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Ealing Town Centre Heat Network Feasibility Report

Prepared for: London Borough of Ealing

Prepared by: Dr Gabriel Gallagher
Mari Roberts
Eric Shen
Ollie Campbell-Lendrum

EXECUTIVE SUMMARY

This report presents the findings of the Ealing Town Centre Heat Network Feasibility Study. The project is funded and supported by the London Borough of Ealing (LBE) and Greater London Authority's Local Energy Accelerator (LEA). The purpose of the project is to identify and evaluate opportunities to develop energy networks in Ealing Town Centre.

Energy Demand and Supply Assessment

An energy demand assessment for Ealing has identified that Ealing Town Centre is a heat-dense area. Key heat demands include the LBE office building Perceval House, Ealing Hospital, Ealing Broadway, and numerous planned developments.

Heat supply opportunities within the town centre are limited. A low carbon heat source for an initial network will likely be centralised air source heat pumps (ASHPs). However, several low carbon heat sources have been identified outside of the assessment area, including two data centres planned in the Southall area, to the west, as well as numerous data centres supplying the Old Oak and Park Royal Development Corporation (OPDC) heat network to the east that could expand in future to connect to the town centre. Future connection to the data centres to utilise the waste heat could lead to wider scale decarbonisation throughout the borough.

Potential energy centre locations within the town centre were assessed and selected following discussions with LBE. A number of town centre planned development sites have been identified as potential energy centre locations for the network. However, proximity to heat demands, technical and commercial risks would factor into the selection of a preferred site.

Proposed Solution

A heat network opportunity has been identified for the Ealing Town Centre area to be developed over two phases:

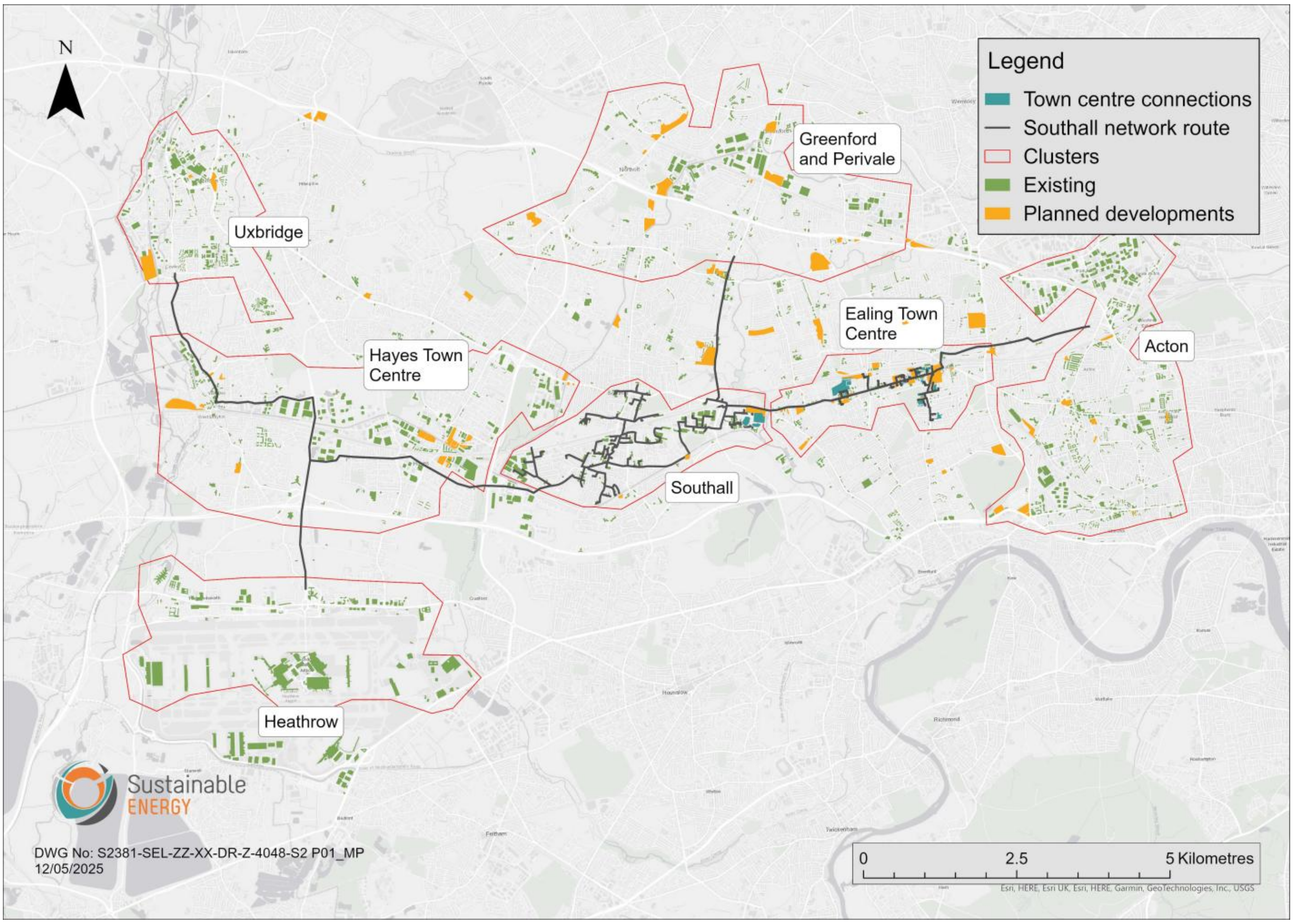
- Phase 1: Connects several key existing public sector buildings such as Perceval House, Ealing Green College, Christ the Saviour CoE School and Christ the Saviour Church
- Phase 2: Extends outward from the town centre along Uxbridge Road and B455 to connect to large private sector demands and planned developments, including Exchange Plaza, Ealing Gateway, and Ealing Studios

A phase 1 planned development energy centre would include 2.8 MW ASHP and 3.6 MW of peak and reserve boilers as well as 50,000 litres of thermal storage once fully built out. The energy centre will require a footprint of 400 m^2 alongside rooftop air heat exchangers. To expand the network to connect phase 2, an additional energy centre may be required in another development area. However, should sufficient space be available for a larger energy centre in phase 1, an additional town centre energy centre may not be required. The network phasing, route and energy centres are shown in the image on the right with details in the table below.

	Phase 1	Phase 2 (Cumulative)
Total heat demand (including losses), MWh	15,136	24,689
Peak heat demand (diversified), MW	7.2	13.0
Low carbon capacity, MW	2.8	5.0
Peak and reserve boiler capacity, MW	3.6	5.8
Heat demand met by low carbon system, MW	13,474	22,357
Heat demand met by gas boilers, MWh	1,662	2,331
% heat demand met by low carbon / renewable	89%	91%
Heat network length, m	2,148	3,165

Future network expansion opportunities were identified, including connection to waste heat offtake from planned data centres in Southall or to the OPDC Heat Network. Connection to these waste heat sources would also allow for the connection of additional heat demands within the Ealing Town Centre area including the University of West London, existing private sector residential sites, and the Green Man Lane network area. A map of the future expansion opportunities within the borough and neighbouring sites is shown below.

A separate study high level heat mapping study has been undertaken for the Southall area. The purpose of this study was to provide the LBE planning team with an evidence base to justify the requirement for heat offtake from the planned data centres in Southall. The results of the study indicate that there is sufficient heat demand in Southall and neighbouring areas (including the town centre) that could benefit from connection to a heat network supplied by heat offtake from data centres. However, further assessment of the heat offtake connection and potential for a heat network in Southall is required. This work is provided in Appendix 9: Southall Data Centre Planning Note.



