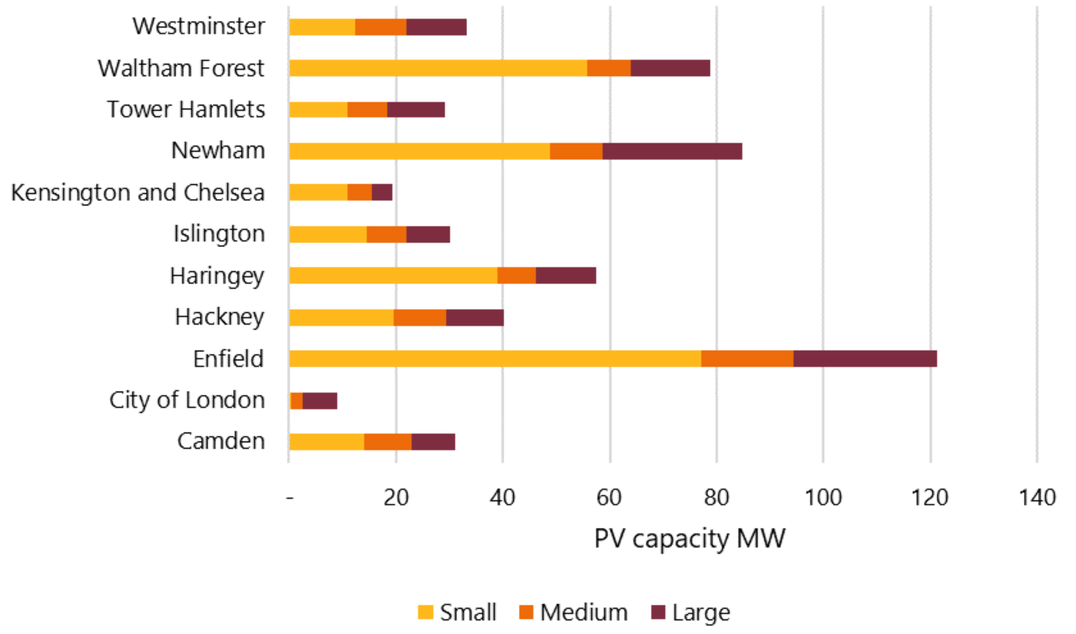


Figure 3—11 PV capacity in 2040 per borough for the Baseline and Network Led scenarios.

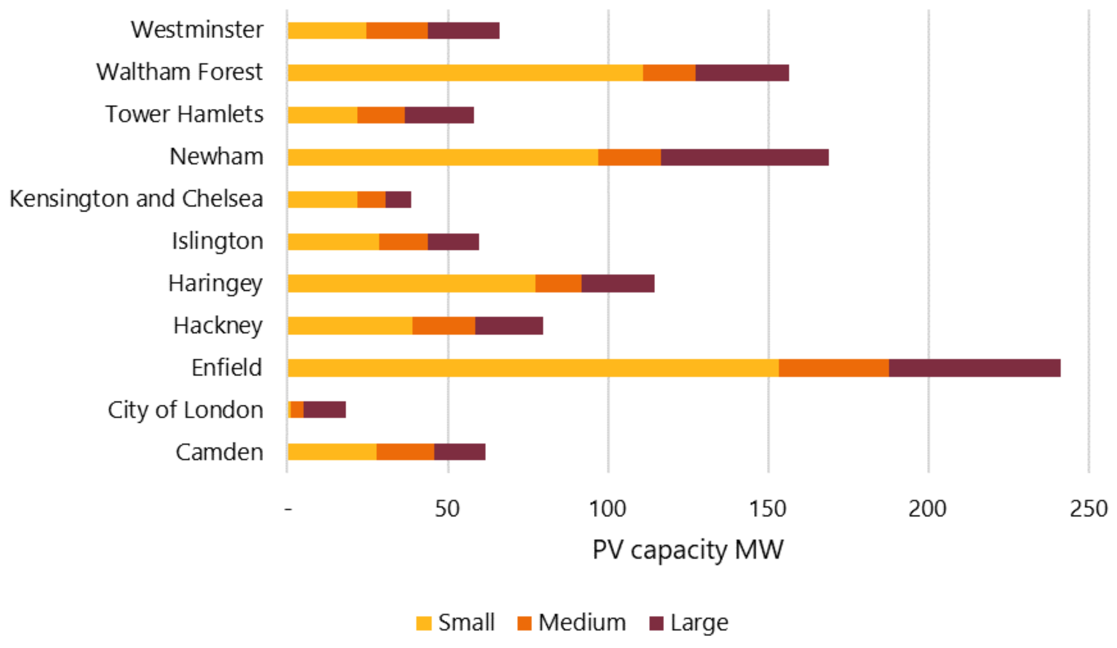


Figure 3—12 PV capacity in 2040 per borough for Net Zero 2040 and Consumer Led 2040 scenarios.

This level of PV deployment represents over an order of magnitude increase from the present day. It is important to note that alongside some carbon savings the main reason PV is so central to scenarios is it represents a significant operational saving. The electricity used from PV panels avoids the need to purchase electricity. This is a high saving, particularly in a domestic context, where Green Book figures indicate that electricity prices will not fall below 20 p/kWh.

If the target is missed, the main impact will be on the energy system's operational costs, as the 1.1 GW of installed PV capacity in Net Zero 2040and Consumer Led 2040 accounts for ~10% of the total electricity demand across the boroughs in 2050. The carbon savings are relatively small, with the electricity grid rapidly decarbonising over this time period.

PV generation is variable, with output being higher in summer. This can mean high stress can be placed on the grid during sunny periods, if high volumes of electricity are exported. For this reason, areas where peak electricity demand is currently in the summer are targeted for deployment – meaning power generated is used locally. Battery installation is generally cost effective to maximise the use of PV meaning the power generated can be used on site. The battery installations are also of use during winter periods, allowing for cheaper night tariffs to be effectively accessed.

3.6.1 Carbon emissions

The carbon emissions are very similar for the three scenarios which hit net zero by 2040, this is illustrated in Figure 3—13.

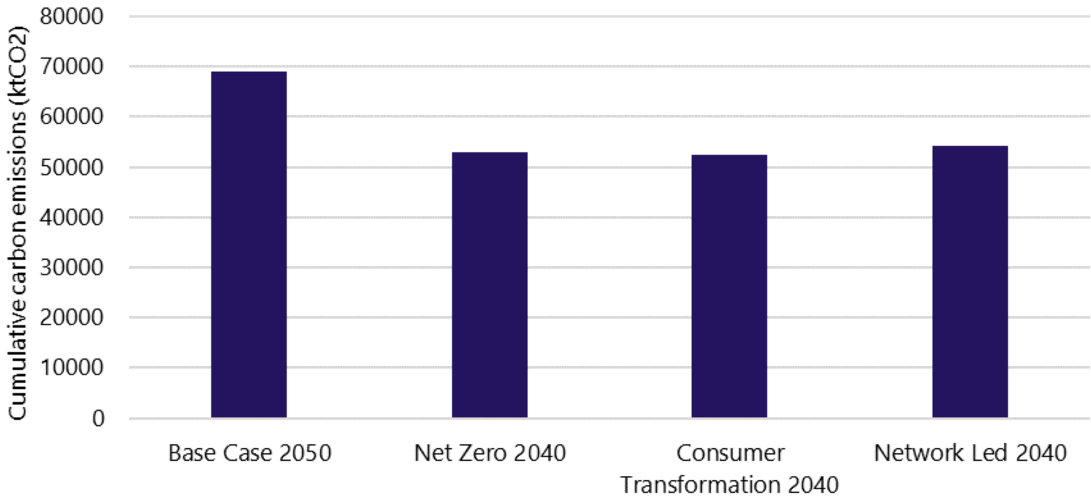


Figure 3—13 Cumulative carbon emissions from fuel consumption per scenario from present to 2050.

Although it hits net zero 10 years later the cumulative emissions are ~25% higher in the Base Case 2050 scenario. A large number of actions are taken in the early years, including the transport sector, and the ongoing decarbonisation of the electricity grid. Consequently, if different boroughs adopt different net zero target dates (as is indicated by the review of local targets) the impact on subregional carbon emissions will be somewhat mitigated.

If a borough is aiming for a 2050 decarbonisation scenario, variations on the Baseline could be explored. This could include considering additional technologies, a key one being hybrid heat pumps. This maintains a gas connection whilst using a heat pump, this is likely to be most suitable in non-domestic contexts, communal systems and in larger houses. Technologies like this can enable intermediate carbon reduction, reducing the increase in total cumulative emissions.

Embodied carbon is considered alongside operational carbon. This is reported in Figure 3—14, it should be noted this is an indicative estimation only at this stage.

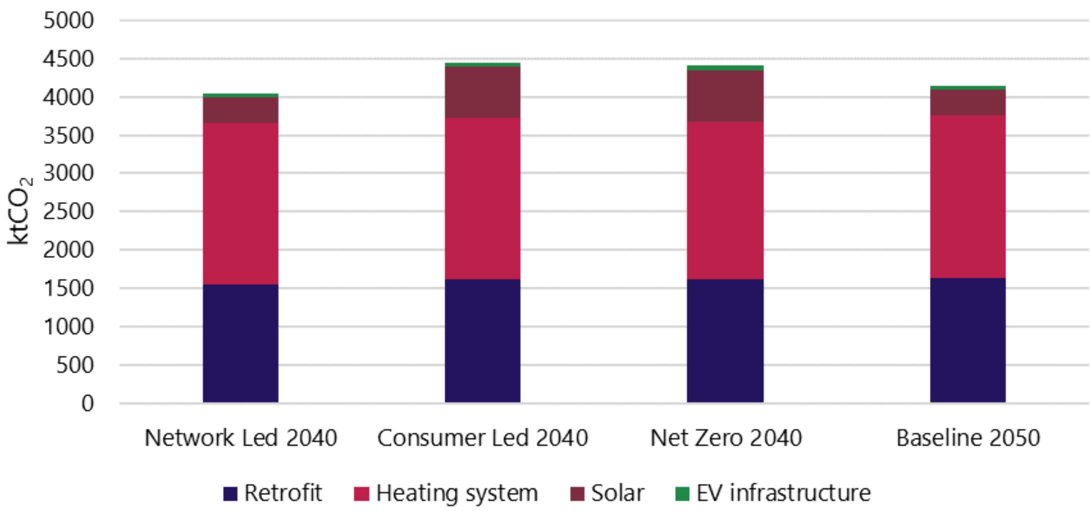


Figure 3—14 Embodied carbon for different scenarios.

The embodied carbon is at least an order of magnitude less than the operational carbon to 2050. It should be noted that as with other elements of the costings in this report replacement costs are not included, only new equipment – such as a switch to heat pump from a gas boiler. This underlines the need to continued need to consider operational carbon as a priority.

3.6.2 Scenario costs

The different scenarios have varying costs associated with them, this is explored in Figure 3—15.

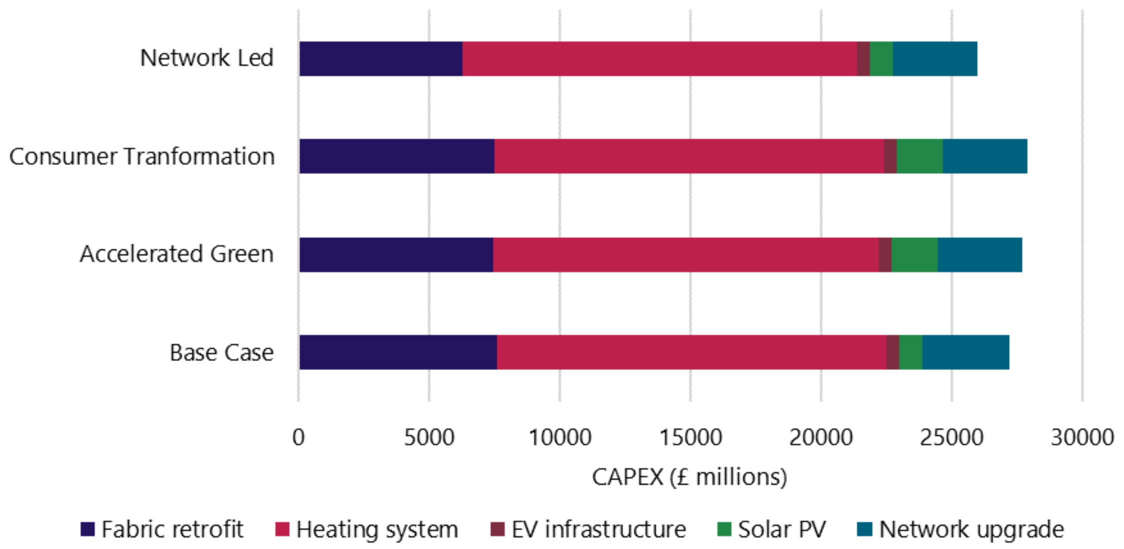


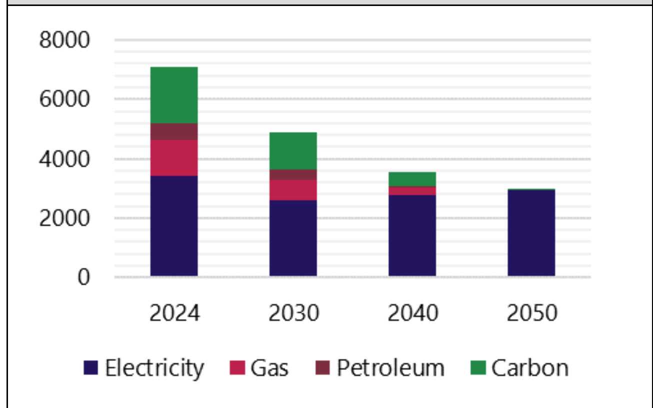
Figure 3—15 Total investment required for each scenario.

A common theme across all scenarios is that the heating system upgrades represent the largest area of investment. This is similar for all scenarios, with total spend ranging from £24.9 billion to £26.7 billion. This reflects the broadly similar technology choices across the scenarios.

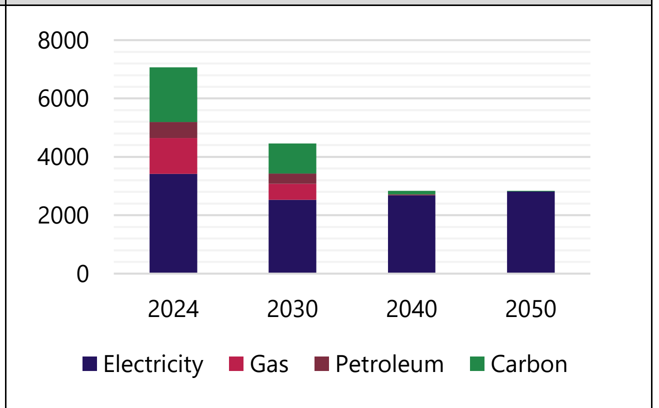
The most noticeable cost difference comes from solar PV. This is a good indication of the engagement of individuals, as the adoption of PV represents additional actions beyond the minimum for net zero. The additional costs of PV are offset by an operational saving in Net Zero 2040 and Consumer Led 2040 of ~£50-100 million a year in 2050. The saving is higher when compared to Base Case as it has a higher level of property level heat pumps than Network Led. In earlier years the saving is greater per pound spent, due to higher electricity prices.

The operational costs (£m) for the four scenarios are explored further in Figure 3—16.

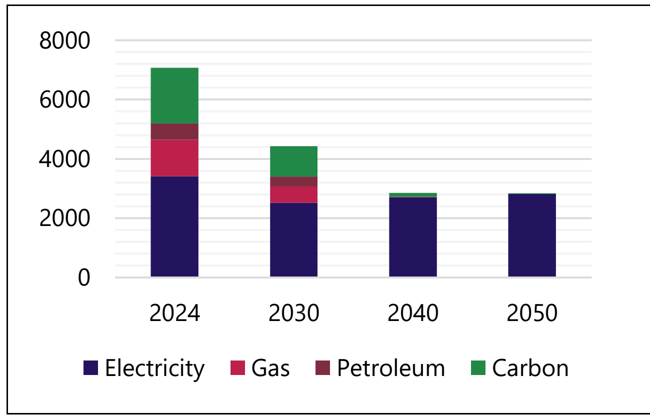
Base Case 2050



Net Zero 2040



Consumer Led 2040



Network Led 2040

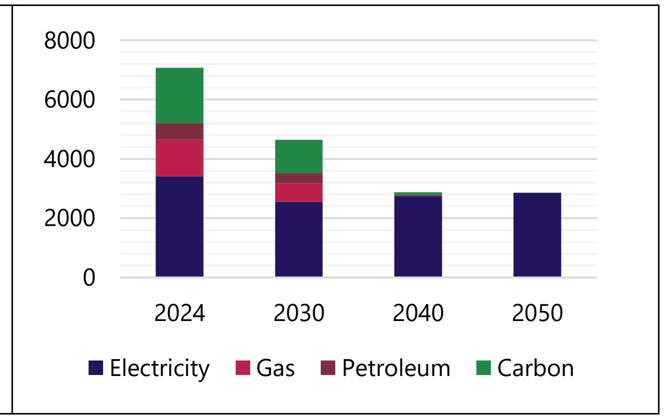


Figure 3—16 Fuel and associated costs (£ millions) for different key scenario years.

All scenarios show a steep decline in fuel costs from 2024 to 2030. Rather than LAEP actions it is the falling energy prices which are responsible for most of the change, with both electricity and gas falling to ~72% of their 2024 cost in 2030 [39].

The Baseline scenario has a noticeably higher fuel cost than the other scenarios in 2040. This is due to the faster deployment of energy efficiency measures and PV reducing demand for fuel.

3.6.3 Green economy

Future investments in energy schemes across the north sub-region have the potential to generate a significant number of jobs over the period from 2024 to 2050. To identify the scale of the impact, jobs generated have been assessed across direct, indirect and induced economic activity streams. The nature of each stream is as follows:

- **Direct**: activity happening directly on-site and within the body directly running the operations other relevant premises.
- **Indirect**: supply chain activity caused by the purchase of products and services to enable direct activity.
- **Induced**: activity generated by the expenditure of wages by on-site and supply chain employees.

To calculate direct jobs, the total value of direct gross value added (GVA) generated in each scenario was calculated by applying GVA to turnover ratios to total expenditure estimates. Subsequently, ratios of GVA per full-time equivalent (FTE) year of employment were applied to the total direct GVA estimates. Estimates of total FTE employment were then divided by the length of assessment period (24 years) to identify the average number of direct FTE jobs supported over the period. This results in the Base Case 2050, Net Zero 2040, Consumer Led 2040, and Network Led 2040 scenarios supporting an estimated 2,530, 2,810, 2,840 and 2,510 direct FTE jobs respectively.

To identify indirect and induced FTE jobs generated by direct economic activity, FTE employment multipliers were applied to the direct FTE job estimates. The multipliers are generated using Buro Happold's economic input-output model, which is regionalised using best-practice Flegg location-quotients to enable for the calculation of jobs created within London and UK. The estimates of London and UK indirect and induced FTE jobs are presented in Figure 3—17 below, it should be noted the UK estimate includes the indirect and induced jobs supported in London.