Economics

A techno-economic model (TEM) was constructed to assess the economics of phase 1 and 2 of the Ealing Town Centre Network. The model allows key parameters to be varied and the associated impact assessed. The 40-year economics and CO_2e savings for each network phase are summarised in below. Figures shown for phase 2 include the previous phase. A conservative connection charge of £600/kW has been included in the base case assessment. However, during a short soft market testing exercise it was suggested connection charges for the Ealing Town Centre Network could be £1,000/kW. The 40-year IRR for this higher connection charge has also been included in the table below. There is also potential for the scheme to be supported through the Green Heat Network Fund (GHNF).

	Phase 1	Phase 2
Cumulative capital costs (incl. contingency), £	£21,635,190	£34,223,674
40-year IRR	2.6%	2.7%
40-year NPV	-£2,249,115	-£2,826,142
40-year social IRR	9.2%	9.8%
40-year IRR (£1,000/kW connection charge)	3.9%	4.2%
40-year IRR with grant funding	16.0%	14.3%
Lifetime carbon savings (40 years), tCO_2e	63,038	123,478

Sensitivity and Risk

Key sensitivity parameters for the prioritised network areas include:

- Capital costs
- Network heat demand and key sites not connecting and key developments not being brought forward
- Energy tariffs including heat sales tariffs, energy centre electricity purchase tariffs and energy tariff indexing
- Heat pump SPF

Key risks for the networks include:

- Securing the energy centre location in Ealing town centre
- Requirement for additional heat sources/supply for phase 2 expansion
- Coordination of network timing with planned developments

Conclusions and Key Next Steps

It is likely that this scheme will be economic if GHNF can be secured and will deliver the required project benefits. The network will offer benefits to the Ealing Town Centre area including significant reductions in CO_2e emissions, reduction in electricity capacity and grid infrastructure upgrades for new developments compared to the counterfactual of individual ASHPs, potential for lower cost decarbonsiation, potential to utilise waste heat sources such as from data centres, and education opportunities. However, the network is reliant on securing a suitable energy centre site and coordination with planned developments. Future expansion and widespread decarbonisation of the town centre and wider borough can be achieved through connection to waste heat offtake from data centres in the Southall area.

If the project is to be progressed, the key next steps include:

- Present the findings of the report to relevant stakeholders including LBE senior staff and elected members
- Undertake detailed techno-economic feasibility study for the Southall area assessing the potential to utilise waste heat from the planned data centres in the area and potential expansion to serve the Ealing Town Centre heat network in the longer term
- Undertake soft market testing with a selection of investors in the heat networks market, to provide LBE with useful feedback on the viability of the scheme from a private sector perspective and provide insight on how investible and deliverable the project is in its current proposed structure and solution

- Undertake a commercial workshop with commercial advisors and senior staff within LBE to identify the preferred delivery vehicle and procurement route for an Ealing heat network scheme, along with the associated levels of control, risks, and a mitigation plan if needed
- Continue discussions with developers to secure a development site energy centre

Ongoing next steps include:

- Continued engagement with the planning officers and developers to coordinate with planned development sites and safeguard land for network route
- Consider applying to GHNF for commercialisation and construction funding
- Continued engagement with building owners to ensure connection to the network

Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ASHP	Air source heat pump
BAU	Business as usual
CAPEX	Capital expenditure
LBE	London Borough of Ealing
CHP	Combined heat and power
CO_2e	Carbon dioxide equivalent
CoP	Coefficient of performance
CSF	Critical Success Factors
DEC	Display Energy Certificate
DEN	District energy network
DESNZ	Department for Energy Security and Net Zero
DHN	District heat network
DHW	Domestic hot water
GIS	Geographic Information System
GHNF	Green Heat Network Fund
GLA	Greater London A
GSHP	Ground source heat pump
HIU	Heat interface unit
HNCoP	Heat Networks Code of Practice
HNDU	Heat Network Delivery Unit
HV	High Voltage
IRR	Internal rate of return
kWh	Kilowatt hour
LBE	London Borough of Ealing
LEA	Local Energy Accelerator
LP	Low Pressure
LTHW	Low temperature hot water
LV	Low Voltage
mbus	Meter Bus
MWh	Megawatt hour
MWSHP	Mine water source heat pump
NPC	Net present cost
NPV	Net present value
OPDC	Old Oak and Park Royal Development Corporation
OPEX	Operational expenditure
PFD	Process flow diagram
PV	Photovoltaics
RFI	Request for information
SPF	Seasonal performance factor
TEM	Techno-economic model
WSHP	Water source heat pump

GLOSSARY

CO_2e	A quantity that measures the global warming potential (GWP) of any mixture of greenhouse gases using the equivalent amount or concentration of carbon dioxide
COP	Coefficient of performance for a heat pump is how many units of heat are produced per unit of input electricity
Business as usual	What would have happened without the change or intervention being considered e.g. a heating system counterfactual might be individual gas boilers, heat pumps or electric storage heating
Counterfactual	The heating system that would have to be installed in a future decarbonised heating solution
District heating	The provision of heat to a group of buildings, district or whole city usually in the form of piped hot water from one or more centralised heat source
Energy centre	The building or room housing the heat and / or power generation technologies, network distribution pumps and all ancillary items
Energy demand	The heat / electricity / cooling demand of a building or site, usually shown as an annual figure in megawatt hours (MWh) or kilowatt hours (kWh)
Combined heat and power	The generation of electricity and heat simultaneously in a single process to improve primary energy efficiency compared to the separate generation of electricity (from power stations) and heat (from boilers)
Department for Energy Security and Net Zero	DESNZ focuses on ensuring energy stability, resilience, and the transition to a carbon-neutral economy to achieve net-zero greenhouse gas emissions. Formerly known as Department for Business, Energy & Industrial Strategy (BEIS)
Green Heat Network Fund	The £288m capital grant funding programme for heat networks announced by Government that opened on 1 April 2022
Heat exchanger	A device in which heat is transferred from one fluid stream to another without mixing - there must be a temperature difference between the streams for heat exchange to occur
Heat Interface Unit	Defined point of technical and contractual separation between the Distribution Network and a heat user
Heat network	The flow and return pipes that convey the heat from energy centre to the customers – pipes are usually buried but may be above ground or within buildings
Heat offtake opportunity	An opportunity to utilise waste heat from an industrial process including EfW plants using heat exchangers
Heat pump	A technology that transfers heat from a heat source to heat sink using electricity (heat sources can include air, water, ground, waste heat, mine water)
Hurdle rate	The minimum internal rate or return that is required for a network to be deemed financially viable

Internal Rate of Return	Defined as the interest rate at which the net present value of all the cash flows (both positive and negative) from a project or investment equal zero, and used to evaluate the attractiveness of a project or investment
Levelised cost of heat	The levelised cost of heat is the unit cost of generating heat over the lifetime of the plant per kWh heat produced
Linear heat density	Total heat demand divided by indicative pipe trench length - it provides a high level indicator for the potential viability of network options and phases
Net present cost	Net present cost is the present value of all the costs of installation and operation over the project lifetime, minus the present value of all the revenues that it earns over the project lifetime.
Net present value	Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time.
Peak and reserve plant	Boilers which produce heat to supply the network at times when heat demand is greater than can be supplied by the renewable or low carbon technology or when the renewable or low carbon technology is undergoing maintenance (also called auxiliary boilers)
Seasonal Performance Factor (SPF)	The average Coefficient of Performance (CoP) of a heat pump over the full heating season.
Substation	A defined point on the property boundary of the heat user, comprising a heat exchanger, up to which the heat network is responsible for the heat supply
Thermal store	Storage of heat, typically in an insulated tank as hot water to provide a buffer against peak demand

1 INTRODUCTION

1.1 General

This report presents the findings of the Ealing Town Centre Heat Network Feasibility Study. The project is funded and supported by the London Borough of Ealing (LBE) and Greater London Authority's Local Energy Accelerator (LEA). The purpose of the project is to identify and evaluate opportunities to develop energy networks in Ealing Town Centre.