[39] This is based on an average of domestic and commercial prices from the central scenario in the Green Book https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

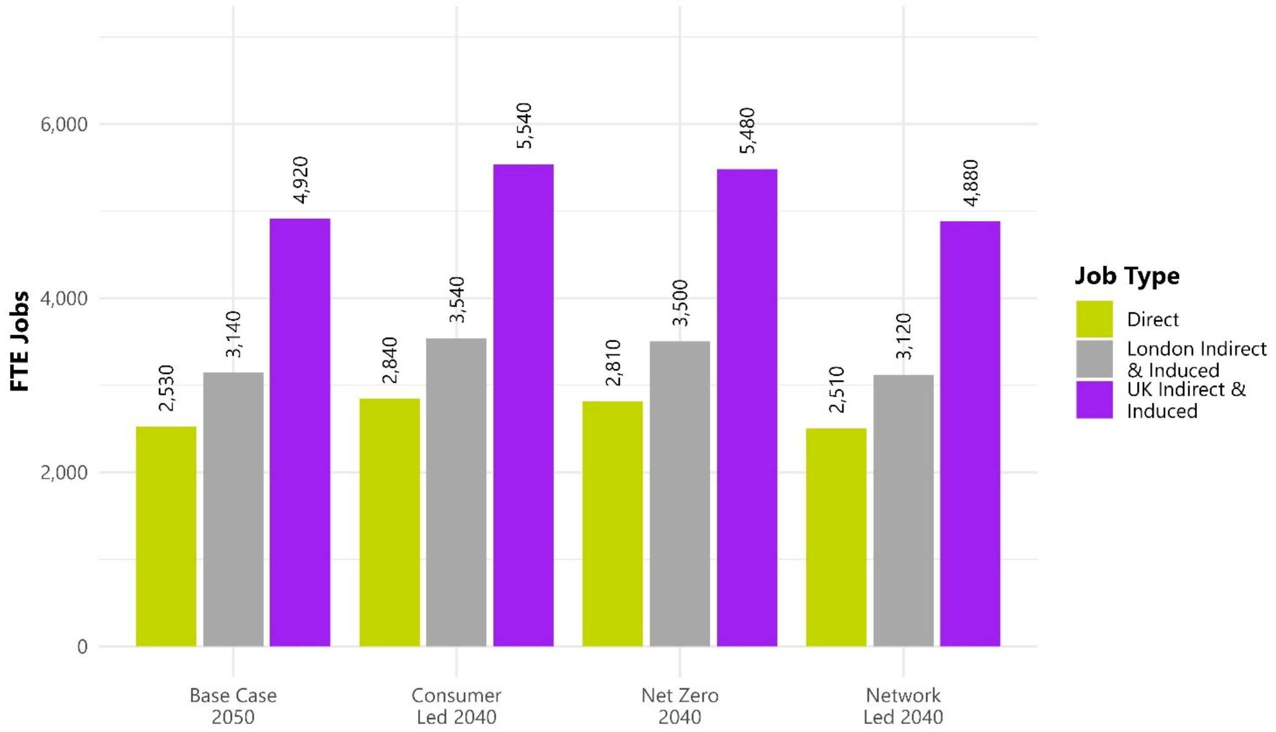


Figure 3—17 Total jobs by scenario.

At the UK level, the Base Case 2050, Net Zero 2040, Consumer Led 2040, and Network Led 2040 scenarios are estimated to support 10,590, 11,790, 11,920 and 10,510 direct, indirect, and induced FTE jobs respectively between 2024 and 2050. The higher number of jobs supported by the Net Zero 2040 and consumer led scenarios indicates a greater employment impact can be generated by following a faster decarbonisation pathway – albeit, at a higher up-front cost.

To identify the green jobs directly created by the investment, the types of proposed interventions were assigned to WPI Economics green economy sub-sectors where appropriate. The assignment was based on a process of reviewing the descriptions of activities included in each sub-sector and the nature of intervention. Figure 3—18 shows the results of the process. Overall, the Base Case 2050, Net Zero 2040, Consumer Led 2040, and Network Led 2040 scenarios are estimated to generate 2.010, 2,320, 2,340 and 2,000 direct FTE green jobs respectively over the assessment period; thereby, having a significant positive impact in developing the green economy of the north sub-region.

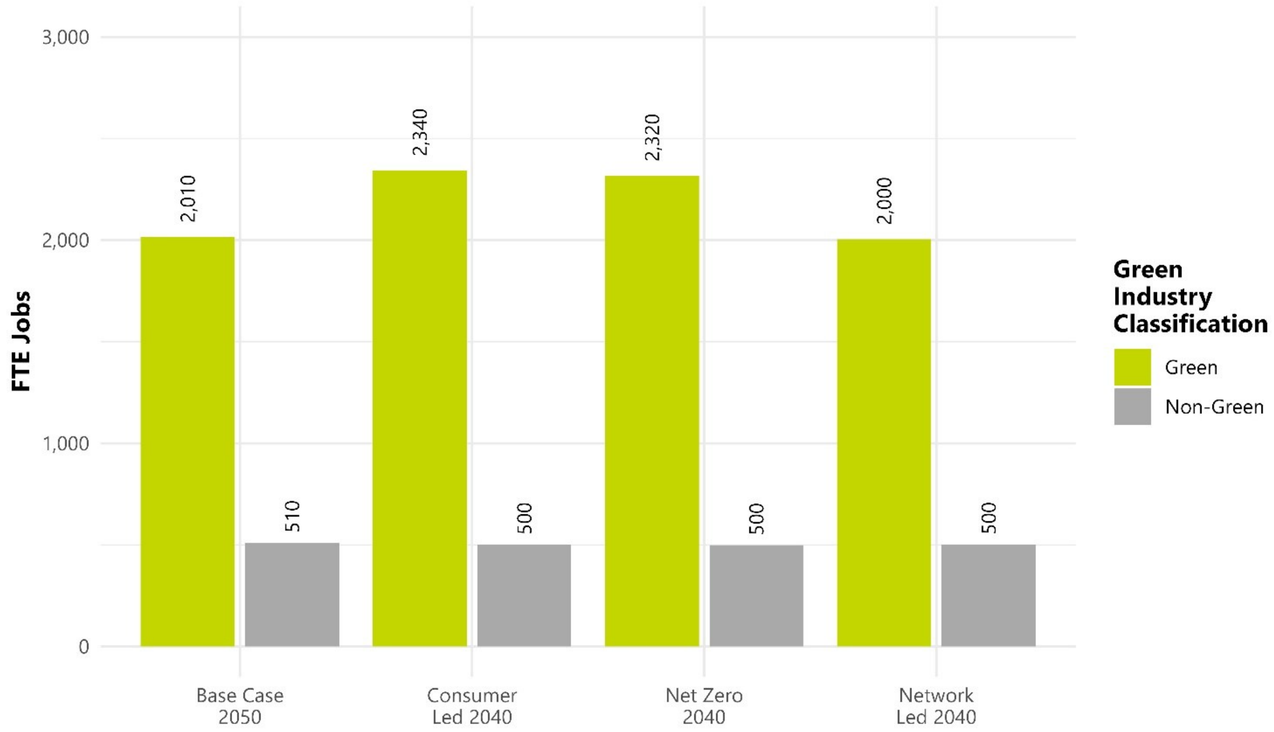


Figure 3—18 Direct jobs by scenario and green industry classification

As noted in sub-section Green Labour Supply2.4.2, the green economy can be defined not only by industries but also by occupations. To address this, the direct jobs created in each scenario have been divided into green and non-green economy occupations. This division employs the same methodology used for calculating the existing resident green labour supply in sub-section Green Labour Supply2.4.2.

The results, presented in Figure 3—19, indicate a lower level of green job creation compared to the industry-based approach. This demonstrates how different definitions of the green economy can lead to varying estimates of green and non-green jobs. For this study, the industry-based green job results shown in Figure 3—18 are considered more appropriate, given the nature of the proposed interventions. However, the occupational results remain useful, as they provide insights into the qualifications that may be required for future green jobs.

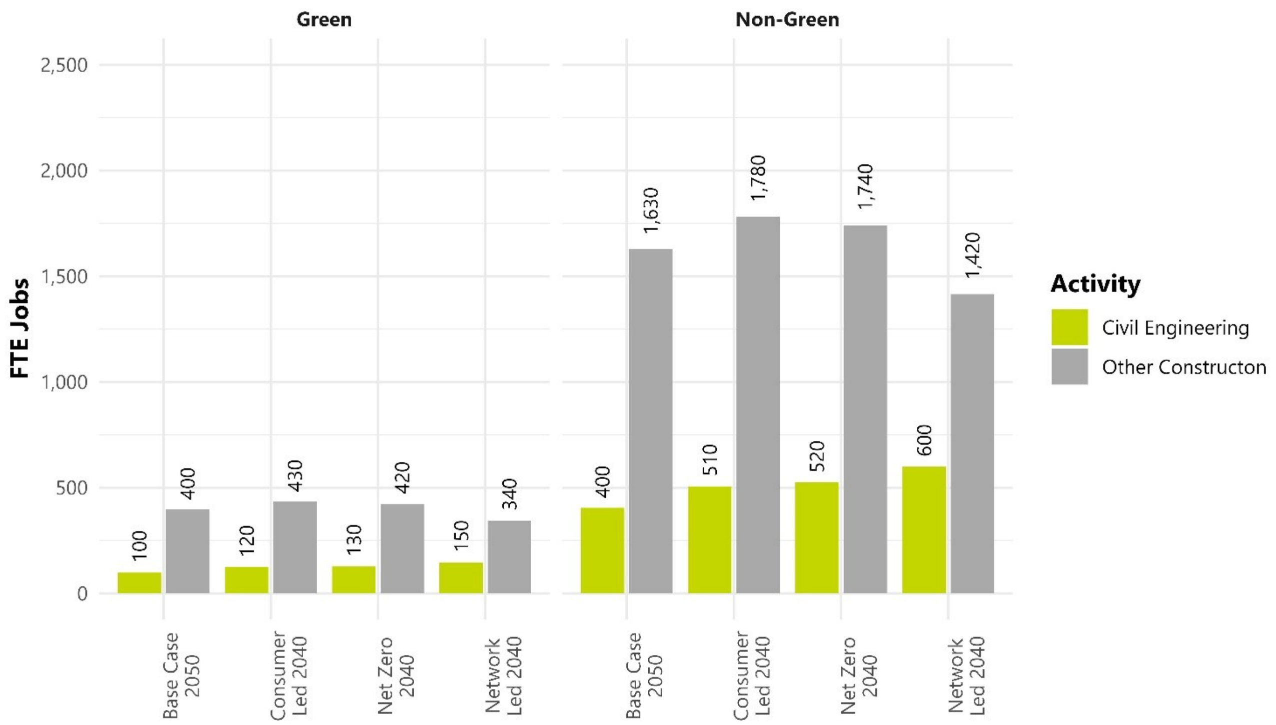


Figure 3—19 Direct jobs by scenario and green occupational classification

Figure 3—20 below identifies the proportion of jobs by qualification requirement in green and non-green occupations. This is created by applying a qualification level by 1-digit SOC proportions from the Census 2021 to the direct jobs by occupation results. The chart shows that green occupations have higher qualification requirements. In all scenarios, 54% of jobs in green occupations are associated with level 4 or above qualifications, whilst non-green occupations sit at 47%. This indicates the overall qualification level for green jobs may be higher and a potential need to upskill workers if the available supply to fill those jobs is not qualified to the right level.

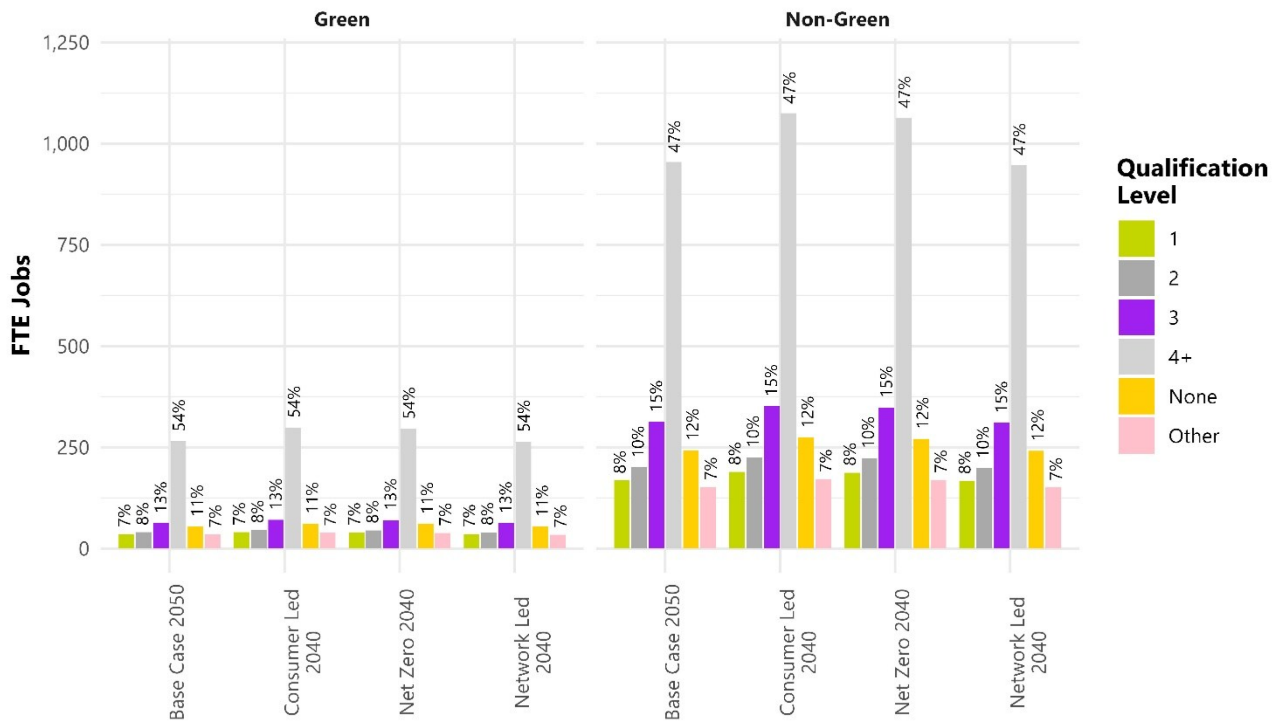


Figure 3—20 Direct Jobs by Scenario, Green Occupational Classification and Qualification Requirement

It should be noted that this analysis of qualification requirements is a snapshot of potential future requirements. Other data sources (e.g. Higher Education Statistics Authority Student Outcomes), occupation to qualification mappings and methodologies exist that can enable for a more detailed examination of future qualification and skill requirements in the green economy. These sources can also be used to look for a detailed look at the supply and demand of labour, resulting in a final gap analysis.

3.6.4 Additional benefit

Investment in new energy schemes will generate additional value in the local, regional, and national economies. To assess the impact, the value of direct, indirect, and induced GVA generated in each scenario has been calculated. This is done by combining ratios of GVA to turnover to planned expenditure over the assessment period, resulting in total direct GVA. Economic multipliers from Buro Happold input-output model are then applied to the direct GVA results for each scenario to calculate indirect and induced GVA generated within London and wider UK respectively.

Figure 3—21 presents the GVA results. The Base Case 2050, Net Zero 2040, Consumer Led 2040, and Network Led 2040 scenarios all generate a large amount of GVA (£25.9 billion, £29.5 billion, £29.6 billion, and £27.5 billion respectively), thereby, making a significant contribution to the UK economy,

Alongside job creation and helping to mitigate climate change the decarbonisation scenarios have additional benefits. These include improving air quality, which brings health benefits and associated savings for health services. At a consumer level the pathways will help reduce fuel poverty, improve resilience to the impacts of climate change (such as heat waves) and improve comfort in the home (this is not only thermal but also factors like noise and damp due to improved insulation).

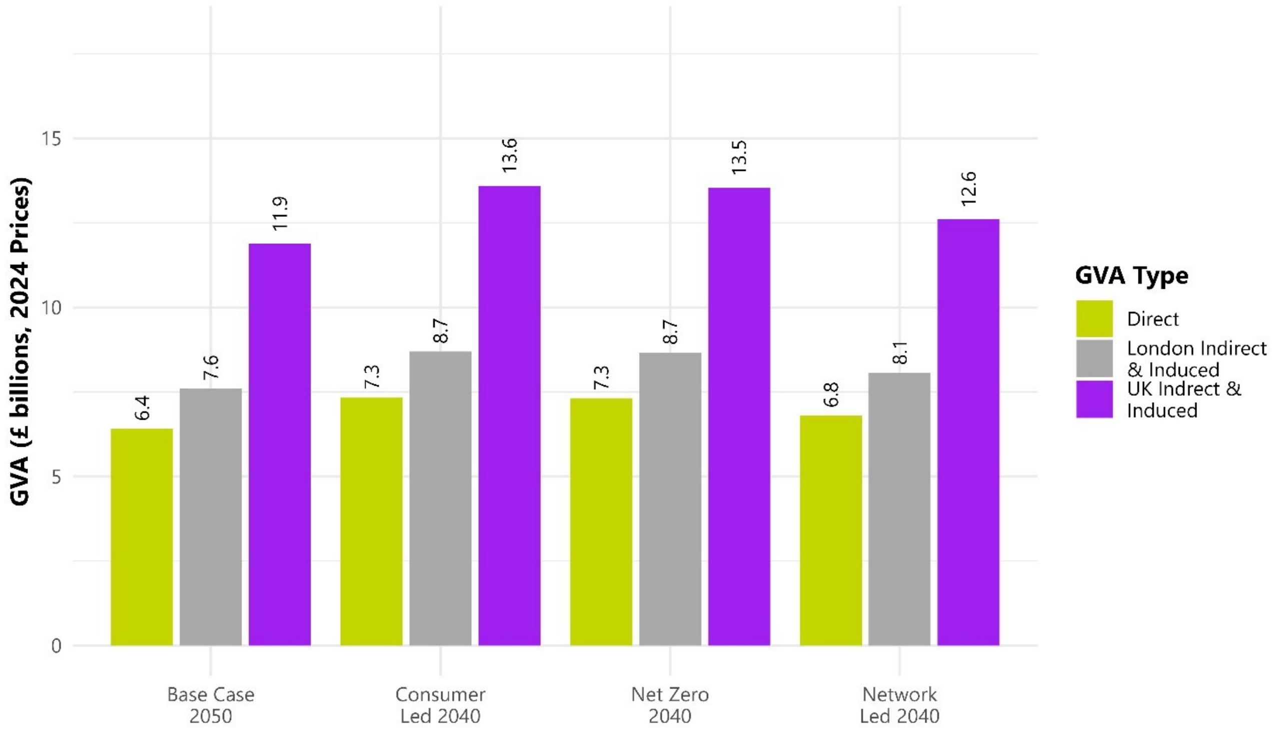


Figure 3—21 Total GVA by scenario future growth and climate.

3.6.5 Growth – planning and population

The LAEP does not only consider decarbonisation of existing energy demands but also future demands. A summary of these is provided in Table 3-3 growth until 2040 and in Table 3-4 for growth to 2050, as a function of housing, commercial and population projections.

Table 3-3 Planning and population growth by borough by 2040 (between now and 2040).

Borough	Projected new housing by 2040	New housing estimated GIA m²	New commercial GIA m²	Estimated electricity demand by 2040 GWh
Camden	9,044	648,433	1,438,194	269
City of London	1,423	86,969	3,795,221	578
Enfield	9,943	849,121	269,313	82
Hackney	9,351	659,226	334,489	93
Haringey	8,706	596,353	288,940	76
Islington	8,638	603,772	250,347	84
Kensington and Chelsea	7,475	491,113	242,322	87
Newham	12,667	805,626	1,068,938	212
Tower Hamlets	51,444	2,999,167	2,325,765	484
Waltham Forest[40]	27,000	1,771,200	52,000	87
Westminster	9,935	624,882	1,549,169	335
Total	**155,626**	**10,135,862**	**11,614,698**	**2,387**

Table 3-4 Planning and population growth by borough by 2050 (between now and 2050).

Borough	Projected new housing by 2050	New housing estimated GIA m²	New commercial GIA by 2050 m²	Estimated electricity demand by 2050 GWh
Camden	14,696	3703	2284190	430
City of London	2,313	141324	6027704	920
Enfield	16,157	1379821	427732	132
Hackney	15,195	1071242	531248	149
Haringey	14,147	969074	458905	122
Islington	14,036	981129	397610	135
Kensington and Chelsea	12,147	798058	384864	140
Newham	20,584	1309142	1697725	339
Tower Hamlets	83,596	4873647	3693862	775
Waltham Forest[41]	27,000	1771200	140553	108
Westminster	16,144	1015434	2460445	536
Total	**236,015**	**15,363,774**	**18,504,837**	**3,786**

Growth data draws on several sources. This includes information from the Planning London DataHub[42] and the National Grid Future Energy scenarios. The approach taken was to select the highest number for new demands (to ensure sufficient capacity). The Planning London DataHub provided a higher number of new demands in total, justifying this approach. During the stakeholder engagement process, boroughs also provided local plan information and additional insights which were used as a cross check for this data. Reviews by borough officers also helped avoid any major omissions. These insights were included in the analysis but are not presented in fine resolution mapping, to avoid issues relating to confidentiality and project status. Assumptions were made regarding floor area and use type if none was available. This allowed industry standard benchmarking to be applied to different demand typologies.

Developments will also have impacts on non-building demands, such as EV charging. These are captured in various EV and related infrastructure projections.

More detailed Phase 2 LAEPs should capture data in greater detail. For example, specific planned developments will often be trigger points for decarbonisation opportunities such as heat networks.

A key assumption for all new developments is they are already net zero compliant. This is an important requirement of a net zero future. There are already enough challenges related to decarbonising the existing building stock without adding additional requirements for net zero retrofit.