1.2 Project Scope

SEL were commissioned to undertake a detailed feasibility study for Ealing Town Centre. The scope of the feasibility study included to:

- Provide an energy demand and supply assessment
- Assess energy centre and central plant options including heat pumps, biomass, thermal storage etc.
- Consider planning and architectural issues and environmental issues / benefits for a heat network (CO_2, NOx, permitting etc.)
- Complete the concept design (RIBA stage 2) for the energy centre, energy distribution systems and network connections
- Conduct a high level economic assessment through techno-economic cash flow modelling and provide the client with a bespoke techno-economic model (TEM)
- Consider grant funding requirements
- Assess social value and risk management
- Identify next steps

1.3 Project Background

London Borough of Ealing is committed to climate action to address the climate and ecological emergency, with a target of becoming Net Zero by 2030. In 2023, Ealing was part of the first stages of the GLA's West London Local Area Energy Planning work (WLAEP), setting out a key evidence base for the future energy strategy in the borough across heat, power, and transportation. The work identified Ealing Metropolitan Town Centre as a key area of decentralised energy potential.

Ealing Town Centre is an area of high heat density, with a large number of existing office buildings, housing blocks, and retail space concentrated along Uxbridge Road. The construction of the Elizabeth Line and subsequent reduction in travel times from the Ealing Broadway and West Ealing stations to Central London has driven further development and planning applications in the town.

To the east of the area, the Old Oak and Park Royal Development Corporation (OPDC) are utilising large volumes of waste heat from data centres to develop a heat network. Initial phases of the network are currently under development, with opportunities for future expansion to neighbouring areas, such as Ealing Town Centre, currently being investigated.

1.4 Project Drivers

LBE has committed to be Net Zero by 2030. Some of the councils' other key drivers for investigating heat networks include reducing carbon emissions and improving energy security. Further details on the council's drivers were discussed during a Critical Success Factors workshop held in January 2025.

2 DATA COLLECTION

A data collection exercise was undertaken to enable detailed energy mapping of existing and future energy demands as well as potential energy sources, barriers and constraints. As part of this process, the energy demand within the assessment area was reviewed, as discussed in section 2.1.

Key internal stakeholders at LBE were consulted to inform the data collection exercise, as discussed in section 2.3.

Potential key network customers were identified and contacted to request details of energy demands and supply systems including half-hourly, monthly or annual energy demands, energy tariffs, details of existing heating systems and plant room locations as well as any future site plans. Key potential network customers are discussed in section 2.3.

2.1 Energy Demand Assessment Area

The energy demand assessment area is shown in Figure 1.

Figure 1: Energy demand assessment area

2.2 Identification of Potential Customers

2.2.1 Planned Developments

All known planned developments within and surrounding the energy demand assessment area were identified and assessed. Planned developments may provide significant energy demands and potentially lower risk connections than privately owned existing sites due to their requirements to connect to a viable heat network under GLA planning regulations. The key documents reviewed included the Development Plan Document (2013), Housing Trajectory

(2023), and The Local Plan Reg 19 (2024). Details of identified planned developments are shown in Figure 2 and Table 1.

Figure 2: Planned developments

Table 1: Current information for planned developments

Name	Details of development	Timing
131 Broadway	• Residential-led development up to 134 co-living spaces with retail provision	Within 1 – 10 years
99-113 Broadway	• Residential-led mixed-use scheme with retail on ground floor • 144 new dwellings	Within 1 – 5 years
Chignell Place	• Commercial led mixed-use with residential on upper floors	Within 1 – 10 years
Sainsbury's	• Mixed-use, featuring a large supermarket, residential, offices and a community library	Within 6 – 15 years
96-102 Broadway	• Residential-led mixed-use scheme, providing up to 120 flats • 958 m^2 of commercial floor space on ground floor	Within 3 – 5 years
Lidl	• Residential-led with retail provision	Within 6 – 15 years
66-86 Broadway	• Residential-led, mixed-use scheme	Within 1 – 10 years
Waitrose	• Residential-led, mixed-use scheme including new homes, a replacement food store and flexible commercial space	Within 6 – 10 years
Sherwood Close	• Redevelopment of the estate to construct of 362 new properties • Development planned over 3 phases, with Phase 1 & 2 already completed	Within 1 – 3 years
42 Hastings Road	• Construction of mixed new development, with student accommodation providing up to 448 bed spaces	Within 6 – 10 years

Name	Details of development	Timing
Exchange Plaza	• Six to ten-storey office building comprising 25,273 m^2 (GEA)	Within 3 – 5 years
CP House	• Construction of part 11, part 13 storey office building with flexible uses	Within 3 – 5 years
Dawley House	• Construction of a multi-storey hotel, containing 170 bedrooms	Within 6 – 10 years
Perceval House Car Park	• Residential development	Within 6 – 15 years
Ealing Town Hall	• Development to provide a new hotel and retain some community and civic facilities	Within 6 – 10 years
49 -69 Broadway	• Commercial-led mixed-use scheme with some residential and cultural/leisure facilities	Within 6 – 15 years
Sandringham Mews	• Residential-led, mixed-use scheme with significant retail employment, leisure and community space provision	Within 6 – 10 years
Broadway Connection	• Construction of 21 storey office-led mixed-use scheme	Within 6 – 10 years
1A The Mall	• Construction of 81 co-living units	Within 3 – 5 years
Eastern Gateway	• Residential-led, mixed-use scheme with significant retail, employment and community space provision	Within 6 – 10 years
Acton Sidings	• Construction of 6,000 residential units	Within 6 – 15 years
Horn Lane	• Construction of 185 residential units	Within 6 – 10 years

2.2.2 Existing Sites

Existing sites within the assessment area were identified and their energy demands were assessed. The following sites have not been included in the energy demand assessment:

- Private individual residential with individual gas boilers or electric heating
- Low-rise retail, commercial, and residential buildings with an annual heat demand of less than 50 MWh

Private individual residential connections are excluded from energy assessment due to the significant stakeholder engagement required and costs associated with connecting to the network. Additionally, any building with an annual heat demand of less than 50 MWh is unlikely to yield significant revenues to justify the costs of connecting the pipework to the building; therefore, it will be excluded from the assessment.

Details of all sites identified and assessed within the energy demand assessment area are shown in Appendix 1: Energy Demand Assessment.

2.3 Engagement with Potential Key Stakeholders and Customers

Key stakeholders and potential network customers were identified, and contact was established where possible. SEL identified potential stakeholders and customers to obtain information such as energy data and tariffs, building use, occupancy levels and patterns, details of existing heating systems and plant room locations. Information requests were sent by email and, where possible, telephone calls. A summary of information received from the data collection exercise can be seen in Table 2.

Table 2: Summary of engagement with potential stakeholders and customers

Contact	Site / organisation	Role	Summary of engagement
Officer 1	LBE	Net Zero Manager	• Client Lead and Call Off Coordinator
Vassia Paloumbi	Lantern UK	Consultant	• LBE project management support
Amy Hammond		Director	
Bill Wilson	Buro Happold		

Contact	Site / organisation	Role	Summary of engagement
Annalisa Guidolin		LEA Project Delivery Unit	• Project Delivery Support/GLA PDU representative
Officer 2	LBE	Principal Project Manager	• Managing redevelopment of Perceval House car park • Provided information for the development and plans for the SSE substation that informed the heat demand and energy centre assessments
Officer 3	LBE	Planning Officer	• Provided information on planned developments and local plan site allocations to inform the heat demand and energy centre assessments • Continued engagement will be required to ensure plans for the heat network are included in the next iteration of the local plan
Officer 4	LBE	Asset Data Manager	• Provided information on LBE social housing assets to inform the heat demand assessment • Continued engagement will be required to progress heat network connection to social housing sites
Officer 5	LBE	Asset Manager	
Officer 6	LBE	Project Director	• Provided information on plans for Perceval House • Continued engagement will be required to ensure plans for Perceval House are aligned with the development of the heat network
Officer 7	LBE	GIS Manager	• Information on land ownership and GIS layers provided
Daljit Bains	Ealing Green College (West London College)	Director of Business Development and Partnerships	• Contacted via email on 26/04/24 • Further Teams call on 30/04/24 • No existing low-carbon technology on site • Interested in connecting to the network and flexible on timings • Continued engagement is required to ensure connection to the heat network
Andrew Rollings and Will Scott	Ealing Broadway Shopping Centre (British Land)	Centre Director at Ealing Broadway	• Contacted via email on 26/04/24 • No response or further engagement to date • Continued engagement is required to ensure connection to the heat network
Admin	Christ the Saviour School	Admin	• Contacted via email on 26/04/2 • No response or further engagement to date • Continued engagement is required to ensure connection to the heat network
Séverine Turgis	St Bernard's Wing (West London NHS Trust)	Energy and Estate Decarbonisation Manager	• Teams meeting on 03/04/24 • Heat Decarbonisation Plan and Electricity Capacity Update received
Ammer Mirza	Redwire Data Centre	Group Commercial Director	• First contacted on 07/02/24 • Second contact on 02/04/24 • No response via email or phone call
Sam Pepper	Aecom	Principal Consultant, Buildings and Places	• Teams meeting on 01/03/24 • Provided information on the current progress for the OPDC heat network and expansion opportunities

3 ENERGY DEMAND ASSESSMENT

Following the data collection exercise, energy demands were assessed for all sites identified within the assessment area. The methodology for estimating energy demands and hourly energy profiles is discussed in section 3.1. A full list of potential demands within the assessment area can be seen in Appendix 1: Energy Demand Assessment.

3.1 Energy Demand Profiles

Energy demands for potential network connections have been reviewed, verified and updated where required (this included the issue of Requests for Information (RFIs) to all key stakeholders). In line with best practice (Objective 2.2 of the Code of Practice), hourly annual energy demand profiles were generated using in-house modelling software which apportions demands to hourly loads over the year, considering degree day data[1], building use and occupancy. All significant existing and planned energy loads were then identified, categorised and mapped.

Where half-hourly data was not available, SEL modelled hourly profiles of heating and domestic hot water demand, normalised against degree day data from the nearest monitoring station (Northolt). Profiles were developed using in-house software and considered building plans, site measurements, building construction and operating parameters. From these profiles peak, baseload, seasonal and annual heat demands were identified.

Where no energy data was available i.e. for planned developments, data derived from hundreds of in-house data collection exercises for similar buildings was utilised and a demand profile for the building was constructed using in-house software or selected from our profile database as appropriate. Relevant Building Regulations were considered for planned developments. Heat demands for residential planned developments have been estimated based on heat demand models completed for a range of residential property types using 2021 Part L regulations and Future Homes Standards where appropriate.

For each building and network phase, the hourly heat demand profile was used to identify the average, maximum and minimum hourly demand throughout the year.

3.2 Energy Demand Assessment Results

Geographic Information System (GIS) software was used to map the identified annual heat demands and key cooling demands across the heat map area. The symbols denote building ownership and site location, and graduate in size according to energy demand. The larger the symbol, the greater the annual energy demand. The demands for all identified sites are shown in Appendix 1: Energy Demand Assessment.

3.2.1 Heat Demands

The total heat demand for all identified sites within the energy demand assessment area is approximately 102,000 MWh. The heat demands for all sites assessed are shown in Figure 3 and a full list is shown in Appendix 1: Energy Demand Assessment. The largest heat demands around the assessment area arise from the Acton Sidings development (19,580 MWh) and the main building at Ealing Hospital (11,553 MWh). The largest heat demands identified within the town centre arise from the Ealing Broadway Shopping Centre (4,065 MWh) and Dickens Yard residential and retail (4,260 MWh), with the largest public sector demand being Perceval House (1,245 MWh).

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[1] Degree days are a type of weather data calculated from outside air temperature readings. Heating degree days and cooling degree days are used extensively in calculations relating to building energy consumption. They are used to determine the heating requirements of buildings, representing a fall of one degree below a specified average outdoor temperature (15.5°C) for one day.