3.6.6 Future climate

Global warming is assumed to result additional cooling demand across all scenarios. Assumptions behind the quantity of cooling are taken from the National Grid Future Energy Scenarios. This aligns to national projections and equates to ~650 GWh of additional cooling demand in 2050 for the subregion. Cooling is a major issue that should be explored in more detail, with cooling poverty raised as an issue in the borough engagement sessions. The UK Government are updating base assumptions in the light of climate change adaption requirements. This is likely to cause an increase in cooling demand beyond that modelled here. Phase 2 borough specific LAEPs could explore this in more detail.

[40] Waltham Forest values are based on the recently published local plan https://www.walthamforest.gov.uk/sites/default/files/2024-02/LBWF_LocalPlan_LP1_Feb2024_compressed.pdf

[41] The domestic figures are based on planning data the publication of the Local Plan for Waltham Forest the figures do not provide any domestic growth beyond the 2040 timeframe. The 27,000 new domestic units is higher than any other publication hence no increase in domestic numbers from 2040.
[42] Provided by the GLA

3.6.7 Future energy demands

The LAEP results in an overall reduction of energy demand (GWh) for the subregion. This is due to the improved efficiency of electrified heating and transport. A summary of demands is provided in Figure 3—22. The demands also account for fabric improvement of properties from the retrofit analysis.

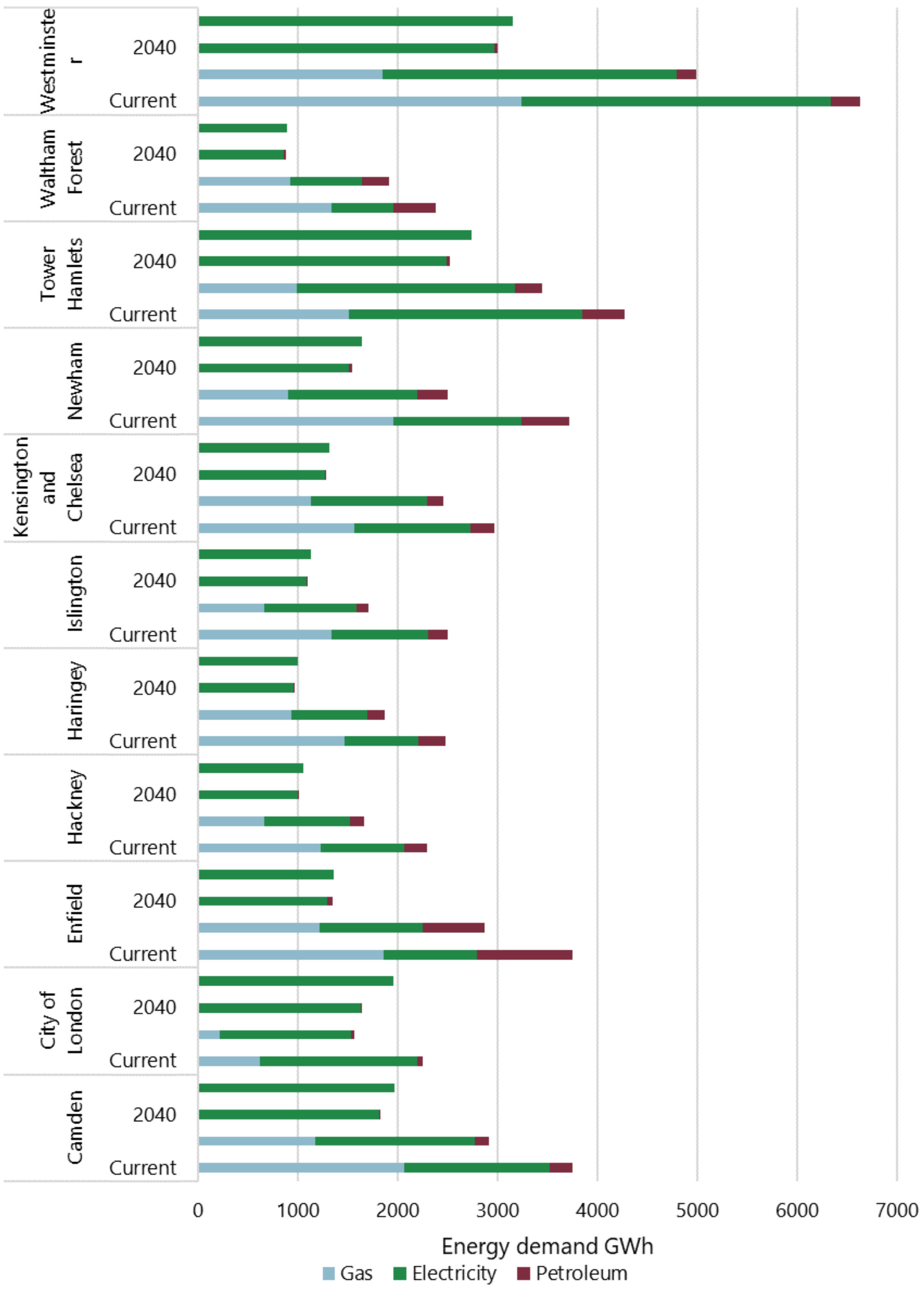


Figure 3—22 Current and projected future energy demand by fuel (gas, electricity and petroleum) for Net Zero 2040 scenario.

Global warming is assumed to result in additional cooling demand across all scenarios, with ~650 GWh of additional potential cooling demand in 2050 for the subregion (this translates to ~165 GWh of electricity to provide the cooling). The increase in electricity demand in 2050 compared to 2040 is due to increased cooling in response to climate change. This additional annual demand is ~5% of the total annual electricity demand increase.

A summary of the geographic distribution of electricity demand increase is provided in Figure 3—23. It should be noted that future large individual energy users, such as data centres, are not captured in this map unless they are accurately represented in planning data. Any contracted demand has been accounted for in the UK POWER NETWORKS data.

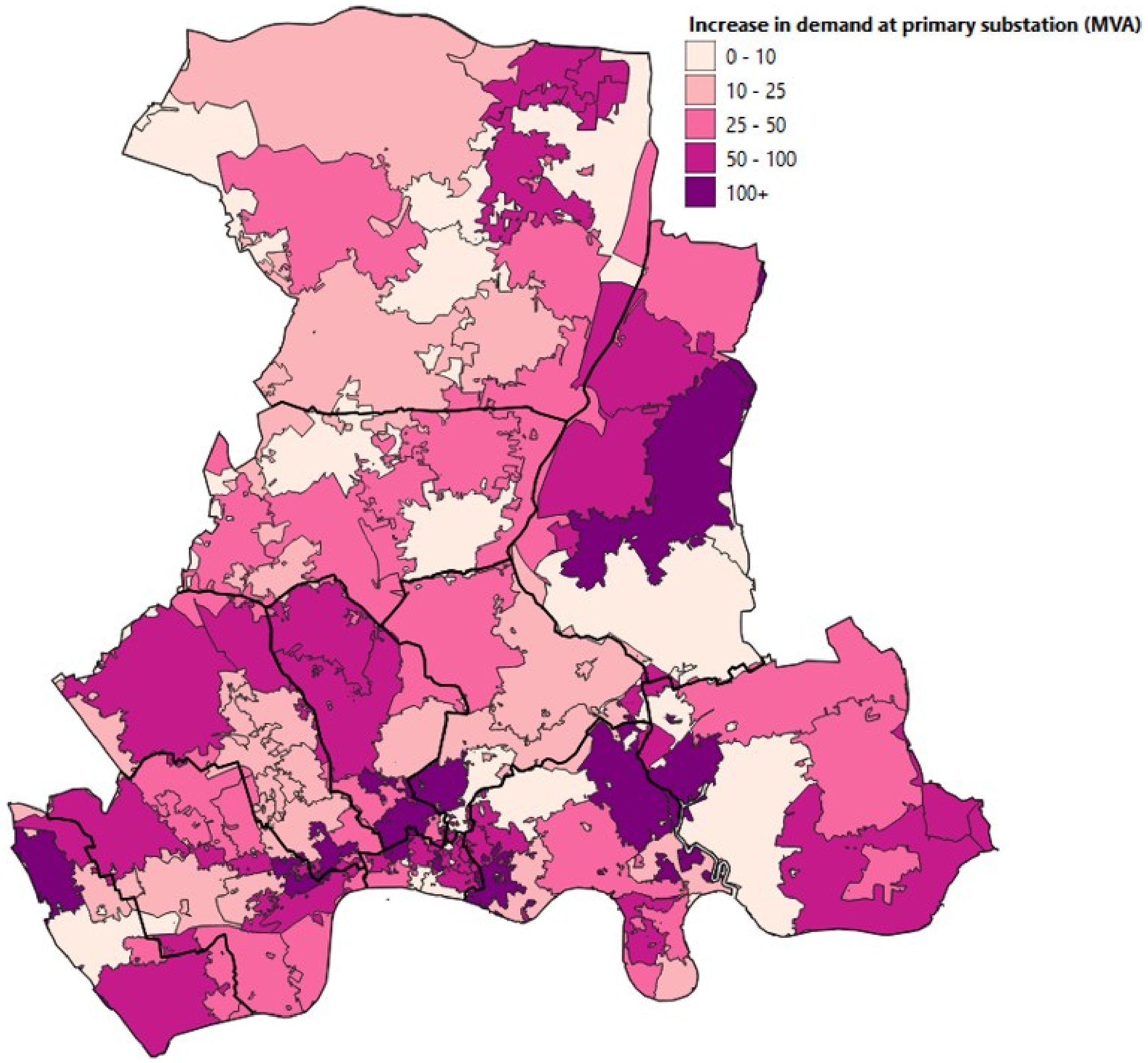


Figure 3—23 Summary of modelled MVA increase for the Net Zero 2040 scenario for different substations across the subregion.

The high concentration of increased MVA in the southern boroughs could be alleviated by broader cross borough heat network transmission. Heat networks can use waste heat sources or more efficient heat sources for heat pumps like the Thames rather than air. However, this is best explored at feasibility level. To ensure suitable provision of electricity for heat networks rather than over reliance on waste heat an efficient centralised air source heat pump heat pump is the main modelled technology[43]. Large cross borough heat sources would remove the need for some of these local pumps and reduce the strain on the grid, particularly in central areas. This is an area that should be explored in future feasibility level studies, allowing for more in depth analysis of heat sources. It is important that electrical network reinforcement should be considered alongside heat network deployment, avoiding digging up the same road twice. In the central, where utility routes are constrained this strategic approach is even more important from a technical achievability perspective.

There is precedent in other countries for large scale heat transmission networks so technologically they can be considered as available technologies. The key challenge is the scale and risk involved as well as the need to co-ordinate across multiple customers and stakeholders with significant policy uncertainty and the risk of stranded assets. As such they may be unlikely to be developed without support from government. This is a similar policy issue to the barriers to developing carbon dioxide pipelines (which move captured carbon dioxide from where it arises to long term storage sites).

[43] In the near-term gas boilers can also be important for reducing peak demand on heat networks, with hydrogen being another potential alternative in the future.

4 Decarbonisation opportunity

This section provides an overview of geographic focus areas and opportunities across the subregion for different low carbon technologies. These fall into six broad groups summarised in Figure 4—1.

	Fabric improvement – considers most cost-effective measures to allow for low carbon technology to function effectively. Links to social indicators such as fuel poverty, considering if poor efficiency is driving fuel poverty.
	Heat networks – examines opportunities at multiple scales from a communal system in a block of flats to multi borough heat networks. Incorporates national models alongside
	Heat electrification – focus on heat pumps rather than direct electric – due to the latter raising risk of fuel poverty. Targets existing gas boilers primarily, electrification of demands like cooking also considered.
	Transport – EV charging infrastructure is the focus. Other elements like increased active travel or public transport uptake are key but not examined in detail.
	Renewable deployment – focus on rooftop PV, targeting onsite usage of electricity generated. Multiple potential owners from homeowners to community groups and business to public sector.
	Flexibility and diversity of demand – key for alleviating constraints of increased electrification. Flexibility is the focus of specific actions, but diversity is integrated into the modelling

Figure 4—1 Summary of core technologies considered in the decarbonisation pathways.

Two different categories for heat decarbonisation are included in the summary table. This is due to heat decarbonisation being in many ways the most complex step in the decarbonisation strategy.

4.1 The role of scenarios in determining decarbonisation opportunities

The outputs from the different scenarios are useful for informing this strategy. When areas have the same technology choice across all scenarios this is considered a low-risk pathway, whereas different choices mean there is less certainty. This approach is key in identifying priority areas in the subsection below, helping to make the reporting timing and scenario neutral – to ensure boroughs can follow their own path for phase 2 (stages 5 to 7) LAEPs. A summary of how the scenarios are used to help identify opportunities for low carbon technology deployment is presented in Figure 4—2.

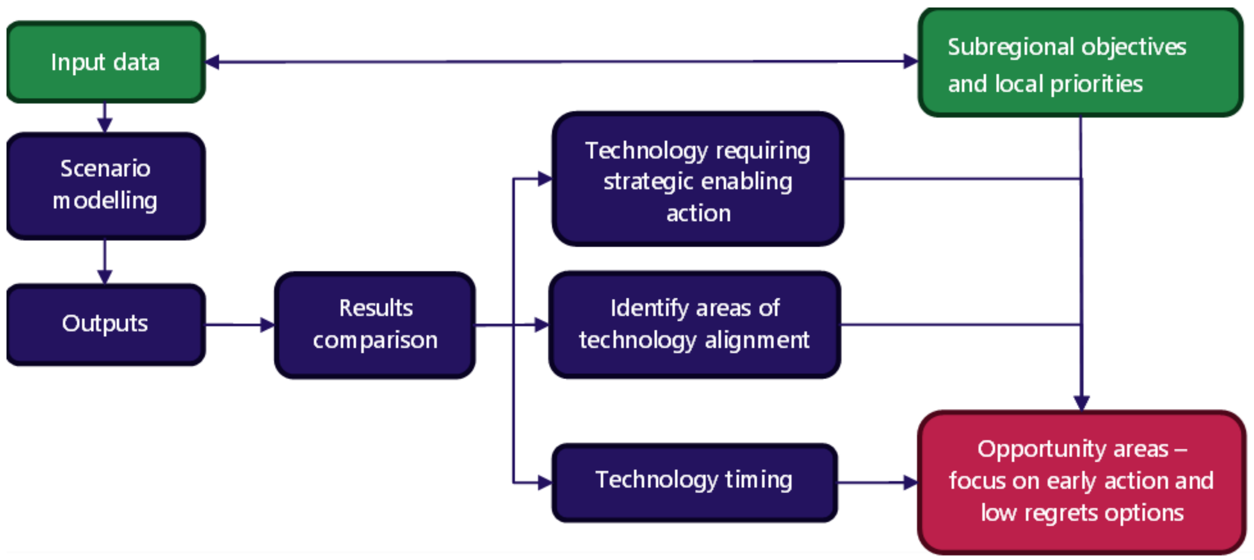


Figure 4—2 High level overview of how scenario modelling helps inform opportunity area selection

Different areas are more suited to different scenarios. A key element being the inner boroughs are well suited to the Network Led approach, where high heat density makes these a nationally significant focus for heat network deployment. Conversely, outer boroughs have larger areas that are more suited to heat pumps. Generally, the Consumer Led approach would be more suitable in these. The more active participation in the energy system will help drive down associated operating costs and through greater flexibility increase the amount of decarbonisation that can happen prior to electricity network reinforcement. The Net Zero 2040 approach acts as a hybrid between the two which allows for faster decarbonisation but as result is heavily reliant on centralised investment and strategy alongside policy and support mechanisms to help individuals actively decarbonise and engage with the energy system.

The Base Case has a longer lead time allowing for more incremental choice by consumers to decarbonise. There is still a strong strategic element for technologies, like heat networks, but also greater opportunity for intermediate decisions. This includes a greater level of retrofit without deployment of new low carbon heating alongside the improvement.

4.2 Fabric retrofit

Fabric retrofit is an important enabler of low carbon technologies and also compatible with any decarbonisation decisions. However, low carbon heating technologies have progressed – meaning certain invasive measures are not as necessary for decarbonisation for certain typologies The fabric first approach was more of an imperative when all heating fuels were carbon intensive and, therefore, the need to reduce the energy demand of buildings to the highest level possible was the top priority. With the electrification of heat through efficient low-carbon technologies and the need to decarbonise at scale, fabric retrofit is more effectively implemented to the extent that fabric improvements are not more expensive than future zero-carbon electricity. Investment costs and operational costs need to be looked at in parallel as the national cost-effectiveness of implementing building stock decarbonisation is imperative[44]. Building typology is also very important, e.g., the impact of fabric retrofit for flats is much more limited than that of detached houses. Small-scale interventions need to look at these parameters to identify suitable projects. At the stock level, a more balanced approach is suggested here.

Counts of different key fabric retrofit opportunities across the subregion are provided in Table 4-1 with Table 4-2 giving a summary for council building stock. It should be noted that some flats will benefit from increased loft insulation and this is considered in the analysis but the majority are not on the top floor so do not have roof space above.

Table 4-1 Subregional fabric retrofit opportunity.

Typology	No. uninsulated solid walls	No. single glazed	No. uninsulated roofs	No. uninsulated cavity walls	Total
Private-rented flat	193,904	71,897	N/A	22,341	**288,142**
Social flat	85,523	41,312	N/A	29,842	**156,677**
Owner occupier flat	117,848	48,743	N/A	14,729	**181,320**
Private-rented terraced house	43,979	4,430	15,911	3,071	**67,391**
Social terraced house	14,180	5,006	4,545	3,309	**27,040**
Owner occupier terraced house	129,139	9,582	33,117	8,046	**179,884**
Private-rented semi/detached house	3,982	430	1,561	811	**6,784**
Social semi/detached house	1,960	355	828	901	**4,044**
Owner occupier semi/detached house	31,796	1,553	6,576	4,911	**44,836**

Table 4-2 Subregional fabric retrofit opportunity on council stock (domestic)

Typology	No. uninsulated solid walls	No. single glazed	No. uninsulated roofs	No. uninsulated cavity walls	Total
Flat	37,732	18,038	N/A	22,061	**77,831**
Terraced house	4,548	2,195	1,534	1,486	**9,763**
Semi/detached house	488	163	337	365	**1,353**
Total	**42,768**	**20,396**	**69,433**	**23,912**	**156,509**

[44] Fabric first: is it still the right approach? | Buildings & Cities (journal-buildingscities.org)

In many instances uninsulated solid walls do not require insulation to allow for heat pumps to function effectively. The majority of the other items flagged in the tables are generally taken forward and improved in the retrofit analysis.

Upgrade of old double-glazed windows is not considered in this analysis. They can be a major cost item but are considered sit in ongoing building maintenance rather than a specific requirement of the LAEP.

Two different overarching fabric retrofit options are considered for the pathways:

- **Shallow retrofit** – focuses on low cost measures with a relatively low level of intervention and disruption. These measures tend to be most cost effective. The actions considered in the modelling for this option were:
    - **Fabric –** do minimum e.g. loft insulation; improve air tightness with draught exclusion, sealing chimneys etc.; in most cases, window upgrades from single glazing to secondary or replacement glazing
    - Improved building operation via building control systems, monitoring and metering
    - Efficient lighting and small power demand reduction via upgrades to electrical equipment
    - Other measures not quantified here but considered effective in reducing demand for heating and cooling, like solar control (e.g., window blinds and boosted natural ventilation with extract fans), e.g.,
- **Deep retrofit** – more invasive measures, causing more disruption but greater energy saving and essential for further technology interventions. Measures typically include more widespread single glazing upgrades, old double-glazing upgrades[45], solid wall insulation, and ventilation with heat recovery or HVAC recommissioning, alongside any shallow measures which are also relevant.
- The full list of measures considered for each scenario for the domestic and non-domestic stock is presented in the methodology Appendix A.[46]

The relative demand of these different retrofit scenarios alongside the adopted retrofit level for the Net Zero 2040 scenario is illustrated in Figure 4—3 and Figure 4—4. The Deep and Shallow retrofit demand presented refers to the resulting demand in the subregion should the total potential measures be applied, based on the shallow and deep definitions. The resulting demand from the Net Zero 2040 scenario refers to a combination of shallow and deep measures applied to properties in a whole systems approach. The appropriate retrofit levels are linked to the recommended heating system upgrade through a decision tree for each scenario. This takes into account other considerations like social and further technical indicators (e.g. building type (e.g., public, residential, etc.), building fabric (e.g., solid/cavity wall), EPC grade, tenure, cost vs income, energy intensity, fuel poverty and conservation/listing status.)

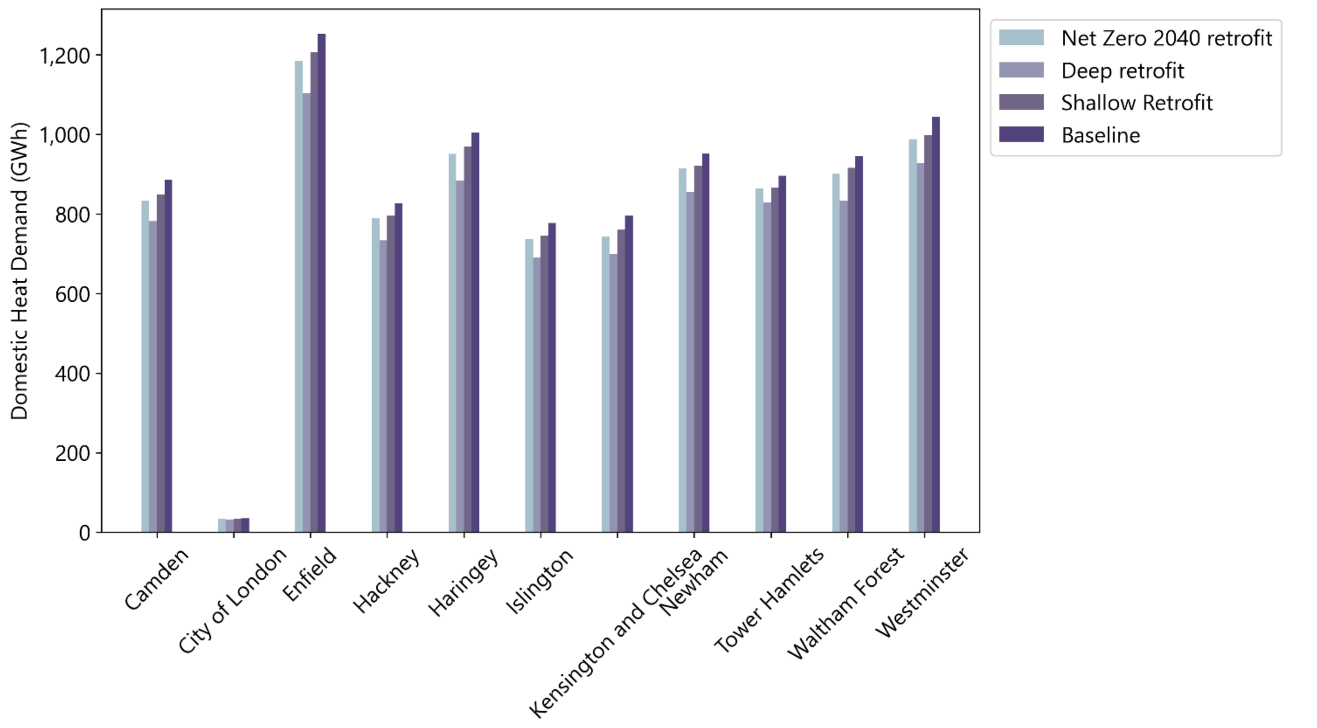


Figure 4—3 Heat demand savings from fabric retrofit in the domestic sector.

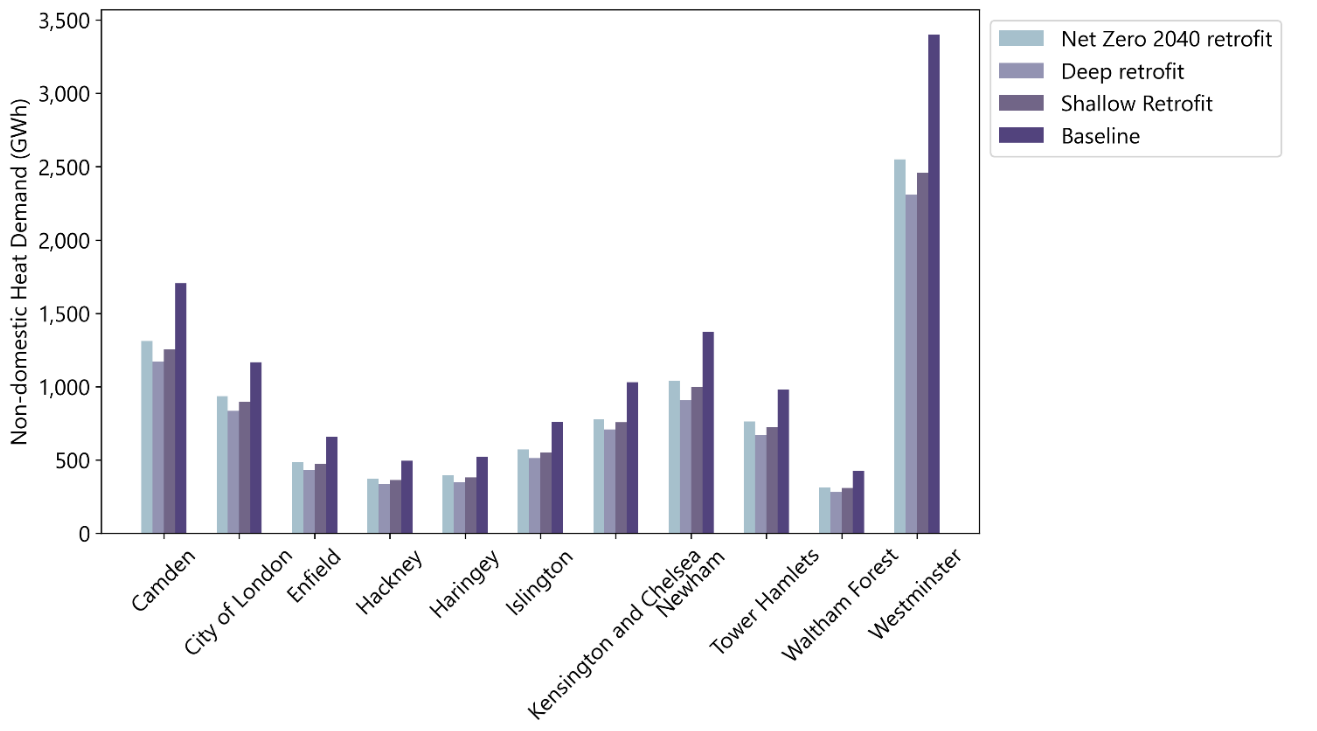


Figure 4—4 Heat demand savings for fabric retrofit in the non-domestic sector.

[45] Old double glazing upgrades are not a focus as although they are important to happen these should be part of building maintenance rather than a change of the property.

[46] Fabric retrofit energy demand reduction per measure and associated costs for domestic buildings derived from:

1. Element Energy 2020 Assumption of trajectories for residential heat decarbonisation to inform the Sixth Carbon Budget (2021) and updated for inflation.
2. Analysis work to refine fabric energy efficiency assumptions for use in developing the Sixth Carbon Budget (University College London) (2020)

For the non-domestic stock, given the available data granularity, which did not include the performance of building elements and systems specifically, the BEES Survey savings were used for the non-domestic typologies as benchmarks.

For the domestic sector Net Zero 2040 aligns more strongly to the shallow rather than deep scenario, highlighting that in many cases relatively non-invasive measures are needed. In the non-domestic sector this is also the case, however, lack of data confidence means the impact of the shallow and deep retrofit is benchmarked across the non-domestic stock typologies. (see footnote). As a consequence the Net Zero 2040 adopted retrofit is actually less than the maximum potential for shallow. The non-domestic retrofit data highlights that Westminster is the priority borough for this in the subregion.

The savings that can be achieved by the different retrofit measures for the domestic are explored in more detail in Figure 4—5 and Figure 4—6.

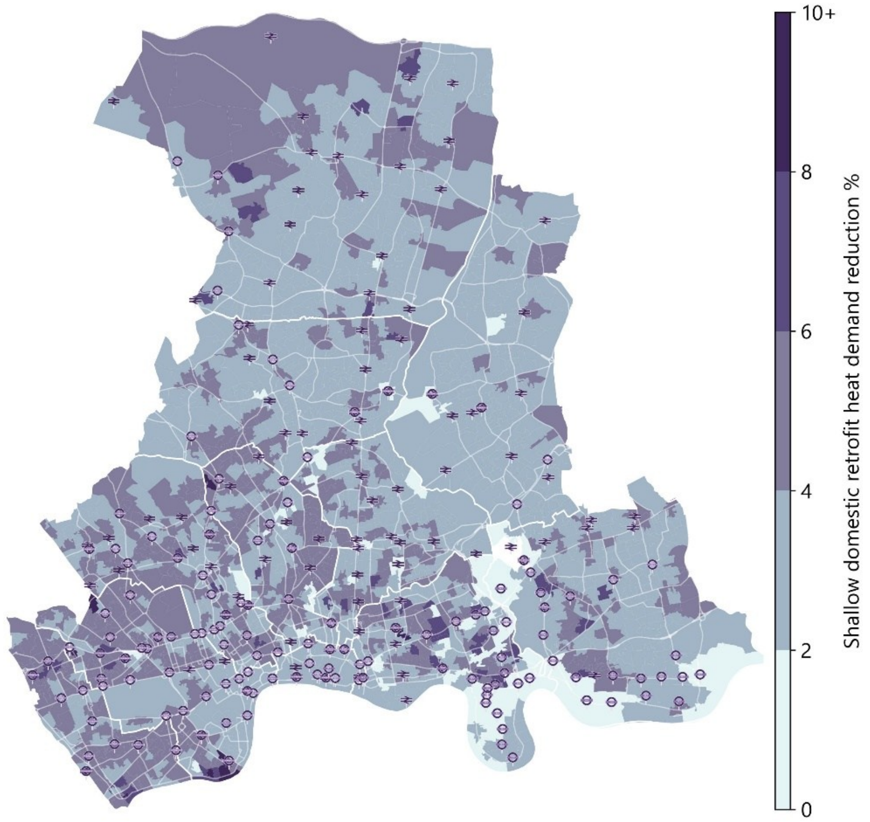


Figure 4—5 Potential heat demand savings from shallow fabric retrofit in the domestic sector.

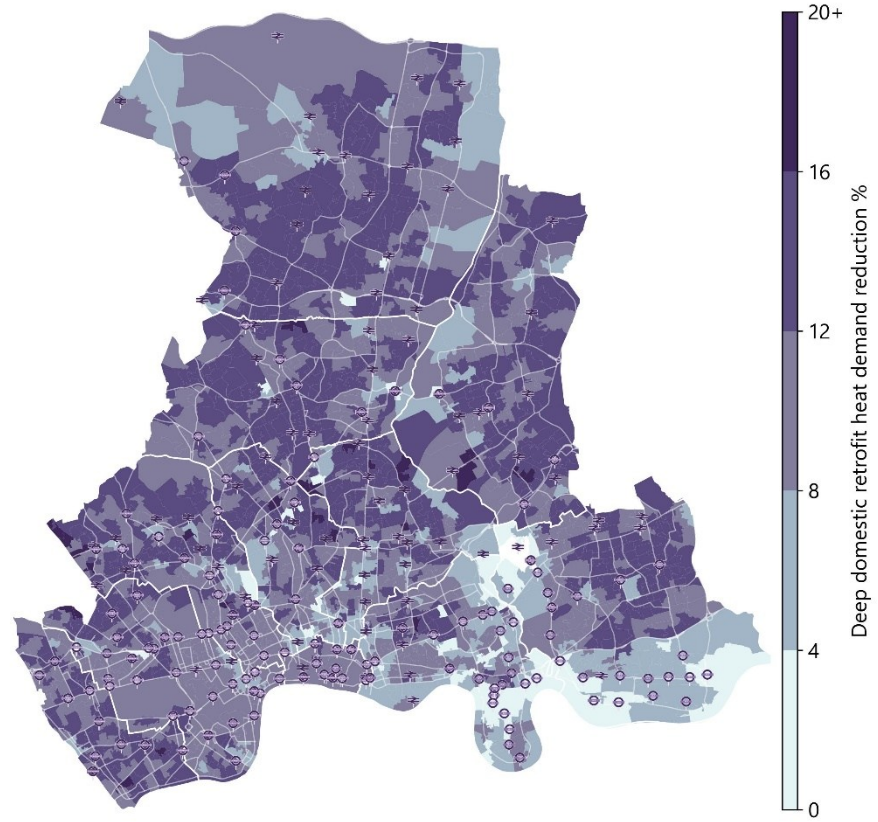


Figure 4—6 Potential heat demand savings from deep fabric retrofit in the domestic sector.

The deep fabric retrofit savings are less homogeneous than shallow retrofit as shallow retrofit is applicable to a wider range of typologies and larger number of properties. This makes the deep retrofit analysis better for identifying specific areas where buildings are least efficient, but in terms of cost effective measures the shallow retrofit acts as a better guide in most instances.

The scenarios use a combination of deep and shallow retrofit, the results savings at LSOA level for Net Zero 2040 are presented in Figure 4—7Figure 4—7. In the scenarios fabric intervention is focused on the shallow measures where possible, with deep measures only being used in the most inefficient buildings. The buildings receiving deep fabric retrofit are thus very similar in all scenarios.

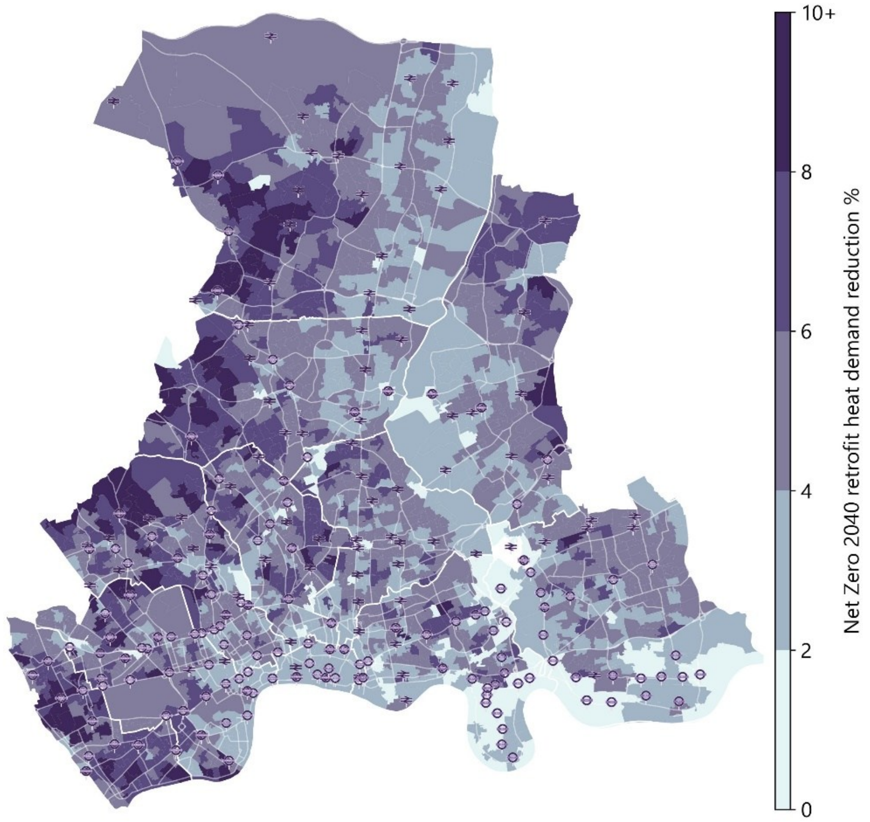


Figure 4—7 Heat demand reduction per LSOA due to fabric retrofit in the Net Zero 2040 scenario.

There are multiple clear focus areas in all boroughs for fabric, some examples are:

1. Camden – the north of the brough, where there is a higher prevalence of houses rather than flats.
2. City of London – relatively little fabric improvement focus, due to very few domestic properties and relatively high efficiency stock.
3. Enfield – most dominant in the west of the borough, for example, to the west of Palmers Green station.
4. Hackney – spread across the brough but slightly higher focus in the north, such as around Stamford Hill station.
5. Haringey – much higher prevalence in the west, with the Muswell Hill area being a clear focus.
6. Islington – the southerly area has relatively efficient buildings needing little retrofit. Outside of this area there is a spread of potential for fabric retrofit. An example being the Highbury area.
7. Kensington and Chelsea – the high number of historic buildings means there is significant opportunity for fabric improvement across the borough. South of Holland Station is an example of particular focus.
8. Newham – the north of the borough, outside of the Olympic Park area, has a good spread of fabric retrofit opportunities, north of Romford Rd being an example.
9. Tower Hamlets – the focus for fabric improvement is in the north of brough, such as the north of Mile End station.
10. Waltham Forest – focus spread across the borough but some focus in east and north of the borough, such as Chingford and Highams Park.
11. Westminster – has a very high proportion of historic buildings, which was noted in the full LAEP as a high focus. The unique nature of building stock in the borough means it merits the more detailed examination of a full LAEP. The Pimlico area is flagged as a large opportunity, with a very high number of single glazed properties.

When moving to Phase 2 LAEPs multiple factors can be considered alongside potential energy efficiency savings to prioritise actions, some of these are explored in Figure 4—8

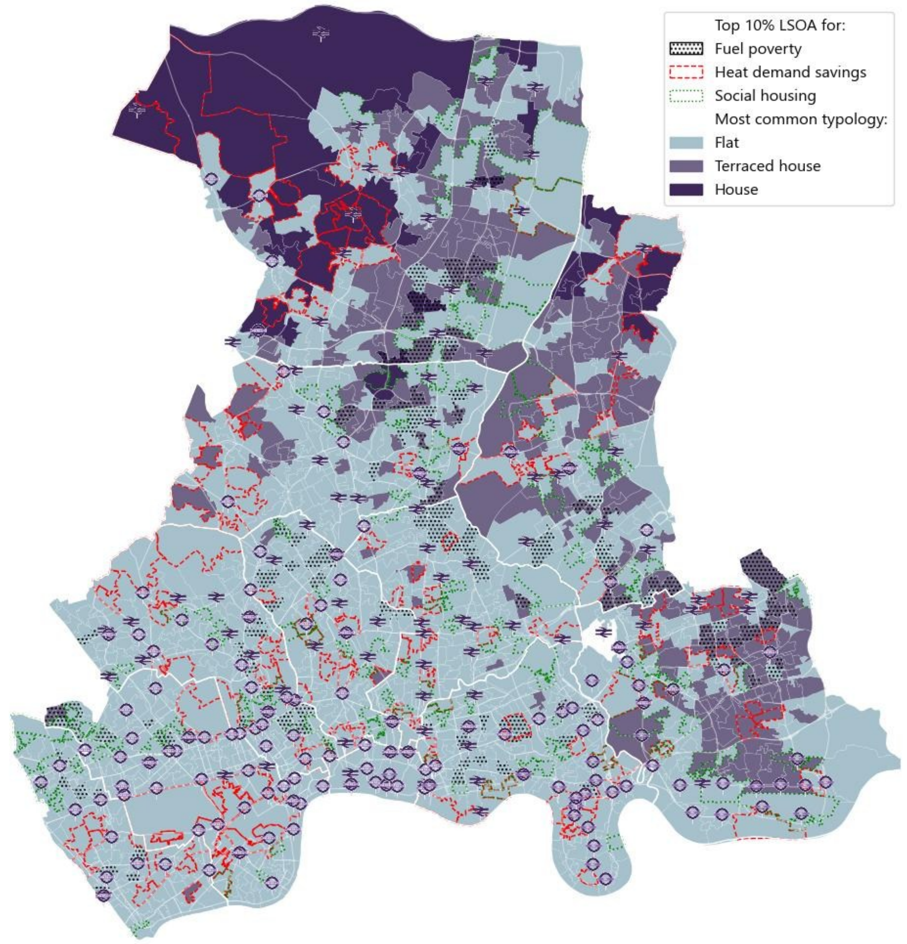


Figure 4—8 Examples of items that can be considered alongside fabric efficiency to help identify priority areas for retrofit.

Social housing and areas in fuel poverty are more likely to receive assisted funding. The top 10% LSOAs for social housing count and fuel poverty ranking have been outlined on the map. Different property types will also represent different approaches to fabric retrofit. Building typology, as the most common occurrence in each LSOA, was also noted on the map. These should all be considered alongside the maximum potential heat saving as an indication of higher retrofit need (the top 10% of LSOAs are highlighted in Figure 4—8) alongside the scenario specific focus areas for fabric to provide an indication of potential project priorities. Borough priorities can be overlayed to further contextualise the focus areas.