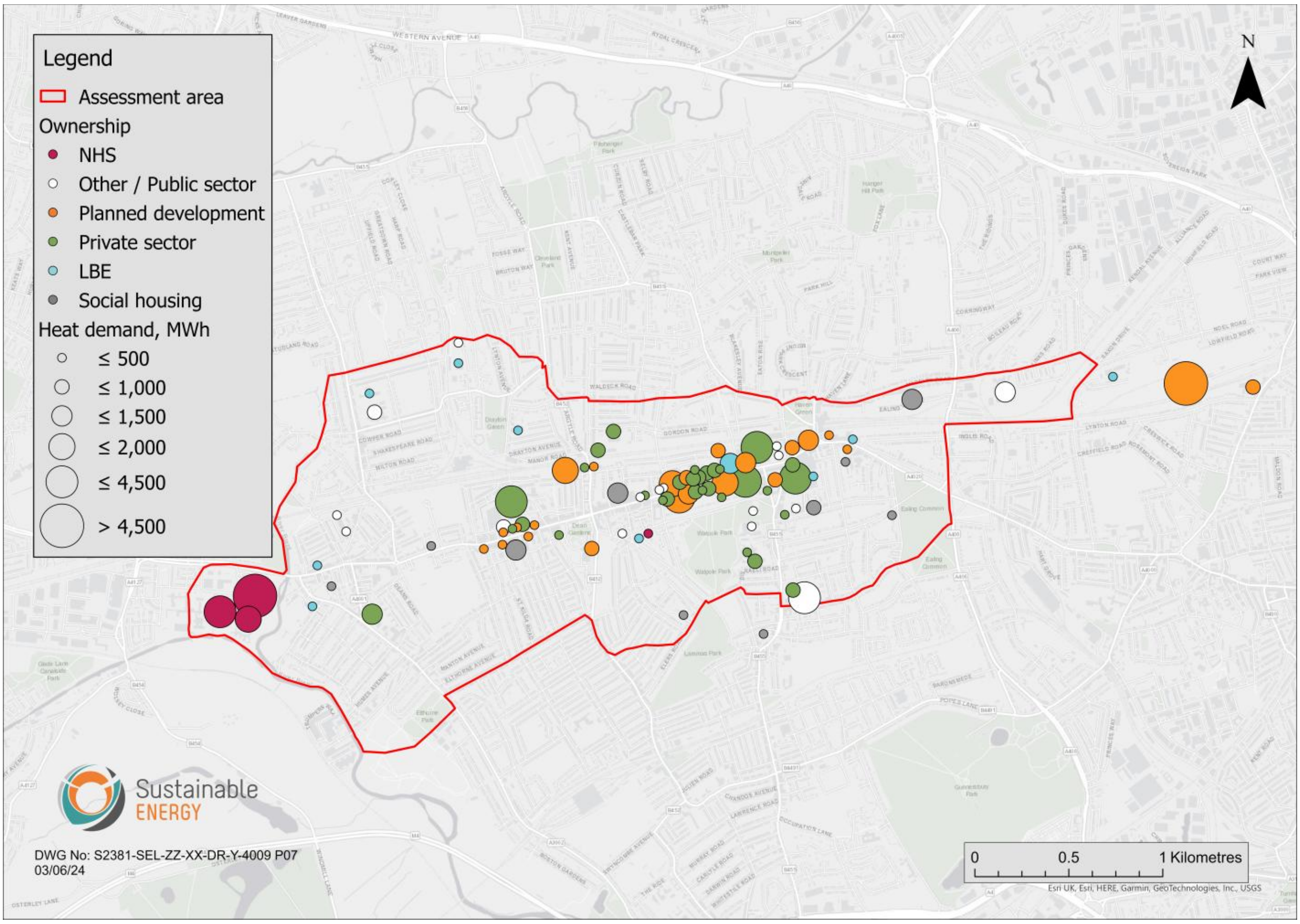

Figure 3: Heat demands

Table 3: Top 25 heat demands

Rank	Name	Ownership	Building use	Annual heat demand, MWh	Annual Peak demand, kW	Source of data
1	Acton Sidings	Planned development	Mixed-use	19,580	7,781	Estimated using data for similar sites
2	Ealing Hospital Main Building	NHS	Hospital	11,553	4,323	Actual data (DEC)
3	Dickens Yard	Private sector	Mixed-use	4260	1,570	Estimated using data for similar sites
4	St Bernard's Wing Ealing Hospital	NHS	Hospital	4,138	1,127	Actual data (metered)
5	Ealing Broadway	Private sector	Retail	4,065	2,327	Estimated using data for similar sites
6	University of West London	Other / Public sector	University	2,693	1,615	Actual data (DEC)
7	Green Man Lane	Private sector	Mixed-use	2,446	883	Estimated using data for similar sites
8	Waitrose	Planned development	Mixed-use	2,340	839	
9	Filmworks	Private sector	Mixed-use	2,346	1,203	
10	CP House	Planned development	Offices	1,964	1,349	Estimated using heat demand model
11	Exchange Plaza	Planned development	Offices	1,712	1,187	
12	49-69 Broadway	Planned development	Offices	1,600	1,126	Estimated using data from similar sites

Rank	Name	Ownership	Building use	Annual heat demand, MWh	Annual Peak demand, kW	Source of data
13	Sainsbury's	Planned development	Mixed-use	1,576	544	Estimated using data from similar sites
14	Three Bridges Medium Secure Unit	Planned development	Hospital	1,512	555	
15	Dawley House	Planned development	Hotel	1,370	573	
16	Perceval House	LBE	Offices	1,245	964	Actual data (metered)
17	Ellen Wilkinson Girls School	Other / Public Sector	School	1,193	1,202	Actual data (DEC)
18	Broughton Court	Social housing	Residential	1,177	580	Actual data (metered)
19	Ealing Town Hall	Planned development	Hotel	1,073	640	Estimated using heat demand model
20	Ealing Village	Social housing	Residential	1,003	455	Estimated using data from similar sites
21	Broadway Connection	Planned development	Offices	990	404	Estimated using heat demand model
22	Ealing Cross	Private sector	Offices	978	1,170	Estimated using data from similar sites
23	Ealing Aurora	Private sector	Offices	927	662	
24	Met Film School	Private sector	College	918	783	
25	Hilton	Private sector	Hotel	881	369	

Figure 4 shows the heat demands categorised by ownership and building use. Only 8% of the heat demand comes from buildings owned by LBE (including social housing), with 29% from private sector, 27% from other public sector (including NHS), and 36% from planned developments. Significant stakeholder engagement will therefore be required to connect the majority of identified sites to the network.

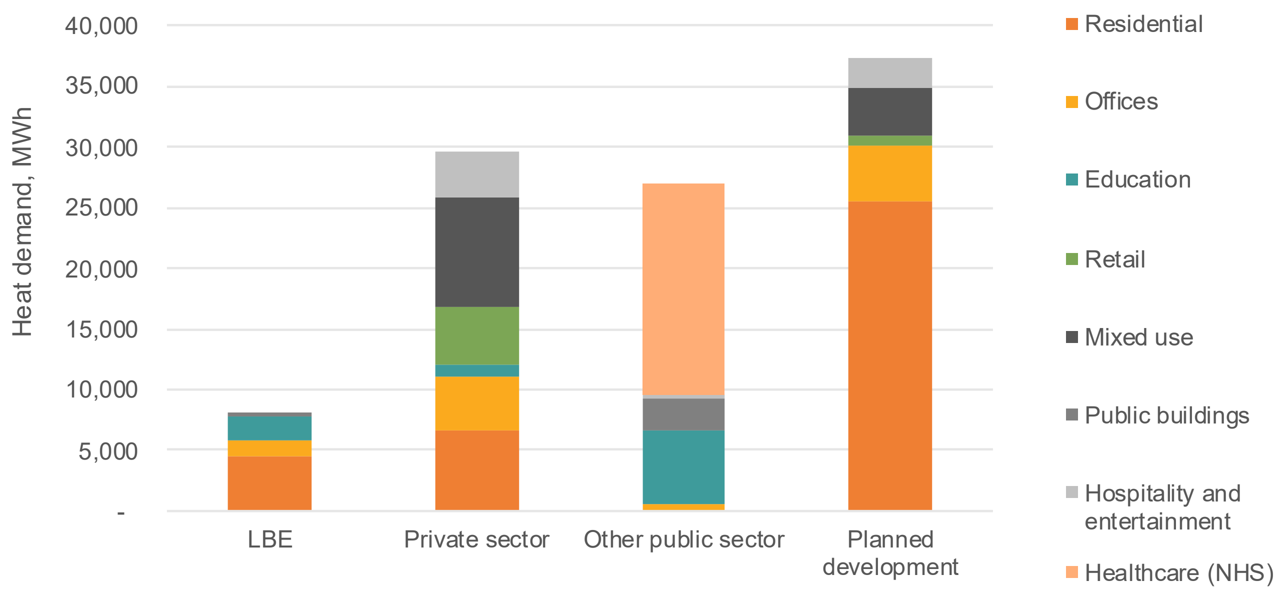

Figure 4: Categorisation of heat demands by ownership and building use

3.2.2 Cooling Demands

Building cooling demands have been identified for offices, hotels, large retail, healthcare, and sports centres within the assessment area based on in-house benchmarks developed from previous project experience and data collections. The total cooling demand for all identified sites is approximately 7,485 MWh. The cooling demands for all sites assessed are shown in Figure 5 and a full list is shown in Appendix 1: Energy Demand Assessment.

The largest demands around the assessment area arise from the Ealing Broadway Shopping Centre (1,570 MWh) and the main building at Ealing Hospital (1,104 MWh), other large cooling loads within the town centre are Perceval House (431 MWh) and the Broadway Connection (372 MWh).