4.2.1 Retrofit next step recommendations

Based on the analysis presented above and a review of inputs from stakeholder engagement a high-level summary of subregional retrofit decarbonisation actions is provided in Table 4—3. These are linked to one of two main task types either technical or data items. The actions captured also considers more general actions for buildings as well as retrofit specifically.

The geographically tied action areas identified above should also be explored through more detailed study (such as Phase 2 LAEPs or feasibilities), more specific borough related focus areas are also included in borough profiles.

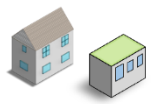
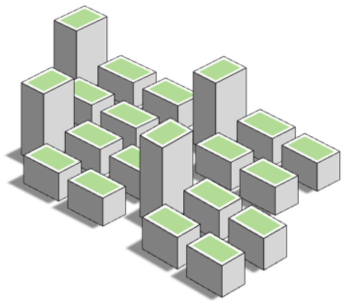
Table 4—3 Summary of subregional actions for retrofit

Theme	Description and action	Activity type	Potential owners
Retrofit (technical)	**Fabric improvement** – is highlighted in many areas. Creating a strong pipeline of retrofit in Phase 2 LAEPs will help grow the supply chain. Mass purchase schemes could also be considered to help drive down prices. Other areas where inter-borough collaboration could help include scaling up interventions based on specific typologies, which could link back to the mass purchase schemes. This should be examined in Phase 2 LAEPs with consideration to potential funding streams. Support programmes such as the GLA's Zero Carbon Accelerator could act as enabler of this and help to create an investable portfolio of projects, alongside other funding support programmes such as the Government's warmer homes grant funding programmes for privately owned homes (owner occupied or privately rented) for low income households.	Project identification, Typology analysis , Project pipeline development, Supply chain development.	GLA and boroughs
	Deep retrofit – identify common areas requiring deep retrofit and progress with these as low regrets action. As helping to achieve decarbonisation without the need for heating system scrappage. Phase 2 LAEPs should help confirm these focus areas.	Project identification	
Retrofit (technical)	**Single glazing** – upgrade of this is one of the most common deep retrofit measures. Groups should be worked with to improve understanding how this can most effectively be achieved, particularly in historic buildings (which is where it is most prevalent) is good to pursue at a subregional level as it impacts all boroughs to an extent. This will help bring down costs of retrofit and may require consideration of planning legislation.	Additional study, Lobbying	Historic England, GLA and boroughs
Retrofit (technical)	**Non space/water heating gas use** – gas is used for multiple purposes outside of services that can be met from heat pumps or heat networks. One of the most common being cooking – this accounts for ~2% of domestic gas demand. However, in the non-domestic sector ~14% of gas demand is non-space or hot water demand – with catering being the most significant sector. Switching away from gas to electrical solutions may present challenges to commercial kitchens but the potentially large carbon savings should be investigated. The shorter lead time than technologies like heat networks could result in early emission reductions. Policy should be explored to phase out all domestic gas cookers. In the non-domestic sector the first step could be to engage the catering sector representatives to consider alternatives. Public sector with large catering facilities would make good initial opportunities to consider in more detail.	Lobbying, Project identification	Catering sector, GLA, central government
Retrofit/ buildings (domestic) (data)	**Building characterisation** – smart meter data allows the impacts of retrofit measures to be tracked in terms of energy consumption, allowing progress to be measured. Smart meter also provides a better indication of current performance of a property than an EPC, where there will often be a lag between low carbon measures (such as retrofit) and an EPC. The smart meter data will also give an indication of occupancy, which is often a major uncertainty in inner boroughs. Currently data sharing agreements for smart meter data at a resolution where these insights can be extracted is not possible. The GLA are already exploring these options and this subregional work highlights the benefits this could bring to progressing LAEPs and putting standardised measures for progress reporting in place. Having a centralised solution like the GLA LAEP DataHub would remove much of the burden from boroughs for processing the data – which most do not have the resource to do effectively.	Data improvements, Lobbying	GLA, Ofgem
Retrofit/ buildings/ renewables (domestic) (data)	**London Building Stock Model** – this provides a good initial basis for much of the analysis. It should continue to be refreshed and could consider integration of other GLA held models such as the London Solar Opportunity Map and access to off-street parking	Data improvements	GLA
Retrofit/ buildings (non-domestic) (data)	**London Building Stock Model** – should be updated to include non-domestic stock. This subregional work is a starting place for this and like the LBSM is open access. Improving EPC data capture is important, with nearly half of non-domestic properties in the subregion not having an EPC score highlights the importance of this issue. Unlike the domestic these are hard to infill due to the non-domestic building stock being less homogenous.		GLA
Buildings (data)	**Planning London DataHub** – is an excellent initiative to provide one centralised source for all London planning data. This makes it easier to understand at a subregional level future development, which is very important for strategic progression of LAEPs – such as cross borough heat networks. However, data available through the Planning London DataHub is not uniform and often requires significant assumptions or input from boroughs to make useable. An excellent start has been made centralising planning data in London, improving field consistency will help the benchmarking process. Ideally, this could even be done in an automated manner by the same team compiling planning data. The Planning London DataHub is considered most valuable to focus on as it will help define project pipeline. However, the same principles should also be considered for SHLAA sites, population projections and wider borough housing and employment trajectories. Another important item with planning data is it is not always clear if the work for which permission is being applied has been completed.	Data improvements	GLA and boroughs

4.3 Heating system decarbonisation

Heating system decarbonisation, with the prevalence of natural gas, is one of the biggest challenges for decarbonisation. Unlike with transport and the ban on fossil fuel cars in 2035 there is not a strong central policy determining the decarbonisation approach. Three different decarbonisation technologies are focused on for heat in this analysis, they are summarised in Table 4-4.

Table 4-4 Summary of different low carbon heating systems considered in different contexts.

Heating system solution	Building(s) type	Usual context for deployment
Single heat pump		Generally, for buildings containing just one or a few small properties, and with relatively small heat demand (for example, a house or standalone commercial property). Demand will be under 100 MWh/yr, otherwise communal or heat network is considered.
Communal system (generally from one centralised solution – such as a heat pump)		Building that contains multiple properties (for example, flats). Larger buildings with communal systems will often be identified for connection into a wider heat network. In some datasets these can be hard to distinguish from small-scale heat networks.
Heat network		Heat networks describe the connection of more than one building to a shared heating system. Varying from a block of terraced houses on a shared ground loop system, to campus scale networks and wider district heating systems. It is the largest district heating systems that are the focus of the subregional analysis. Generally, these will be in areas with high heat density and/or proximity to waste heat sources and/or areas with growing number of planned new development are suitable for heat network. For listed buildings, planning permission for heat pump installations could be challenging, making heat network more suitable option.

Whilst the largest number of low carbon heat technologies are generally property level heat pumps (as shown in section 3.5) this is not reflected in the total heat demand. Property level heat pumps meet 5,484 GWh/yr of heat demand in 2050 under Net Zero 2040 whilst heat networks meet 11,378 GWh/yr, communal systems meet 1,743 GWh/yr. This is due to large heat networks connecting larger individual heat demands, most notably the large non-domestic heat demands in central London. The dominance of heat networks is also reflective of the subregion having the highest heat density in the UK.

4.3.1 Heat networks

Heat network opportunities are identified in all boroughs in the subregion. The greatest opportunities are in the central boroughs in terms of demand density. This is shown in Figure 4—9. Three different parameters are considered for heat networks. Two are based on analysis in this study which use of different heat densities (8 MWh/yr/m and 16 MWh/yr/m), these are based purely on demand and are then viewed in the context of heat sources. The other Heat network areas are defined by the DESNZ Heat Network Zoning (HNZ) model, which identifies heat network opportunities across England, including large waste heat sources. DESNZ's HNZ model is continuing to be developed with further updates expected. The outputs presented captured from a March 2024 model run and are indicative.

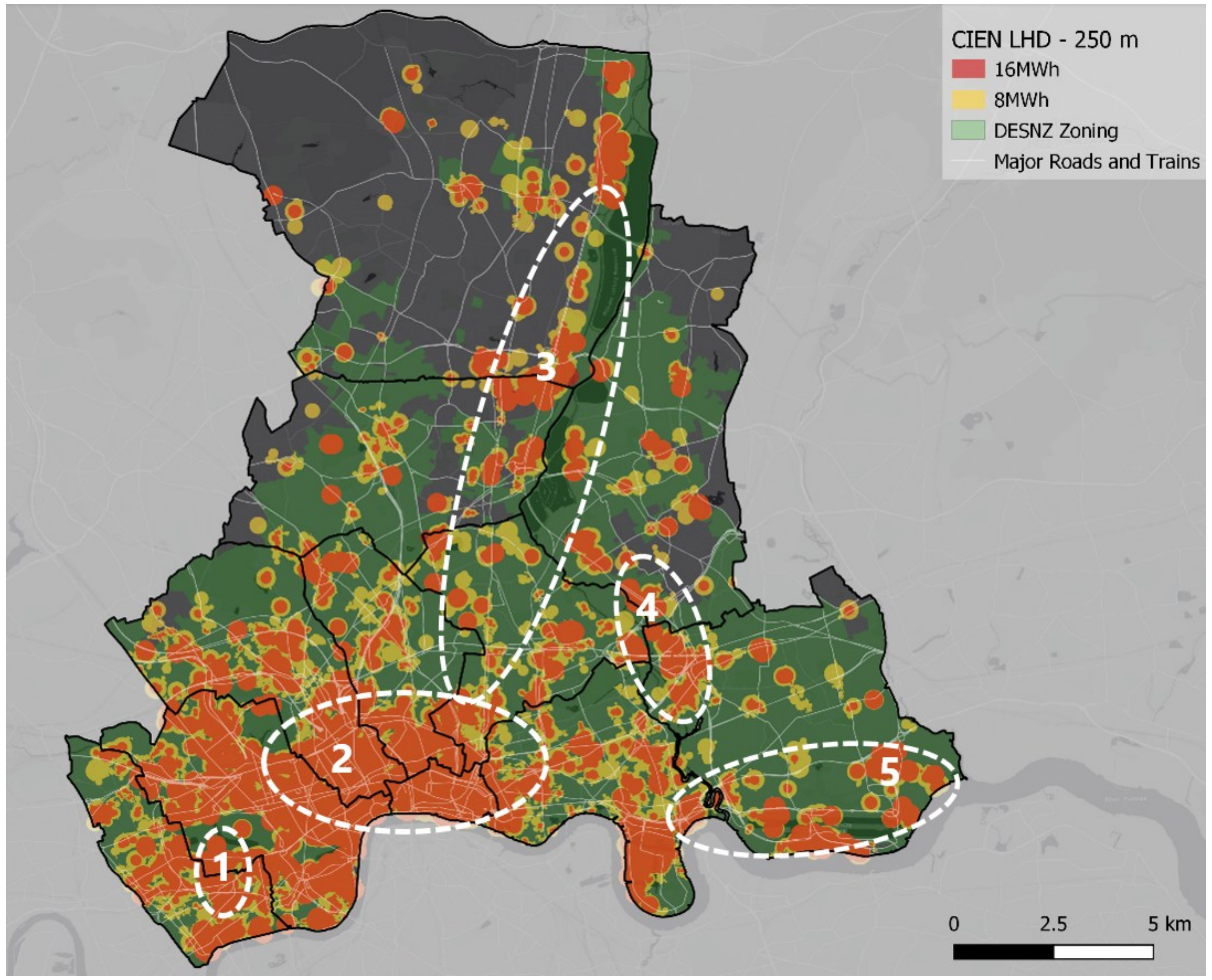


Figure 4—9 Overview of initial cross brough heat network focus areas.

There is a strong alignment between the modelling outputs in this study and the DESNZ model giving additional confidence to the outputs (although the DESNZ model is still a draft output – with the data presented a historic version). The main difference is the demand in the subregion is so high the DESNZ model covers the majority of the area, rather than focusing on more precise opportunities. To help a more focused deployment, the Net Zero 2040, Consumer Led 2040 and Base Case 2050 scenarios focus on the specific areas identified in this study (marked in yellow and orange). It is considered a risk that if the whole subregion relies so heavily on heat networks as it will slow adoption of other low carbon heating technology and the overall rate of decarbonisation.

A key element of heat network viability is low cost heat sources, including waste sources. Some key potential waste heat sources are highlighted in Figure 4—10 – some, such as Thames Water pumping stations and sewers, were considered but not shown on this map due to data sharing agreements.

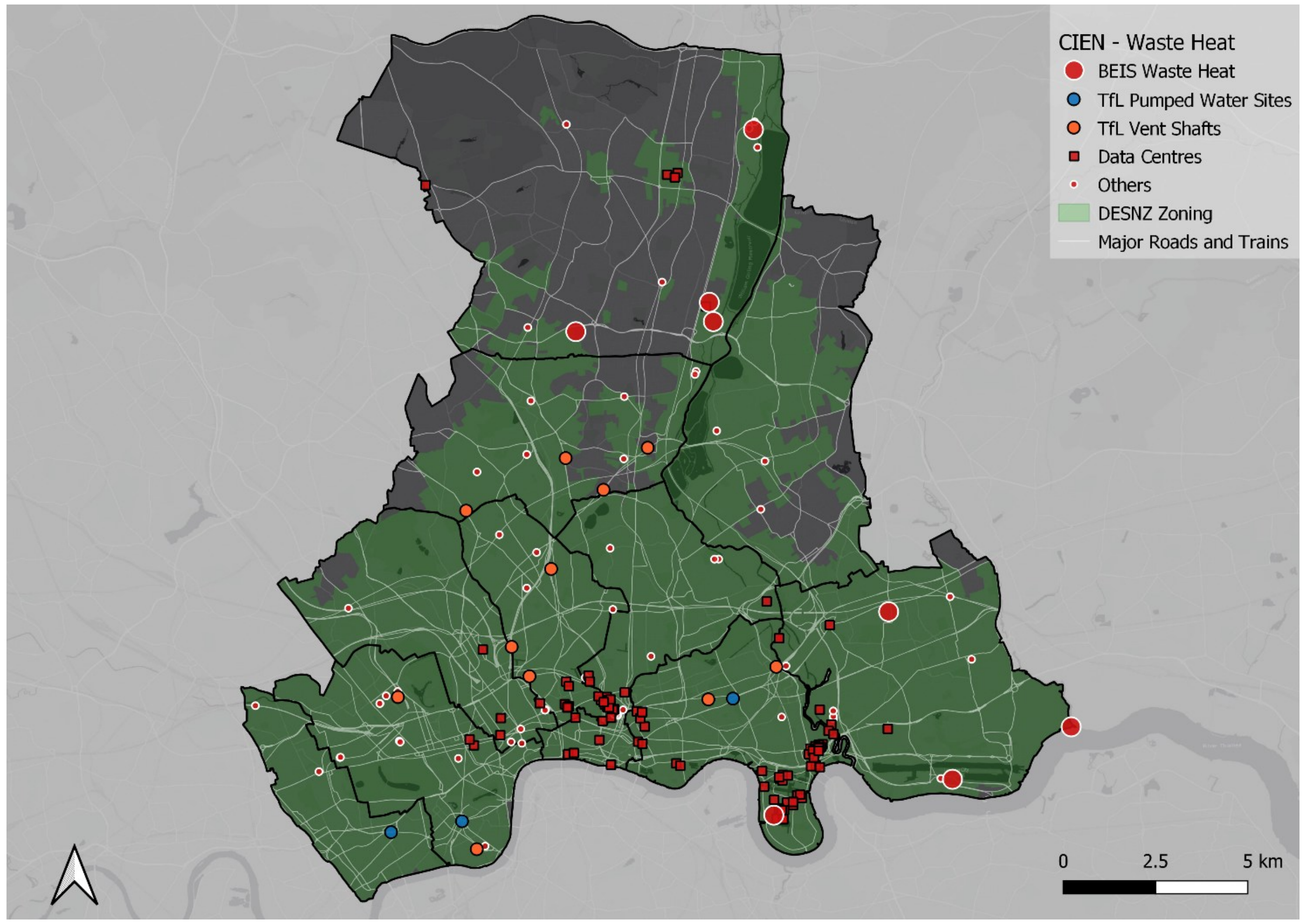


Figure 4—10 Geographic overview of some of the waste heat sources considered.

Waste heat sources alongside renewable opportunities (like water source heat pumps) were considered alongside heat density to identify five initial areas of focus in Figure 4—9. It is important to note there are many large heat network opportunities being examined in the subregion already, including at an individual borough level. These are important but considered more in individual borough profiles, instead the focus here is on cross brough opportunities. Five initial cross borough areas of focus are identified:

1. This connects historic buildings around the Royal Albert Hall, Imperial and the Natural History Museum. This is already being progressed through feasibility stages and is included in the Westminster AZP. Heat sources could include boreholes in Hyde park, to help overcome spatial constraints.
2. This is the single densest area of heat demand in the subregion and in the UK. It is dominated by non-domestic demands and includes three AZP areas (Westminster, Islington and City of London). The main challenges are the limited space for large energy centres and, although there are heat sources such as sewers, vent shafts, the Thames, data centres and pumping stations, they are not of the same scale as the calculated heat demand. This means transmission of heat into the area is a major subregional consideration which will require a significant amount of cross-borough coordination.
3. Includes the Energetik Edmonton energy from waste site (the largest single waste heat source in the subregion) in the north and covers an indicative corridor of large heat demands it could serve, ideally connecting into the more central boroughs (i.e. area 2). There is substantial complexity in this route, whether it would be better going through Waltham Forest[47] or Haringey and Hackney. Also, there is complexity whether the heat is most suitable to be used in outer boroughs or inner boroughs. The former has the benefit of boroughs not being disrupted to lay infrastructure without seeing heat benefits, whilst the latter is technically the most expedient due to lack of space for heat plant in inner boroughs. In either case the heat available from Energetik, although large, is not big enough to supply all the heat network opportunities in the CEIN subregion. Additional plant capacity such as centralised heat pumps could be more easily developed in the outer boroughs and piped in through the same route. Again, Enfield is likely to be able to do this with generally more space and large centralised grid infrastructure – from a power plant in the borough.
4. The Olympic Park area is an AZP – with considerable potential to expand the existing heat network in the area with an exclusivity concession in place of which LLDC (London Legacy Development Corporation) is joint Concession employer. There are data centres and Thames water pumping stations in the area which could supply additional heat. LLDC are one of the major stakeholders to bring this forward. As well as covering Waltham Forest, Tower Hamlets, Hackney and Newham in the initial focus it could expand to interconnect areas 3 and 5.
5. Is the main route considered for using heat from the major waste water treatment works at Beckton. Initially this would be concerned with Newham and Tower Hamlets but could also be a route in for heat towards area 2. Additional heat would be required if this was the case, potential sources could be the Thames or could take advantage of existing and planned data centres in Tower Hamlets and Newham.

One of the benefits of the subregional approach is it allows strategic interconnection of heat networks to be explored. This is done in Figure 4—11, with various stages of proposed transmission and existing heat network routes being displayed.

[47] In Waltham Forest the area highlights the potential of a strategic heat main through the Lea Valley area, this route has been explored in other studies, including decarbonisation of the Olympic Park network. The route is also key in a soon to be completed Heat Mapping and Energy Master Planning study of Waltham Forest.

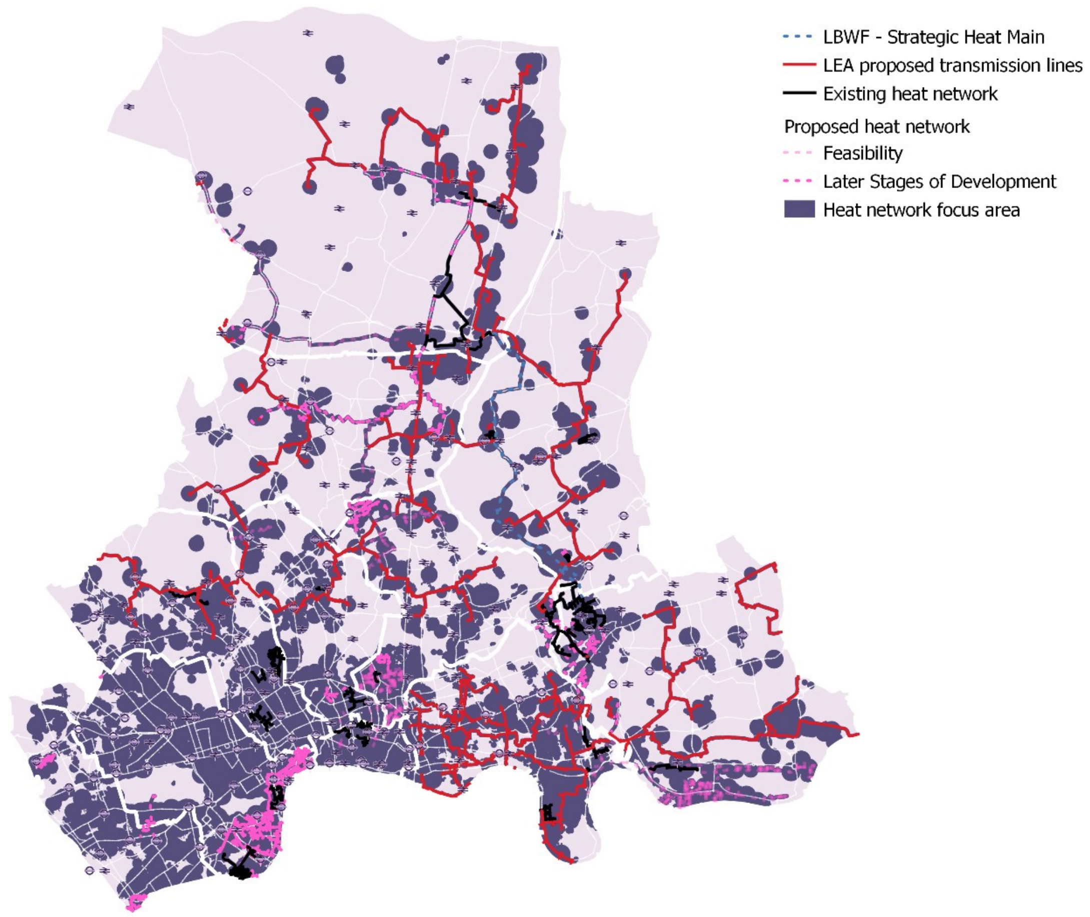


Figure 4—11 Heat network focus areas and potential.

One of the key inputs of the map is a recent GLA study[48] which focuses on the optimal use of waste heat sources and is represented by the LEA proposed transmission lines in the key above. This is important to continue as it should help minimize the cost of heat supplied through heat networks, improving its economic viability compared to gas. This is key to avoid decarbonisation elevating the risk of fuel poverty.

Developing heat networks at this scale has variety of technical, political and financial challenges – these are summarised in Table 4-5.

Table 4-5 Cross borough heat network challenges

Category	Blocker
Technical	Supply resilience
	Asset ownership
	Scale of project
	Difference in heat network development timescales across boroughs
Political / Governance	Ownership monopolies
	Council money shared with other boroughs
	Key decision making
	Differences in ownership structures across borough
	Differences in planning policy across boroughs
Financial	Agreement on fair heat sales price
	Source of capital investment

[48] Waste Heat Strategic Areas Summary

Exploring a centralised route to procurement and development of these major transmission routes is key to unlocking the heat network potential in the subregion. Although it needs to be explored in detail a centralised approach to procuring this delivery appears to be most suitable. This would also help align utility work, which is key given the scale of heat network deployment identified. The DESNZ approach to Heat Network Zoning and the associated role of a Zone Coordinator will help support the role out of these transmission corridors.

4.3.2 Communal networks

Communal opportunities are initially appraised separately to heat networks, identifying all buildings which would suit a communal system. These opportunities are illustrated in Figure 4—12.

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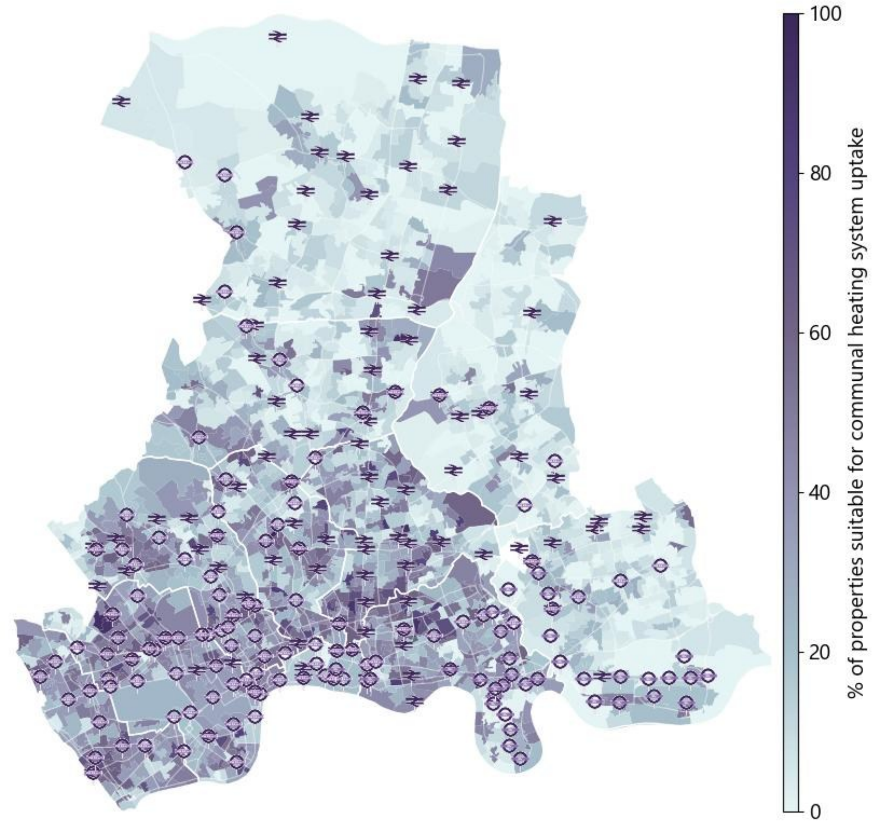

Figure 4—12 Buildings suitable for communal systems.

Switching from individual gas boilers to a communal heat pump is considered low regrets. By changing to a communal system, the most challenging aspect of connecting to a heat network will be completed. This will allow future connection to a heat network. With the scale of heat network deployment across the subregion this pragmatic approach is important as the scale of heat networks means lead times will be relatively long.

Areas favoured for communal networks, but not wider heat networks are generally in outer boroughs. In the Network Led scenario in particular this is relatively uncommon as heat networks are so widely spread that stand alone communal systems are comparatively rare.

4.3.3 Individual systems decarbonisation - Heat pumps

Individual heat pumps are most commonly associated with houses rather than flats in the scenario modelling (this is common across all scenarios). Smaller flats sometimes have individual heat pumps selected in the pathway analysis but communal systems are the most common solution, particularly in conservation areas.

The distribution of heat pumps is shown in Figure 4—13. Unsurprisingly the areas with the least opportunity for individual heat pumps are generally those with the highest heat density and identified for heat networks.

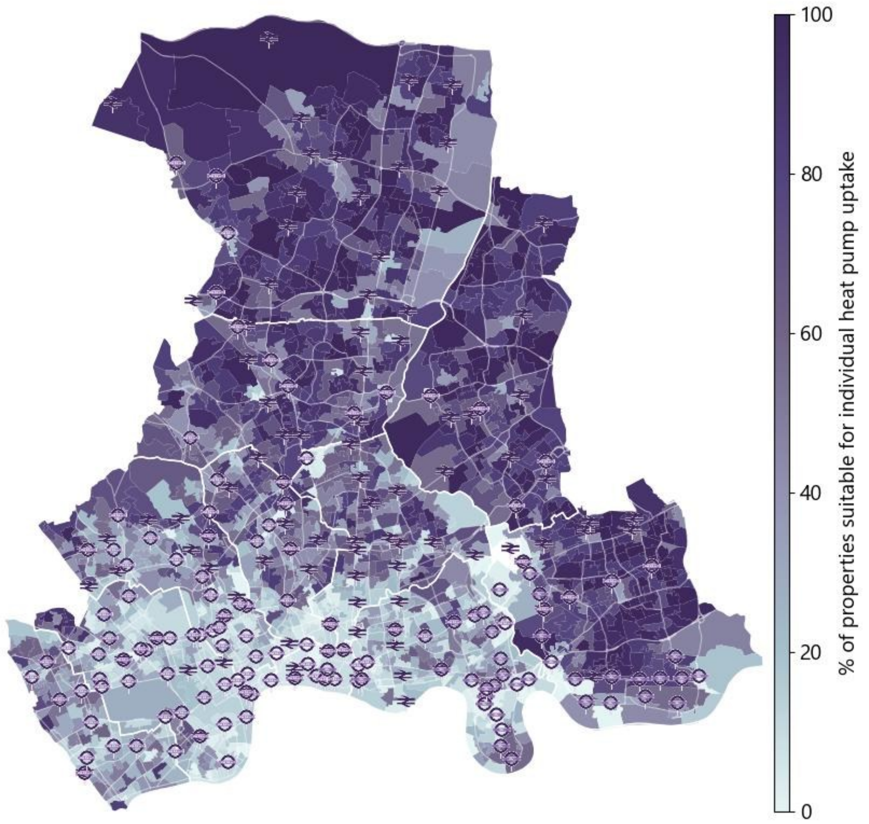

Figure 4—13 Buildings suitable for individual domestic heat pumps.

With the strain heat pumps place on the electricity network there are some benefits to spreading the deployment across boroughs, helping to reduce immediate constraint on the lower voltage elements of the network. With the high number of heat pumps that are required, there will in the very near term need to be a greater shift towards replacing boilers with heat pumps at end of life. With average boiler replacement this should allow a 2040 target to be hit.

It is important to note that shared loop ground source systems are not considered in this analysis but they could be viable in some instances instead of standard individual heat pumps. This would generally be the case in areas where there are a high number of terraced houses, typified by the LSOAs that are small in area but identify a high number of heat pumps in Figure 4—13.

4.3.4 Heating system next step recommendations

Based on the analysis presented above and a review of inputs from stakeholder engagement a high-level summary of subregional heat decarbonisation actions is provided in Table 4—6. The geographically tied action areas identified above should also be explored through more detailed study (such as Phase 2 LAEPs or feasibilities), more specific borough related focus areas are also included in borough profiles.

Table 4—6 Summary of subregional actions for heating.

Theme	Description and action	Activity type	Potential owners
Heat (technical)	**Cross borough transmission networks** – explore transmission of heat across borough boundaries. Key sources include the Thames, Beckton and Energetik as well as large data centres. Understanding how these can most effectively be used to supply heat, including in the more central boroughs where spatial constraints limit the opportunity for centralised air source heat pumps. This is important as the best heat sources in these boroughs cannot supply all the demand for heat networks, meaning a broader strategy is required to understand where heat can be most effectively used. The GLA are already exploring this through technical heat network studies exploring waste heat opportunities.. This is a useful first step with more detailed work required, the enhanced data from the subregional work should be considered to enhance the analysis. To progress the scale of this ambition a working group could be created through the new Zero Carbon Accelerator to further define each of the main transmission opportunities. This should be a mix of funders, public sector organisations (GLA, boroughs, DESNZ) as the core but also private bodies such as the heat source owners.	Additional study - Transmission study / feasibility study. Heat source strategy Working group	GLA, boroughs, heat source owners, DESNZ
Heat (technical)	**Centralised systems in flats** – are a key enabler for removal of gas boilers. This is challenging as it requires combined actions of many individual property owners. Mechanisms should be explored to promote the uptake and deployment of centralised systems in flats. In the social housing sector this is relatively easy, though leasehold properties may present a challenge, but it is the private sector that requires the largest transition. This is relevant to both communal systems and heat networks. This is a complex issue so the first step is to explore how this can be successfully enabled without widespread scrappage and minimal disruption. Also, models where this can be effectively implemented in the private sector need to be explored, where the alignment of multiple actors is key.	Further study, Lobbying, Engagement.	GLA to explore process, social flat owners would be an initial starting point, boroughs will also be useful – with a focus on their own stock
Heat (technical)	**Waste heat** – quantify the waste heat potential in more detail and make findings available, including the grade of heat. Related to this is more active engagement with key sectors like data centres and consider requiring these to supply waste heat. Active engagement with waste heat providers is the first step for this, allowing for proper assessment of the heat source and how accessible and suitable it is. The creation of a standardised template for waste heat grade assessment will assist with this – central funding through a programme like the Zero Carbon Accelerator or other programmes could assist completion of this. Considering policy to mandate waste heat connection to heat networks should also be considered, the suggested template could act as an evidence base for this.	Additional study - Waste heat potential study [in progress], Engagement - with waste heat stakeholders Engagement Prepare template/guidance	GLA, DESNZ, waste heat owners, boroughs (Phase 2 LAEPs).
Heat (technical)	**Cooling poverty** – was identified as an issue in the stakeholder engagement sessions and the need to address the effects of climate change especially considering vulnerable demographics.	Additional study - cooling poverty Lobbying	GLA and boroughs, central government

Theme	Description and action	Activity type	Potential owners
	This should be explored and mapped alongside more common metrics like fuel poverty. The London Climate Risk Map[49] can be the basis of further studies on the combined needs of those affected by heating and cooling fuel poverty. Evidence base development for the consideration of cooling poverty outcomes to be included in future funding schemes as a result.		
Heat (technical)	**Heat pumps –** at the building level and in terms of heat delivered are the most important heat decarbonisation technology. There is a skills shortage for the rate of deployment required and this would also limit supply chain issues. Coordination and knowledge sharing at the subregion and London-wide to understand key success factors in the deployment of heat pumps, technical and local commercial models. Establishing a strong pipeline is key for giving the market confidence to overcome these issues. Exploration of policies relating to end of life boiler scrappage for heat pump replacement is one potential short term policy. However, if the LAEP target is to be met there will need to be interventionist policy such as gas boiler phase-out which would require central UK government commitment.	Guidance on technical and commercial models. Lobbying	GLA and boroughs initially, potentially Ofgem and DESNZ
Heat/networks (technical)	**Data centres** – are increasingly recognised as a potential source of waste heat for heat networks. These opportunities should be explored, with a focus on the larger data centres for subregional work. These are of the scale most suitable for cross borough transmission routes (smaller heat sources could also connect). Planned data centres should also be considered. This is important as data centres are very large electricity users with the largest having such high demands they could often fall outside of a standard LAEP. In London there are multiple applications for data centres including one of 300 MVA. For scale this is the equivalent of 75-100,000 domestic heat pumps. This would impact the National Grid transmission level as well as the UK POWER NETWORKS distribution network. Data centres could thus create bottle necks in the extra high voltage networks, potentially limiting low carbon heat. The use of waste heat partly offsets this – allowing progression on the decarbonisation pathway and potentially being a catalyst for network deployment. Ideally boroughs should be in a position where they can more proactively manage data centre developments based on known capacity constraints using levers such as planning policy. Opportunities to explore the use of waste heat from data centres in heat networks could be explored through planning policy and conditions and s106.	Engagement, Planning policy, Additional study – Planning Implementations Mechanisms (in progress)	GLA, data centre owners and boroughs
Heat/networks (technical)	**Thermal storage** – identification of sites that could site large thermal stores to match the scale of heat network ambitions. These thermal stores would reduce the need for electricity network reinforcement as heat network deployment increases and with the use of heat pumps as well as waste heat. They can also help reduce operational costs (benefiting from low energy prices to charge the store) and energy security of the system.[50] Public land assets and unused brownfield land which is not suitable for housing are likely to be major opportunities. Options will also need to be explored in more spatially constrained inner boroughs – to reduce dependency on cross borough transmission heat networks for initial large-scale deployment. One of the first steps for encouraging thermal stores could be exploring how boroughs could deliver this, potentially through site allocations. Heat network developers are likely to include thermal storage, however, in the UK is not of the scale seen in other countries where heat networks are more widely spread. The spatial constraints associated with the heat dense areas of London makes this an important subject to consider alongside other strategic heat network elements – such as heat transmission.	Additional study, Planning policy	GLA and boroughs
Heat/networks (data)	**Infrastructure planning** – through this work the use of the GLA Infrastructure Mapping Application (IMA) was explored for use in decarbonisation planning. This was very promising, identifying areas where roads would soon be dug up for infrastructure works. Aligning this to strategic heat network route deployment would avoid digging up roads twice. However, data sharing arrangements means details of this analysis cannot be shared. Unlocking this will help ensure opportunities to minimize costs and impacts are not missed. It will also help prioritise heat network deployment, which will be useful given the large volume identified and ongoing DESNZ heat network zoning and AZP. This action will help create a timeline for deploying the cross borough transmission networks.	GLA and IMA members	GLA and IMA members

4.4 Transport decarbonisation

Actions for boroughs in transport, aside from decarbonising their own fleet will, be focused on deployment of chargers in the public realm. The future distribution of these on street chargers, based on NEVIS[51], are displayed in Figure 4—14.

[49] Climate Risk Map | London City Hall

[50] The benefits of thermal stores are well established in both industry and academic literature. One example being a recent scientific study that indicates a 12.3% saving in electricity costs and 83.4% saving in emissions https://www.sciencedirect.com/science/article/pii/S0960148124009558

[51] Developed by Cenex NEVIS standards for National Ev

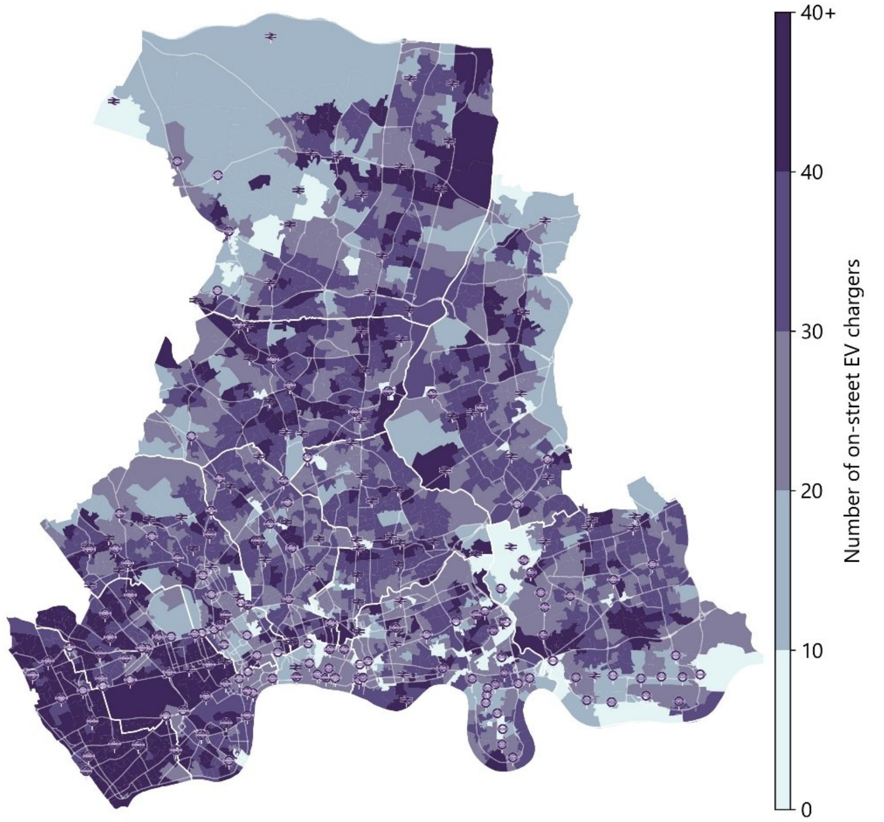

Figure 4—14 On street EV charger deployment.

This highlights that every borough has a number of areas that require on street chargers. This is one of the areas of EV infrastructure where boroughs have a stronger degree of influence. It is important to note that many of the areas flagged for on street chargers are also those that have a relatively high level of deprivation. Developing EV infrastructure in these areas is therefore important to ensure equal access to charging infrastructure. This is of particular importance in outer broughs where active travel and public transport are less dominant modes of transport.

Areas with a high opportunity for off-street charging are often the inverse of the on-street focus areas – see Figure 4—15.