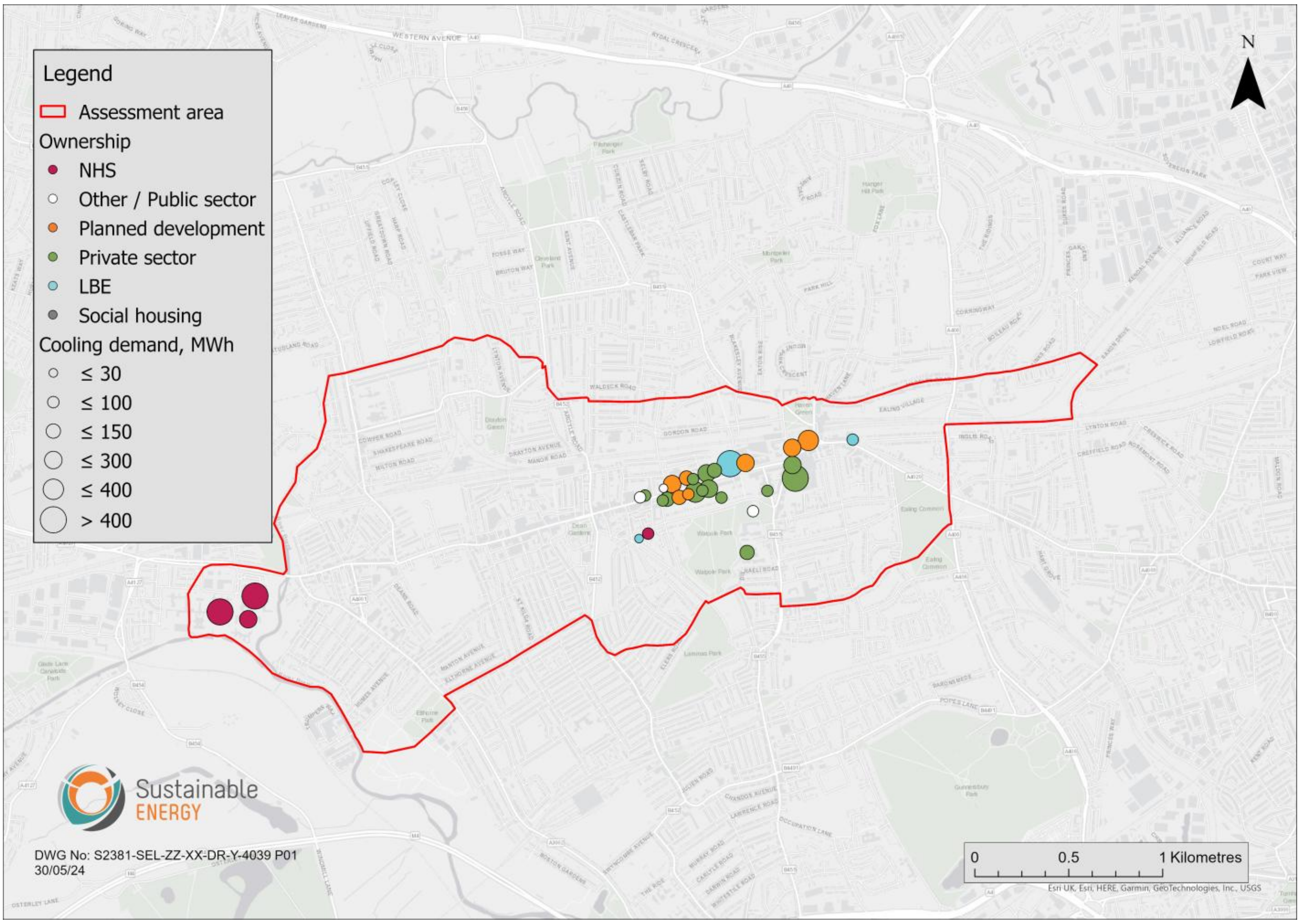

Figure 5: Cooling demand

3.3 Summary

Table 4 summarises the results of the energy demand assessment. The majority of energy demands have been estimated based on data for similar sites, with only 19% of heat demands from actual data and 0% of cooling demands. The total cooling demand is significantly lower than the heat demand within the assessment area, which results in very little benefit in a combined heating and cooling network. Therefore, this will not be further assessed in the following chapters of the report.

Table 4: Summary of energy demand data sources

	Total demand, MWh	% from actual data	% based on data for similar sites/energy demand model
Heat demand	102,021	19%	81%
Cooling demand	7,485	-	100%

4 HEAT SOURCE AND ENERGY CENTRE ASSESSMENT

4.1 Potential Energy Centre Locations

Potential energy centre locations were investigated to identify sites that could accommodate sufficient plants to supply a network. Each potential location has been considered based on land ownership (prioritising council-owned land), planned development sites, and proximity to potential key heat customers and heat sources. Figure 6 and Table 5 show the key identified locations.

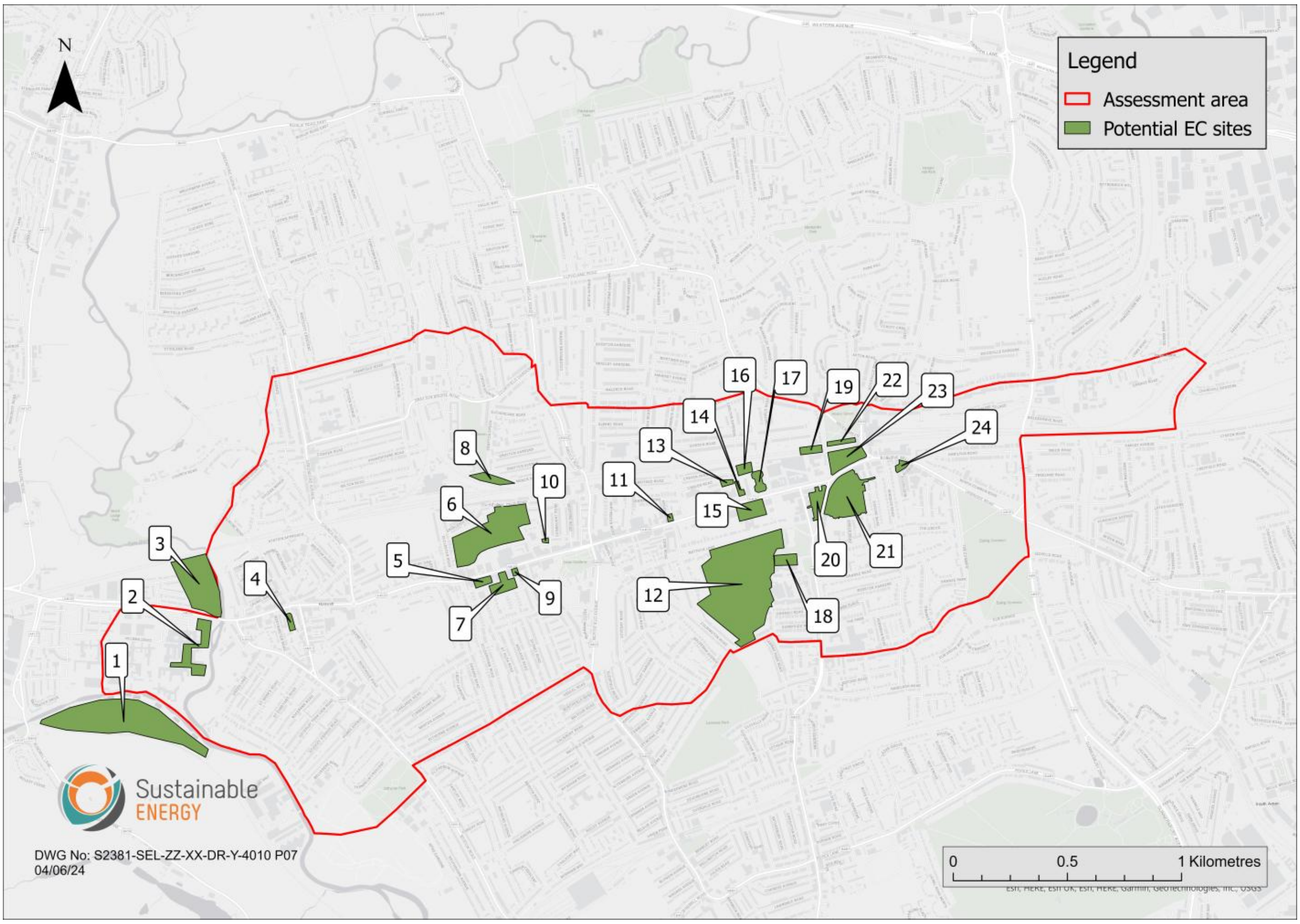

Figure 6: Potential energy centre locations

Table 5: Potential energy centre locations

Map ref	Site name	Site ownership	Current use	Comments	Considered further?
1	Hanwell Meadow	LBE	Green space	• Potential for GSHP to supply Ealing Hospital • Located next to Grand Union Canal – potential for WSHP • Significant distance from town centre buildings (~3 km)	No, as significant distance to key heat loads
2	Hospital Car Park	NHS	Car park	• Potential for ASHP to supply Ealing Hospital • Located next to River Brent – potential for WSHP • Significant distance from town centre buildings (~3 km)	No, as significant distance to key heat loads
3	Brent Meadow	LBE	Green space	• Potential for WSHP to supply Ealing Hospital • Significant distance from town centre buildings (~3 km)	No, as significant distance to heat loads
4	George Street Car Park	LBE	Car park	• Potential for ASHP to supply a network around hospital • Significant distance from town centre buildings (~2 km)	No, as significant distance to heat loads
5	99-113 Broadway	Private sector	Planned development	• High-level plans with potential to incorporate EC into development plans • Town centre retail converting to residential-led mixed-use scheme with ground floor retail • Close proximity to existing Green Man Lane network	No, as limited space on site
6	Green Man Lane	Private sector	Mixed-use	• Existing site with EC and heat network • Existing energy centre unlikely to have sufficient space for expansion to wider town centre area	No, as limited space on site
7	Sainsbury's	Private sector	Planned development	• High-level plans with potential to incorporate EC into development plans • Supermarket converting to residential-led mixed-use scheme with reprovision of a supermarket • Close proximity to existing Green Man Lane network	No, as limited space on site
8	Access House	Private sector	Planned development	• High-level plans with potential to incorporate EC into development plans • Self-storage warehouse, planned for 'Mixed-use intensification' • Opposite side of railway to majority of demand	No, as high risk due to railway crossing
9	59-65 Broadway	Private sector	Planned development	• High-level plans with potential to incorporate EC into development plans • Supermarket converted to residential-led with retail provision • Close proximity to existing Green Man Lane network	No, as limited space on site
10	Witham Road Car Park	LBE	Car park	• Potential for ASHP • Close proximity to existing Green Man Lane network	No, as limited space on site

Map ref	Site name	Site ownership	Current use	Comments	Considered further?
11	Arden Road Car Park	LBE	Car park	• Potential for ASHP to supply town centre • Located on edge of town centre (~400 m from Perceval House)	No, due to distance from key heat loads
12	Walpole Park	LBE	Green space	• Potential for GSHP to supply town centre • Located on edge of town centre (~400 m from Perceval House)	No, as likely opposition to loss of public green space
13	Ealing Central United Bowls Club	Private sector	Planned development	• High-level plans with potential to incorporate EC into development plans • Located in town centre (~250 m from Perceval House)	No, as limited space on site
14	Premier Inn	Private sector	Planned development	• High-level plans with potential to incorporate EC into development plans • Same building as Redwire data centre • Located in town centre (~100 m from Perceval House)	No, due to unknown development plans and high risk private ownership
15	49-69 Uxbridge Road	Private sector	Planned development	• High-level plans with potential to incorporate EC into development plans • Offices and police station converted to commercial led mixed-use with some residential • Located in town centre (~50 m from Perceval House)	No, due to unknown development plans and high risk private ownership
16	Perceval House Car Park	LBE	Planned development	• Potential for waste heat from Redwire Data Centre or ASHP to supply town centre • High-level plans with potential to incorporate EC into development plans • Would require loss of development land (ground floor/basement and roof), necessitating a strong economic case • Located behind Perceval House	Yes
17	Perceval House	LBE	LBE offices	• Office floorspace could be redeveloped to house energy centre, however, would require significant reconfiguration and structural assessments • Limited roof space available for air heat exchangers • Potential for high temperature ASHP to be installed to serve the building prior to network connection and export excess heat into the heat network once the network is developed	Yes, through supply of heat from on site ASHP only
18	Ealing Green College	Other / Public sector	College	• Potential for GSHP utilising green space at Walpole Park • Located on the edge of the town centre (~500 m from Perceval House)	Yes – for phase 2 as existing site
19	Springbridge Road Car Park	Network Rail (LBE leased)	Car park	• Potential for ASHP to supply town centre • Multi-story car park located above the railway line • Minimal noise and visual impacts	No – due to unknown structural suitability

Map ref	Site name	Site ownership	Current use	Comments	Considered further?
				• Structural assessment would be required to determine suitability of site • Located on the edge of the town centre (~400 m from Perceval House)	
20	Sandringham Mews	Private sector	Planned development	• High-level plans with the potential to incorporate EC into development plans • Residential-led mixed-use scheme	Yes
21	Ealing Broadway	Private sector	Planned development	• High-level plans with the potential to incorporate EC into development plans	No, as space may be limited
22	Haven Green Car Park	Other / Public sector (TFL, Network Rail, and Ealing Ltd.)	Car Park	• Potential for ASHP to supply town centre • Located on the edge of the town centre (~500 m from Perceval House) • Located on the opposite side of the railway to the majority of demand	No – as opposite side of railway to demands
23	Arcadia Centre and Broadway Connection	Private sector (British Land)	Planned development	• High-level plans with the potential to incorporate EC into development plans • Located on the edge of the town centre (~350 m from Perceval House)	Yes
24	Eastern Gateway	Private sector	Planned development	• High-level plans with the potential to incorporate EC into development plans • Located on the opposite side of the town centre to demand (~700 m from Perceval House)	No, as significant distance from key heat loads

4.1 Renewable and Low-Carbon Heat Sources

Potential low-carbon or renewable energy sources that are within or near the assessment area were assessed to identify any that may have the potential to supply a heat network. No existing heat generation technologies were identified within or near the Ealing Town Centre assessment area.

4.1.1 Long List Options

A long list appraisal of all potential low-carbon heat sources to supply a heat network in Ealing was undertaken and shown in Figure 7 and Table 6.