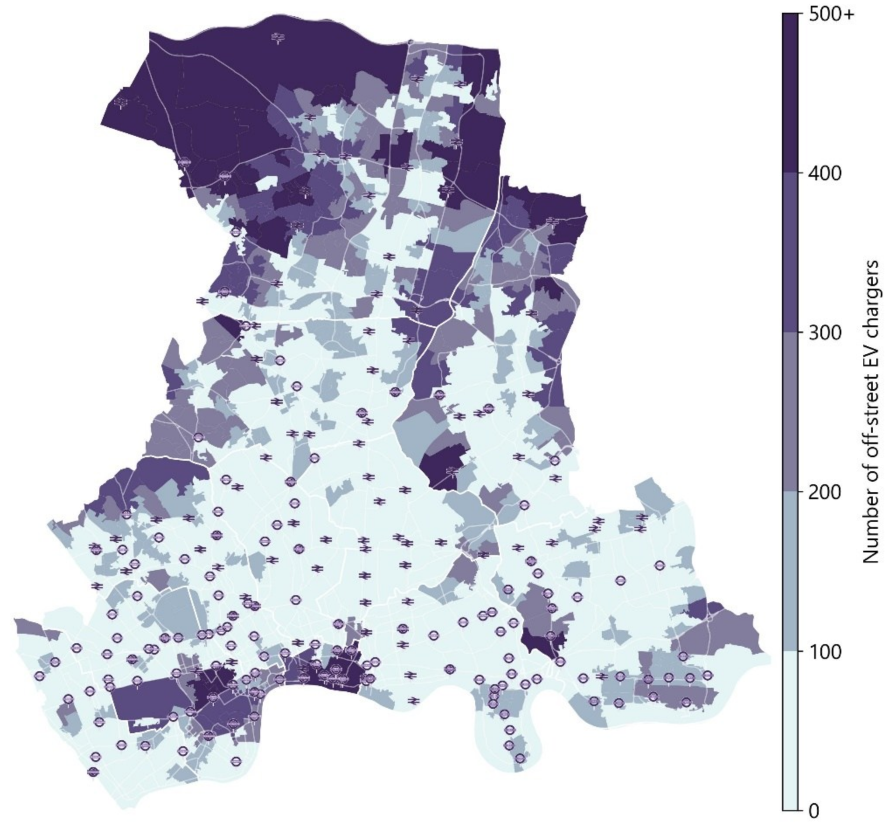

Figure 4—15 Cars with access to off-street parking.

Areas with high levels of off-street charging will rely on home owners to invest in their own charging infrastructure. This is considered a low regret option, as the relative price of a home charger (compared to the cheap tariff it will access for charging) means those purchasing an EV will likely purchase a charger.

The majority of properties with off-street parking are owner occupied which simplifies the adoption pathway. However, to enable effective decarbonisation promotion of EV chargers in rental properties with off-street parking is an action to take forward.

Large car parks and transport hubs are a focus for centralised charging infrastructure (the locations are illustrated in Figure 2—21 and Figure 2—22). These are key strategic charging locations for vehicles external to the borough.

Potential actions to consider include linking these hubs with PV deployment, either through canopies or depot rooftops. City Airport, which is one of the largest car parks in the subregion, is a good example of where this approach could be suitable.

The scenarios align to the GLA's Accelerated Green 2030 target of 27% reduction in mileage overall. To ensure agency of individuals, car numbers align to the national NEVIS model, meaning people will have the ability to use a car but will do so less frequently. The greatest percentage reductions in mileage are focused in the inner boroughs, representing greater access to public transport and active travel.

4.4.1 Transport next step recommendations

Based on the analysis presented above and a review of inputs from stakeholder engagement a high-level summary of subregional transport actions is provided in Table 4—7.

Table 4—7 Summary of subregional actions for transport

Theme	Description and action	Activity type	Owner
Transport (technical)	**Freight charging** – the scale of freight charging means centralised planning infrastructure would be beneficial. This is also due to HGVs travelling long distances and potentially having a fleet with mix of hydrogen or electric charging. Cross borough freight hub planning could benefit delivery management to reduce freight emissions through reduced mileage. Stakeholders should work together to ensure a cogent subregional strategy for charging, aligning to the freight industry needs.	Freight charging strategy	London Councils, GLA, TfL, freight industry, Central Government, boroughs, DNOs (both Cadent and UK Power Networks)
Transport (technical)	**Strategic public charging infrastructure** – there is a large focus on on-street parking infrastructure. To enable delivery of this, work should be undertaken to improve understanding of locations and timelines for deployment along priority corridors or specific areas to allow this to be co-ordinated.	Engagement, Project identification	TfL, boroughs, UK Power Networks, London Councils/GLA
Transport (technical	**Modal shift in outer boroughs** – outer boroughs such as parts of Enfield, Haringey, Waltham Forest and smaller part of Camden have a high opportunity for modal shift. Improved public transport uptake is required to improve this. Approaches to explore include schemes promoting public transport usage as well as improving public transport access.	Engagement, Project identification	TfL, boroughs
Transport (technical)	**Rental chargers** – EV chargers for rental properties with off street parking should be considered. This is unlikely to be a priority for property owners and the fact this issue will be spread across London makes it well suited to be initially considered at a subregional level. Policy routes could be explored to ensure adequate EV charging at property level. Boroughs will also be a useful element of addressing this issue, providing more geographically tied insights. Landlords will also have to be engaged in the policy forming process.	Policy	London Councils/GLA, landlords, boroughs
Transport/ renewables/ networks (technical)	**PV canopies** – a subregional approach is useful as it could create economies of scale and improve the supply chain for what is still a relatively uncommon technology in the UK. These would also make useful sites to integrate large scale batteries. Some potential projects are identified at the subregional level, which could be progressed through feasibility by relevant stakeholders. These projects could also be of a suitable scale for including community energy groups. This would be particularly relevant if further analysis is undertaken in phase 2 LAEPs to identify a pipeline of projects.	Planning policy, Additional study, Engagement	GLA, boroughs, car park owners, community energy groups

4.5 Renewable generation

The focus of this section is on solar power particularly rooftop PV, being the most common opportunity across the subregion. The wind resource is poor in London and limited to minor opportunities, which or not significant or scalable on a subregional scale.

Some consideration is given to large scale PV. The high price of land this is not a preferred option in the subregion, there are several large reservoirs/water bodies on boundary of Enfield, Waltham Forest and Haringey which could be explored further, except for those protected. Stakeholder engagement highlighted that Thames Water are considering some of these options. The main opportunity for large scale PV in most boroughs (apart from rooftop) is large car parks, where PV canopies can be used. With a high deployment of EV chargers in these areas it means there is a demand for the electricity on site, increasing scheme economic viability.

These opportunities could be explored further in Phase 2. Canopies can also bring additional benefits such as shading, which with climate change is likely to become an increasing consideration in the summer.

4.5.1 Rooftop solar generation scale

London benefits from the freely available London Solar Map, which quantifies the theoretical potential for rooftop PV across the capital. This is illustrated for the subregion in Figure 4—16.

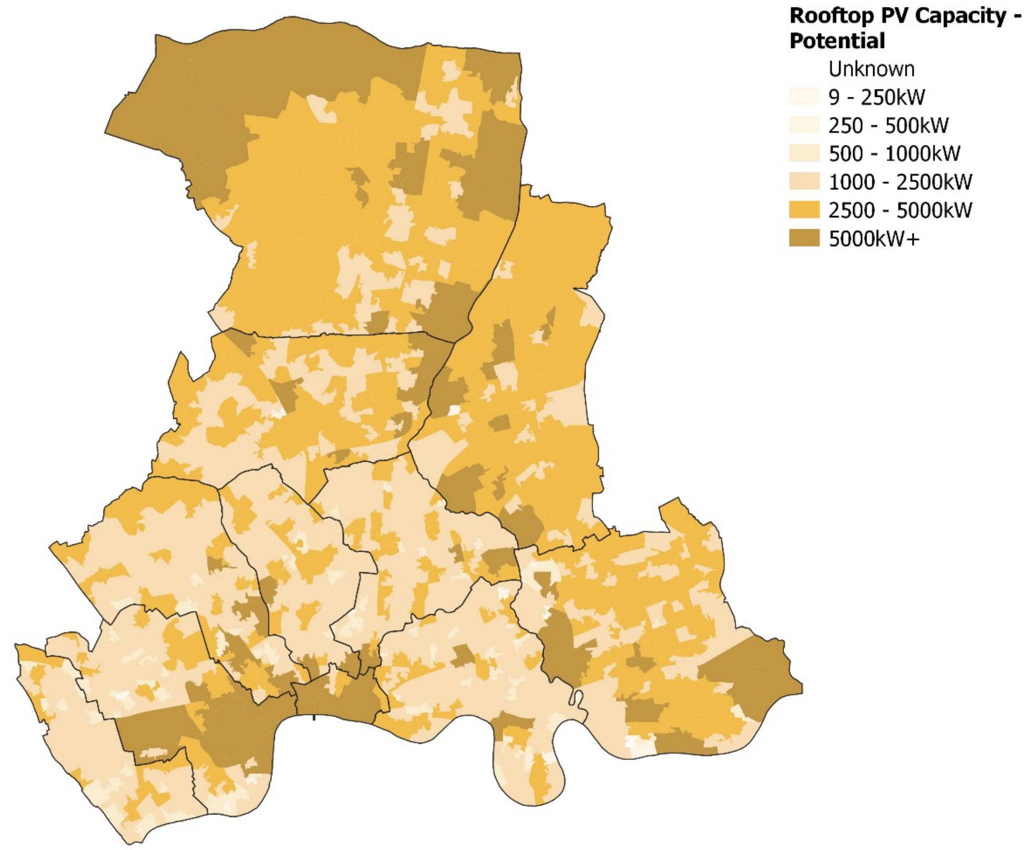

Figure 4—16 PV theoretical potential from the London Solar Map.

When sites progress through feasibility the potential will often be revised downwards. However, even with this taken into account the level of PV potential in the subregion is far greater an opportunity than is realistic to achieve. For this reason, the opportunities were refined to focus on areas most suitable and likely to deploy PV. Section 4.5.2 provides a summary of the process used to determine these priority areas and identifies some to focus on.

4.5.2 Rooftop solar generation – delivery

This work was able to draw on a large survey of London residents, this provides insights into how residents form different social groups view different technologies. One key aspect is tenure and is explored in Figure 4—17.

Figure 4—17 Talk London Survey results for interest in domestic rooftop PV.

This shows that overall, there is support for PV but this is noticeably weaker in socially rented properties than either owner occupied or the private rented sector. However, the social sector is well equipped for PV deployment with economies of scale and fewer property owners to engage. The survey data does highlight that alongside any deployment in the social sector an education piece is required to bring some residents onside.

The private rented sector, although positive, are harder to engage as the residents do not own the properties and owners are unlikely to see benefits of deployment. This means owner occupied properties are generally the easiest and this combines with a strong level of interest. This is incorporated into the modelling alongside the ability to pay (which is assed by number of mortgages at census Output Area). Other factors for incorporated include the future technology projections with properties that are likely to have an off-street EV charger and individual heat pump having increased likelihood of uptake. This is because the increased electrical demand at these properties means that PV becomes more financially viable. These properties are also generally larger, meaning space for battery installation is also more likely.

Buildings where there are multiple tenures and owners (such as blocks of flats) are considered for PV. However, complexities of roof ownership and additional complexities means these are somewhat less favoured than buildings with one owner. Blocks of flats flagged for PV deployment therefore tend to be on council or other public sector owned buildings.

In non-domestic properties the timing of constraint on the electrical network is a key consideration (this is illustrated earlier in Figure 2—32). In areas with a large number of non-domestic properties there tends to be more constraint during the summer, due to the presence of air conditioning. Solar PV generation will be highest on days when electricity is at its highest in these summer constrained areas. Consequently, PV deployment can help relieve stress on the grid and is of most value to the rooftop owner as it will generally mean avoiding the cost of buying electricity.

These and other factors (detailed in Appendix A) are used in the modelling to identify the preferred areas for PV. The distribution of PV deployment is provided in Figure 4—18.

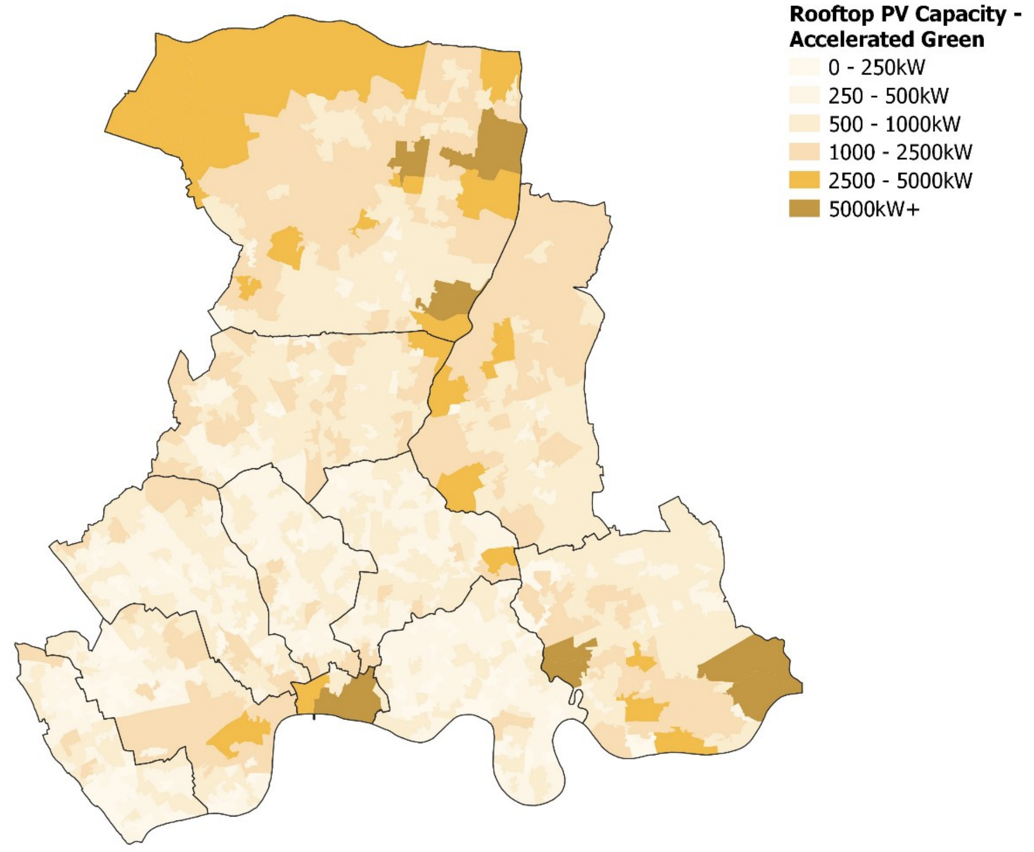

Figure 4—18 Overview of PV deployment by LSOA in the highest deployment scenario considered.

Areas which are not highlighted for PV deployment should still consider it, as PV will still add value in these areas.

4.5.3 Renewable generation next step recommendations

Based on the analysis presented above and a review of inputs from stakeholder engagement a high-level summary of subregional renewable actions is provided in Table 4—8. The geographically tied action areas identified above should also be explored through more detailed study (such as Phase 2 LAEPs or feasibilities), more specific borough related focus areas are also included in borough profiles.

Table 4—8 Summary of subregional actions for renewables.

Theme	Description and action	Activity type	Owner
Transport/ renewables/ networks (technical)	**PV canopies** – a subregional approach is useful as it could create economies of scale and improve the supply chain for what is still a relatively uncommon technology in the UK. These would also make useful sites to integrate large scale batteries. These projects could also be of a suitable scale for including community energy groups.	Planning policy Additional study, Engagement	GLA, boroughs, car park owners, community energy groups
Renewables (technical)	**Mass purchasing** – Solar Together has had mixed success, in part impacted by price spikes, but mass purchase of PV is key for driving the price down with the ambition deployment seen in the scenarios. Deployment of PV and batteries can provide significant flexibility services.	Project identification, Procurement	GLA and boroughs
Renewables (technical)	**Joint development** – developing PV alongside broader electrification can help decrease operating costs, particularly when combined with batteries and potentially flexibility services, to	Project identification, Procurement, Engagement,	GLA, boroughs, UK Power Networks, central goverment

Theme	Description and action	Activity type	Owner
	maximise PV usage and strain on the grid. This includes heat pump or EV deployment. The first step is to explore mechanisms such as standardised funding streams or technology offerings to promote this uptake. This can be combined with the mass purchasing opportunity above. The domestic sector is an important target for this – with houses rather than flats generally able to benefit the most.	Policy	
Renewables (data)	**London Solar Opportunity Map** – newer LIDAR data is now available, capturing more recent developments. This would allow for more accurate assessment of the solar potential. In general, the LIDAR coverage in the CEIN subregion is good, meaning issues of missing data (which appear elsewhere in London) are not an issue in this instance). The potential listed in the data set would generally be considered a theoretical value. It has been reported by boroughs that when installing PV panels if the London Solar Opportunity Map is used as a comparison to what can actually be installed the actual value is often substantially lower. Ideally, an additional lower value should be added which is more likely to be practically achievable – this is a challenging item as roof specific criteria are needed for an accurate assessment.	Data improvement	GLA

4.6 Flexibility

Flexibility and diversity are two important components of the energy system. Flexibility refers to the ability to change generation or consumption/demand patterns to support the electricity network. In fossil fuel-based energy systems, with the ability to easily dispatch additional generation to match demand there has traditionally been relatively little need for demand to be flexible. However, renewable generation is generally not dispatchable and, often more importantly in the local context, the electricity network cannot always distribute the electricity required at times of peak demand. This issue will increase with the electrification of heat and transport. Higher flexibility refers to either demands being able to vary to match what the grid can supply or for local technology to provide additional supply.

Diversity refers to natural differences in demand. This accounts for the fact that not everyone in the subregion will be using all of their appliances at once, for example, every household charging an EV, having a shower, cooking a meal, using the tumble dryer and having the heating on full at the same time. Currently, particularly with electric heating, electricity networks assume a very low diversity. This means the electricity network must have capacity to supply the full demand for heat to every consumer on the network at any time if electrification of heating is to take place. If this is not the case upgrades to the electricity network would be required before a building could switch from a gas boiler to a heat pump.

As energy networks become more advanced with integration of technology like smart meters and distributed storage, there is more opportunity for consumers to directly supply flexibility services and for a more detailed understanding of diversity. This shift in how the electricity system functions is increasingly being captured by the phrase Smart Local Energy Systems (SLES). In some of the higher electrification scenarios increased flexibility and assuming greater diversity in demand is key to helping reduce high electricity network reinforcement costs.

As it is naturally occurring in the energy system diversity is not a specific action area but there are focal areas for flexibility. Whilst the widespread electrification of heat and transport will require reinforcement of the electricity supply, flexibility can help increase the amount of electrification before reinforcement is required. The role of flexibility is increasingly being recognised by UK POWER NETWORKS, particularly from the DSO perspective, with various services being offered – these are described in Table 4-9. Prices associated with flexibility opportunities will vary, up to date information can be found on the UK POWER NETWORKS website.

Table 4-9 Summary of UK POWER NETWORKS flexibility services that can be participated in.

Service	Description	Application in pathways context
Demand turn up HV & LV (for both low voltage and high voltage assets, all connections)	In times of excess generation demand is increased. In the current system excess generation is often mitigated by curtailment or reduction of flexible generation connection, the service thus helps reduce payments going to generators to stop producing power. In these times of excess generation, the grid will normally have a large share of renewables, meaning use the electricity will tend to have lower associated carbon emissions.	A cheap time to charge batteries and storage systems, essentially receiving payment for charging. As well as electrical storage this can also include charging thermal stores. For example, if a heat pump system includes a hot water tank, which the heat pump could charge in times of excess generation. The same principle, at a larger scale, exist for heat networks – where large thermal stores and electric heating technologies present multi MWs of flexibility.
Demand reduction HV & LV (for low voltage and high voltage assets, all connections)	This is set up to help reduce demand at times of peak. The flexibility provider must be able to reduce demand from a historic baseline for at least 30 minutes.	This can either be not using a technology such as charging EVs (although as this is based on a historic historic EV charger baseline, opportunities for EV charging are likely to be somewhat limited) or through reducing demand by use of onsite generation or batteries. Large scale energy users (such as industrial processes, commercial and leisure facilities) could also be a target. Greater opportunity mapping is required with these as demand suitability for flexibility will change from site to site.
Demand reduction LV (low voltage assets only, only small connections – such as domestic)	This is similar to the demand reduction for HV & LV but is purely focused for smaller electricity users.	Likely to be the most accessible to residents. Helps enable deployment of heat pumps and EV chargers at a local level without grid reinforcement. Opportunities are similar to the HV & LV context. Switching from inefficient direct electric heating to more efficient electric heating technology could in some contexts also enable the reduction required for participation.

Opportunities for flexibility are now published by UK POWER NETWORKS's Open Data Portal[52], this highlights postcodes where flexibility services are required. A heat map of these opportunities is provided in Figure 4—19.

[52] https://ukpowernetworks.opendatasoft.com/pages/home/ and the tender page is available at https://dso.ukpowernetworks.co.uk/flexibility/tender-hub

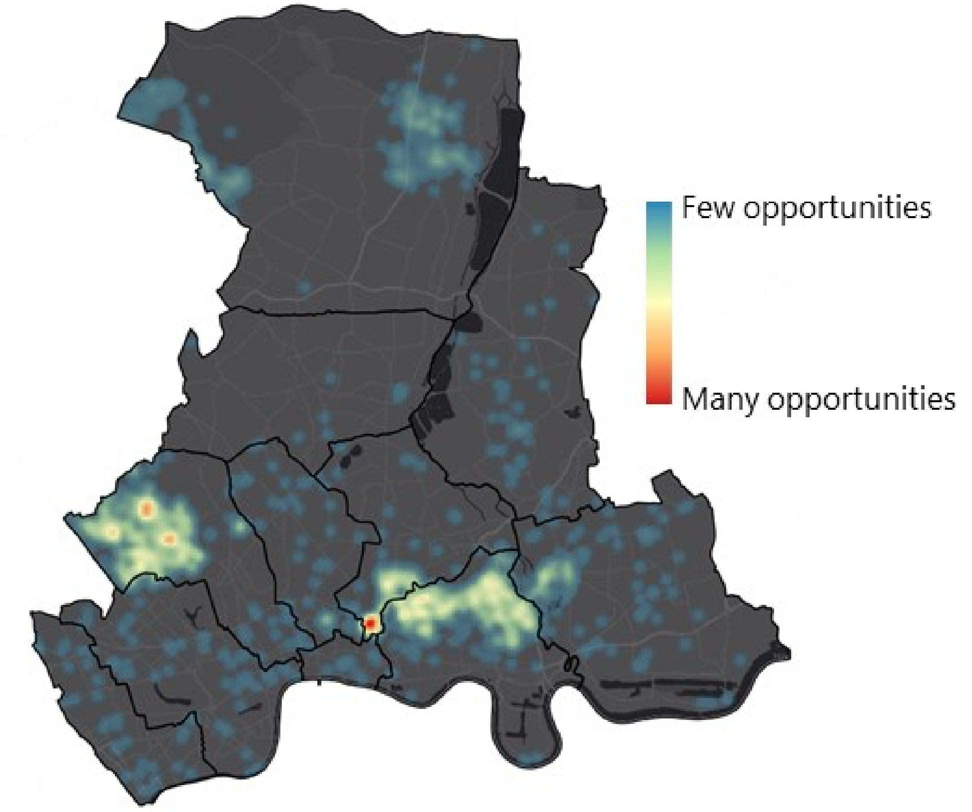

Figure 4—19 Current opportunity areas for flexibility service participation. Based on UK POWER NETWORKS postcode level flexibility data.

This shows the focus is on areas where reinforcement is already planned, with flexibility providing support until these upgrades are in place.

With increased electrification, even with flexibility, upgrades will be required to the electricity network – particularly in areas without heat networks. However, flexibility means more low carbon technology can be installed before upgrades are required – resulting in lower cumulative carbon emissions.

The opportunities for building level flexibility in the long term is considered to broadly align to these which will see the greatest increase in demand. Building level flexibility is considered further in 4.6.1.

4.6.1 Building level flexibility opportunities

Flexibility is considered in this pathways analysis using the network information, alongside the low carbon technologies and opportunities across the subregion. For example, a large house with a driveway (and EV charger) as well as heat pump and PV has a large opportunity for flexibility. By having PV panels batteries become an increasingly cost-effective technology, further adding to the flexibility opportunity.

To engage with flexibility services a means to communicate with the network is required, typically through a smart meter. As highlighted in the baseline the distribution of smart meters is not consistent across the subregion. Short term future projections are provided in Figure 4—20.

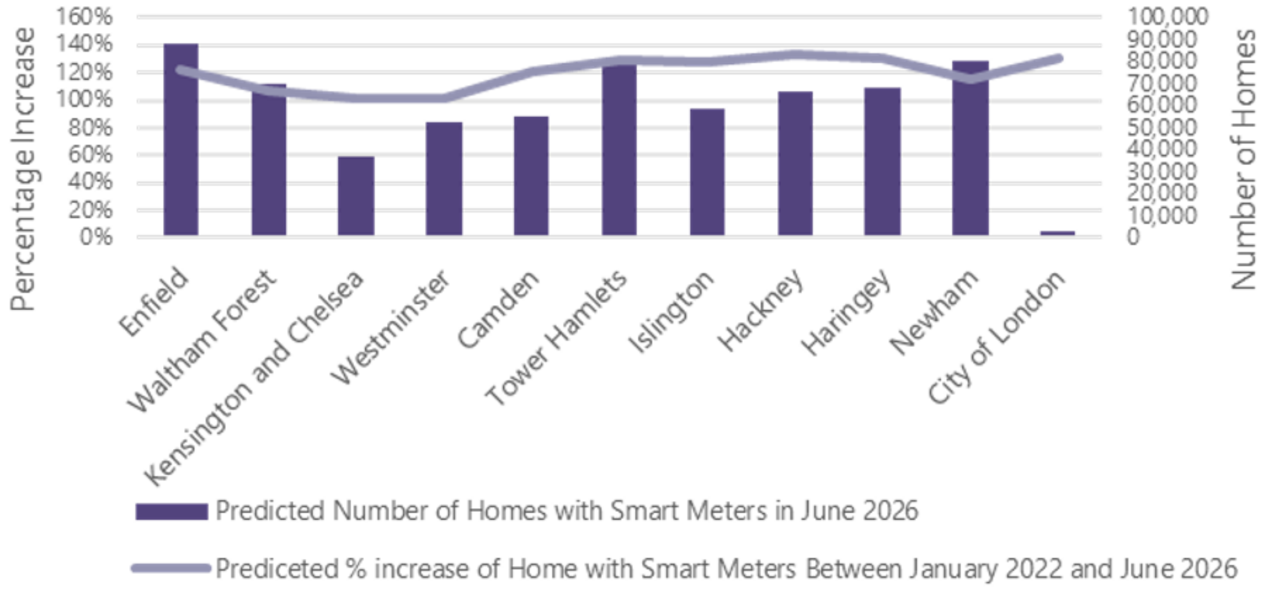

Figure 4—20 Forecasted number of smart meters by borough. Data provided by SmartDCC.

Tower Hamlets, Camden and Hackney all have high projected increases in smart meters, which is important as they currently have the highest flexibility opportunities. Smart meters will help enable greater participation in flexibility services. Westminster and Kensington and Chelsea both show relatively low numbers of current smart meters and low projected increase. This is potentially linked to the historic properties in the area and should be explored.

Smart meter deployment as a minimum should occur alongside the uptake of low carbon technologies allowing the ability to participate in flexibility services. An education piece is important alongside the deployment of flexibility offerings. One of the key findings from the Talk London survey was that social renters have the lowest levels of interest in smart meters and flexibility services. This is important as it means that many of those most in need of bill reduction are not benefiting from the services these devices offer.

There is a potential educational action which could be initiated by borough or community groups communicating the benefits of smart meters and how they can be used effectively to help reduce bills. Given the results of the Talk London survey this should initially focus on social housing.

Smart meters could also play a significant roll for monitoring progress towards decarbonisation. Complexities relating to smart meter data access means addressing some of these issues at a subregional level will reduce strain on boroughs. Some suggestions actions and next steps relating to smart meters are provided in Appendix C.

4.6.2 Network scale storage opportunities

Large scale battery storage is growing across the UK. However, this tends to be at higher voltage levels often being located next to large grid and primary substations. The increased demands highlighted in Figure 3—23 can be expected to generally align to opportunities for centralised battery storage. Large scale battery storage is not modelled further than this high-level opportunity identification. One of the key reasons for this is in the areas with high electrification it is often the infrastructure below the primary and secondary substations that require the most reinforcement and upgrades – where these batteries will have somewhat limited impact. A level of battery storage is considered at property level alongside PV deployment.

Of greater interest for large network scale storage is thermal stores. These present a much lower cost per unit of energy stored than a chemical battery. They can be charged at times of low electricity prices and release demand at peak. One of the main challenges for thermal stores in London is the high price of land and lack of space in inner boroughs, where heat density is greatest. With large scale transmission of heat across multiple boroughs this issue can be somewhat reduced. Constructing heat network energy centres near large substations can help keep costs low in terms of infrastructure and can help to balance demand at the substation level. Further consideration of this at a project level is a suggestion for future work coming out of this analysis.

4.6.3 Flexibility and network next step recommendations

Based on the analysis presented above and a review of inputs from stakeholder engagement a high-level summary of subregional flexibility and broader network actions is provided in Table 4—10 (this excludes items which are covered previously). The geographically tied action areas identified above should also be explored through more detailed study (such as Phase 2 LAEPs or feasibilities), more specific borough related focus areas are also included in borough profiles.

Table 4—10 Summary of subregional actions relating to flexibility and electricity networks more generally.

Theme	Description and action	Activity type	Owner
Networks (technical)	**Flexibility** – UK Power Networks run flexibility tenders regularly. A longer lead time for flexibility areas will enable more participation in the services. Boroughs, the GLA or energy suppliers could help bring together many properties to provide a larger aggregated service in line with UK POWER NETWORKS's needs. Ways to promote engagement with flexibility should be explored. A mechanism for this would be to have occupiers express an interest in participating and then if a flexibility opportunity arose this would help quicker ramping up of uptake. Boroughs could potentially also put forward their assets – allowing for quicker assessment of opportunities.	Further study, Engagement, Project identification	GLA, boroughs and UK Power Networks Aggregators Energy suppliers
Networks (data)	**Identification of flexibility opportunities** – including these in a centralised portal and potentially linking these to aggregated flexibility offerings from boroughs or the GLA. This could be linked to smart meter and low carbon technology deployment data. Appendix C explores specific items relating to smart meters and the GLA are already progressing items in this area.	Lobbying, DNOs Engagement	GLA, Ofgem, UK Power Networks
Networks (data)	**Headroom at lower voltages** – lack of detail on headroom below the primary substation level is a key shortfall in the ability of this work to identify short-term bottlenecks. UK Power Networks have, after completion of this analysis, addressed this with some additional information relating to secondary substations becoming available through their Open Data Portal. Monitoring the availability of any new data from UK Power Networks is likely to be a key element of the DataHub work, to allow for good alignment of work – particularly as the LAEPs progress towards more detailed project pipelines.	Data improvements	UK Power Networks and the GLA and boroughs to add in Phase 2

5 Next steps

This chapter provides a brief summary of the subregional LAEP priorities and their strategic considerations as well as what is next for the subregional LAEPs. These are important to consider in the context of section 4 which includes a list of some next steps for specific themes. Three additional next steps, which cut across all themes, are provided in Table 5—1.

Table 5—1 Summary of next steps and actions for cross cutting themes.

Description and action	Activity type	Potential owners
Education – the Talk London survey flagged a few issues that represent easy wins. A major one was related to views of smart meters and tariffs among social housing occupiers. This group was least interested in smart tariffs, which should be addressed as they are one of the groups with the highest risk of poverty and would thus benefit the most from improved rates. This will become increasingly important if their heating system switches from gas to electricity. The Talk London Survey results should be reviewed as a basis for focusing engagement in terms of theme, demographic and geographic elements.	Awareness / publicity, Engagement	Social landlords, boroughs, community groups
Data streamlining - Consolidation of data post Phase1 to improve coverage (baseline data especially for the non-domestic stock and planning data, local existing and pipeline projects), monitoring of projects and spatial links for faster decision-making. This is a key item to consider for Phase 2. The GLA DataHub is a key enable of this and is already starting to be used as such.	Data improvements	GLA and boroughs
Data alignment – data alignment is generally challenging; this varies from whether building TOIDs or UPRNs are used to historic LSOA boundaries in some current government datasets. The GLA are already creating standard templates to align these. In general the suggested preference is to encourage as much detail as possible as LAEPs and similar modelling is undertaken. The higher level of detail allows for aggregation creating commonalities.	Data improvements	DESNZ, GLA and DNOs

5.1 Subregional priorities

Key opportunities which are common to the boroughs vary somewhat with the characteristics of each borough. Areas with higher population densities tend to be priorities for heat networks making use of waste and low carbon heat sources; with less focus on building level solutions. More suburban areas are likely to benefit from retrofit at a building level, switching to heat pumps for heating, along with switching vehicle fuels. Common no-regret measures include a range of building fabric efficiency improvements and a shift towards active travel.

Low carbon technology supply chain

Fabric retrofit priorities are likely to focus on the social housing sector where progress is faster than in the private sector; this can help develop the supply chain for retrofit. One area which should be considered is privately rented stock, where limited incentives to invest exist without regulation. The Warm Homes Local Grant is seen as a key mechanism to drive that and also provide guidance and confidence in the market.

The number of heat pumps and EV chargers to be deployed suggests that investment in training and skills for installers should be prioritised; helping existing providers such as gas boiler installers transition to installing low carbon solutions.

Heat networks

Five priority strategic heat network areas have been identified, including: from Newham along the river to Tower Hamlets (and potentially in toward the City of London and further west), making use of waste heat from data centres and wastewater treatment; Enfield from Energetik – with heat transmission mains extending south into central London; the area around Olympic Park; Kensington and Chelsea and Westminster around the Royal Albert Hall and other significant historic buildings; and the major focus for heat demand density in Westminster, Camden, Islington, Hackney, City of London and Tower Hamlets. This last is one of the highest heat demand density areas in the UK, coupled with very limited land for energy centres and space for utilities makes it a complex opportunity to realise and would benefit substantially from a wider development approach – rather than borough-by-borough strategy.

Westminster, Islington, City of London and LLDC are already part of the advanced zoning programme and heat networks exist or are being developed in each of the areas identified already but not at the scale or pace indicated in the Net Zero 2040 scenario. The scale of these networks and their cross-boundary nature suggests a role for the GLA perhaps in co-ordinating their development and in working to secure infrastructure funding.

Transport priorities

Investment in new public transport capacity and active travel routes is critical to achieve the carbon emission reduction targets. This requires cross-boundary working and co-ordination. This is outside the scope of the study.

Provision of EV charging on-street for areas of boroughs with limited off-street parking is common in inner boroughs. EV charging priorities at the subregional scale include opportunities for freight charging and public charging hubs along key transport corridors.

Given the significant reliance on electrification of heating and transport sectors, the Subregional LAEP data has been provided to UK Power Networks Distribution System Operator (DSO), who will use this to enhance their forecasting activities (known as the Distributed Future Energy Scenarios (DFES), which shapes network plans[53]. It is likely that even with the widespread deployment of heat networks, substantial reinforcement will be required in central boroughs. A more widely deployed approach to flexibility could make best use of the existing headroom in the network in the meantime.

5.2 Strategic economic and labour considerations

There are large number of policy, deployment and financial elements to consider at the subregional scale. Although for these to be delivered there is a need for substantial national policy drivers from the UK Government (such as MEES, clarification of boiler phase out, large scale grants, addressing the price gap between gas and electricity).

Investment

One of the key elements is financing and funding for the billions of investment required. Due to the nature of the proposed solutions and stakeholders it is clear that a coordinated approach at the subregional scale is preferred. Not only does this give improved visibility of different technical information and data, it also gives improved visibility for the public and private sectors. For the public sector, there is the potential to develop more comprehensive policy initiatives that reflect the interconnectivity and phasing of proposed interventions and, where relevant, develop cross-borough procurement models to improve consistency of outcomes and improve cost-effectiveness through bulk purchasing. For the private sector, investment is more likely if there is policy and certainty on longer-term objectives set out by the GLA and boroughs. Some financial incentives and funding models will follow existing initiatives, e.g. Green Heat Network Fund (GHNF). Other technical solutions, such as the retrofit of domestic housing stock, will need further development.

Local skills and training

To maximise the employment benefits of the proposed interventions, the GLA and Boroughs should look to use mechanisms such as s106 agreements and contract terms and conditions to encourage employment of local people and fund training initiatives to provide people with the right skills to unlock green job opportunities. Conditions could also be

[53] See Appendix E for UK Power Networks note

used to encourage the use of local suppliers, helping to reach the estimated number of indirect and induced jobs within London identified in Section 3.

In addition, a cross-organisation push to further drive the development of green skills in the existing labour force of London will be highly beneficial in ensuring green economy opportunities are grasped in full. This can be done by expanding the breadth and boosting funding for programmes such as the GLA Skills Academies Hubs, of which, five are up and running that are targeted towards improving the green skills base. Furthermore, coordination between higher education institutions and other organisations will be important, taking account of the analysis in section 3 that indicates a higher proportion of green occupations require level 4 and above qualifications compared to non-green occupations.

In the context of this report, particular focus should be put on delivering training opportunities such as retrofit bootcamps to upskill existing workers and prepare them for the green transition. Retrofit bootcamps would primarily target the green enhanced skills occupation group identified in section 2 of the report, which incorporates workers whose roles are likely to change because of the introduction of new green technologies and activities.

5.3 What next for the subregional LAEP

For the majority of boroughs the next step in the LAEP will be progressing to a full Phase 2 LAEP, as outlined in Figure 5—1. Specific recommendations are provided to each borough in bespoke borough profiles and even if a Phase 2 LAEP is not pursued by a borough these profiles are still a basis for actions to consider.

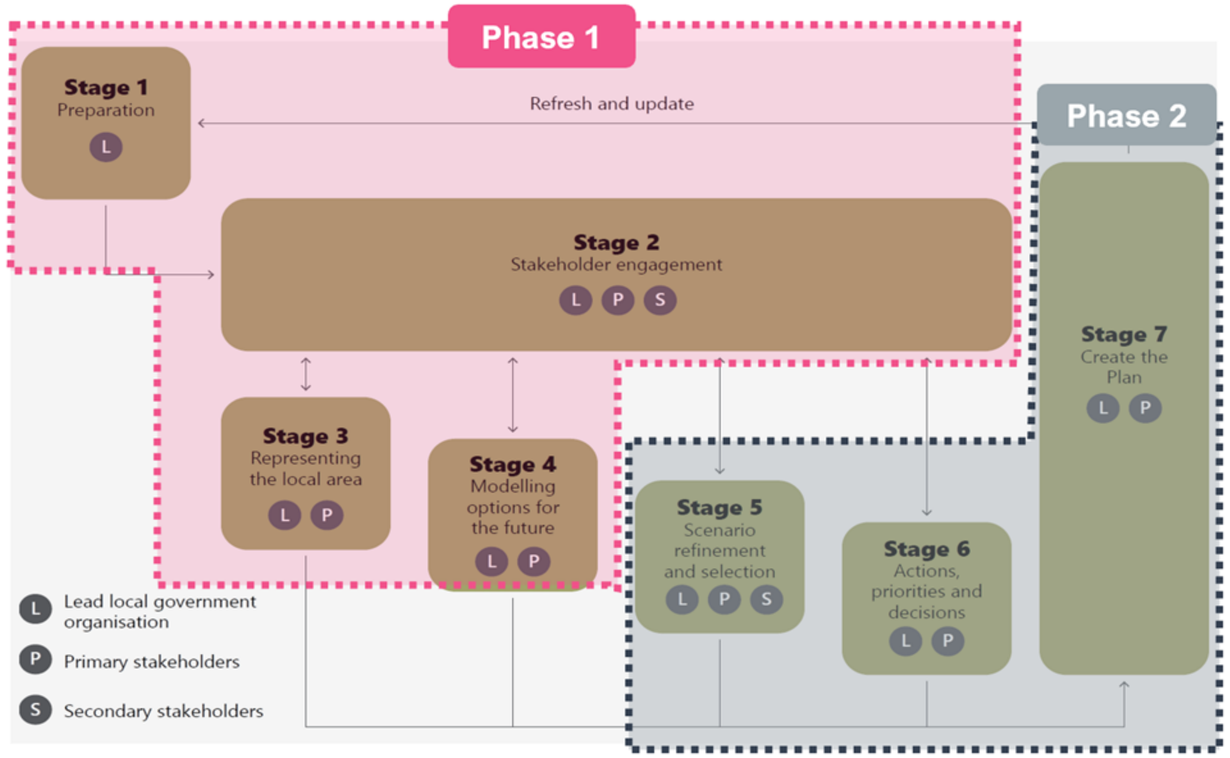

Figure 5—1 Energy Systems Catapult LAEP stages.

At the subregional level prioritisation of actions and decisions are a key element to progress – as shown in Stage 6 of Figure 5—1. This should include the next steps highlighted throughout the report. There are also many key items as discussed above, such as strategic heat networks, that are best considered from a delivery perspective at the subregional level. This report provides a basis for creating a more cogent approach to realising the opportunities that are more suited to a wider viewpoint than that of individual boroughs – whilst supporting the progress to more detailed next steps of borough specific LAEPs.

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