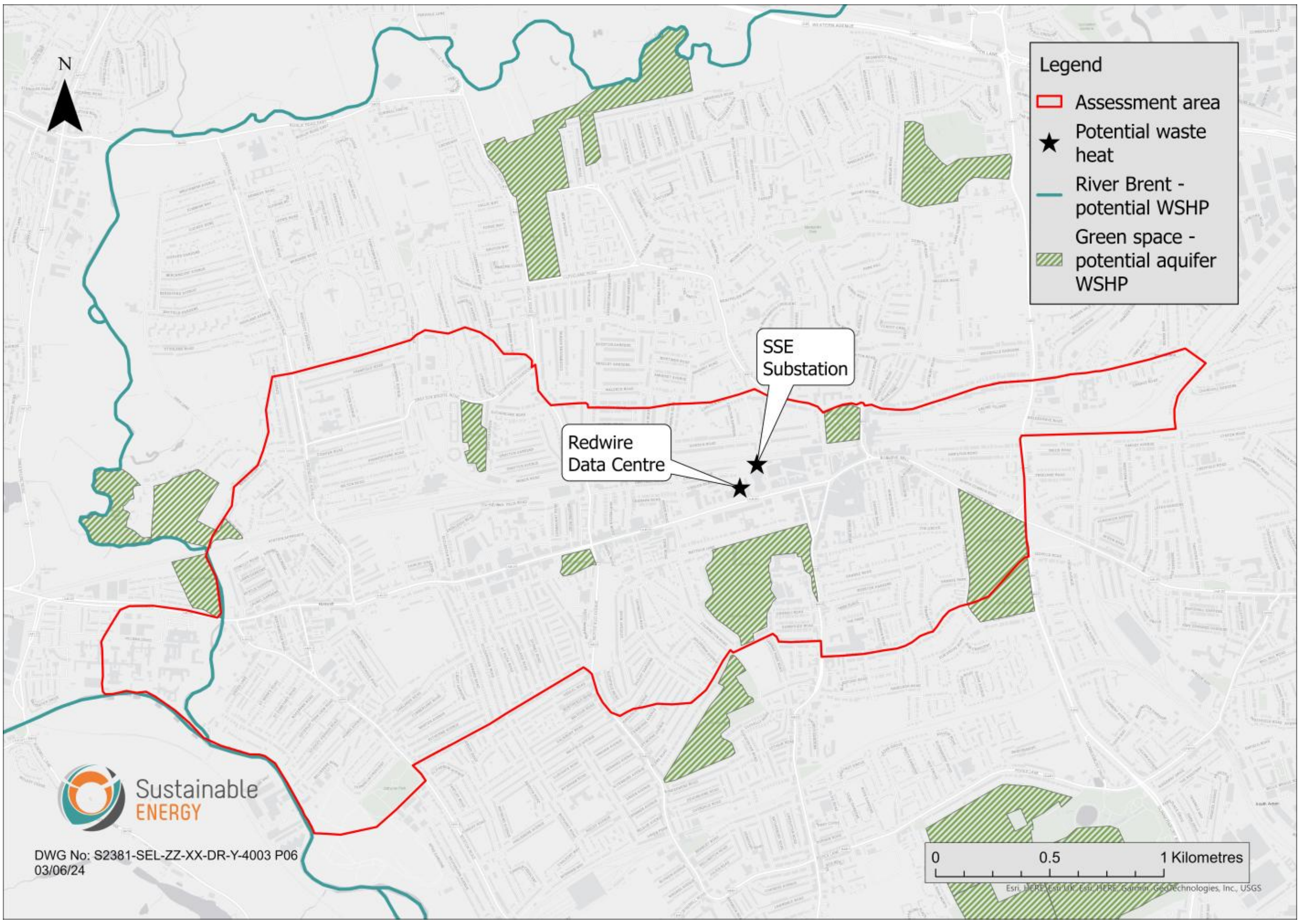

Figure 7: Potential heat sources

Open loop ground source heat pumps are a potential source of heat for a district heat network. To determine the viability of this source, existing borehole records were assessed using the British Geological Survey (BGS) GeoIndex map[2].

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[2] British Geological Survey: GeoIndex - British Geological Survey (bgs.ac.uk)

Table 6: Summary of potential heat sources

Technology		High level technical viability considerations	Considered further?
Open loop heat pump	Water source heat pump (WSHP)	• Unknown flow rate and temperatures of River Brent as it passes through Ealing • The closest point is approximately 2.5 km from Ealing Town Centre, potentially more suitable as a heat source for Ealing Hospital	No, due to from key heat loads distance
	Mine WSHP	• No previous mine workings in the area	No, due to no previous workings
	Waste WSHP	• No waste water works in the area • Potential to utilise sewers to serve waste WSHPs, however, unlikely to be sufficient capacity to serve the town centre heat demands	No, due to no existing works
	Aquifer WSHP	• Existing boreholes near the assessment area suggest limited opportunity, full findings of which are presented in Appendix 2: Borehole Assessment • Test borehole required to assess available resource	No, as existing boreholes suggest limited opportunity
Centralised air source heat pump (ASHP)		• Potentially lower initial CAPEX than WSHP, however higher operating costs due to lower CoP • Significant space requirement for air heat exchangers • Not dependent on accessing ground or open water • ASHP at a large scale may have a cooling effect on the local environment	Yes
Individual ASHPs		• Not impacted by delays to development timing and changes to phasing • No losses from heat network • Space required at each building for heat pumps and heat exchangers • Visual and noise impacts on residents • Lower SPF for smaller heat pumps • Heat demand is not diversified, and significantly greater heat pump capacity required • Higher capacity electricity connections are required for each building and may result in significant grid reinforcement costs	Yes, as low carbon counterfactual
Closed loop ground source heat pump (GSHP)		• Significant number of boreholes required • Limited publicly owned and non-utilised green space around Ealing Town Centre	No, due to space requirements
Biomass CHP		• Air quality and smoke control zones limit opportunities for biomass within town centres • High cost of fuel compared to mains gas • Larger space requirements compared to other heat sources because of solid fuel delivery and storage • Frequency of fuel deliveries, and congestion issues that this may cause • Would require a sustainable source of fuel to be considered low-carbon	No, due to limited space available, air quality and economic viability

Technology	High level technical viability considerations	Considered further?
Energy from waste	• No existing or planned energy from waste plants in proximity to the assessment area	No, as no sites near assessment area
Gas CHP	• Potentially improved economic viability achieved through private wire sales, where sufficient electrical demand is present • Air quality issues, however, abatement measures likely to be viable • Higher carbon emissions compared to some other technologies so should be regarded as an interim option alongside heat pump only • Not eligible for Green Heat Network Fund (GHNF)	No, due to high CO_2e and ineligibility for GHNF
Gas boilers	• High CO_2e • Potentially lower OPEX than electric boilers • Considered as potential back up and peak only	Yes, as back up and peak only
Electric boilers	• Expensive if used during peak electricity usage times • Low upfront CAPEX to install • Possible price reduction per kWh in future • High grid connection costs • Considered as potential back up and peak only	Yes, as back up and peak only

Waste heat	• Small Redwire data centre located in town centre close to Perceval House:
	    ◦ Datasheets suggest cooling provision of up to 3.6 MW from which waste heat could be utilised
	    ◦ Higher temperature than ambient air will result in higher CoP heat pumps
	    ◦ No engagement received to confirm capacity or interest in network
	• Two planned data centres in Southall area totalling >350 MW electrical capacity:
	    ◦ Data centres of sufficient scale to offer potential to supply heat for the whole borough (further details provided in Appendix 9: Southall Data Centre Planning Note
	    ◦ As Southall heat network in early stage of development, will be a viable option for later phases only
	    ◦ Potential for expansion of any network to connect to the town centre
	• Excess waste heat from OPDC to the east of town centre:
	    ◦ Heat that could be input into the network via transmission main and enable future expansion of network
	    ◦ Timeframes result in it only being a viable option for later phases
		Yes, as potential future heat supply from Southall and/or OPDC

Solar thermal	• Significant land required for collector arrays • Significant initial capital costs • Low operating costs per kWh • Disconnect between seasonal times of generation and demand	No, as no space available near key heat demands

4.1.2 Short List Options

As a result of the long list assessment, two potentially viable solutions were shortlisted for further consideration. These technologies have the potential to meet the client's key priorities by providing affordable low-carbon energy. A short list appraisal of each option was then undertaken to consider possible risks, benefits, and disbenefits of the selected options. The following options have been shortlisted and are explained in further detail:

- ASHP low temperature hot water (LTHW) network
- Individual ASHPs at buildings – low carbon counterfactual

4.1.2.1 ASHP LTHW Network

ASHP systems utilise external heat exchangers to facilitate the exchange of heat between the ambient air and the heating medium. Key considerations for an ASHP solution are the space available for the installation of external heat exchangers, noise, visual, and cooling impacts on the local environment. Figure 8 illustrates an ASHP energy centre supplying a heat network.

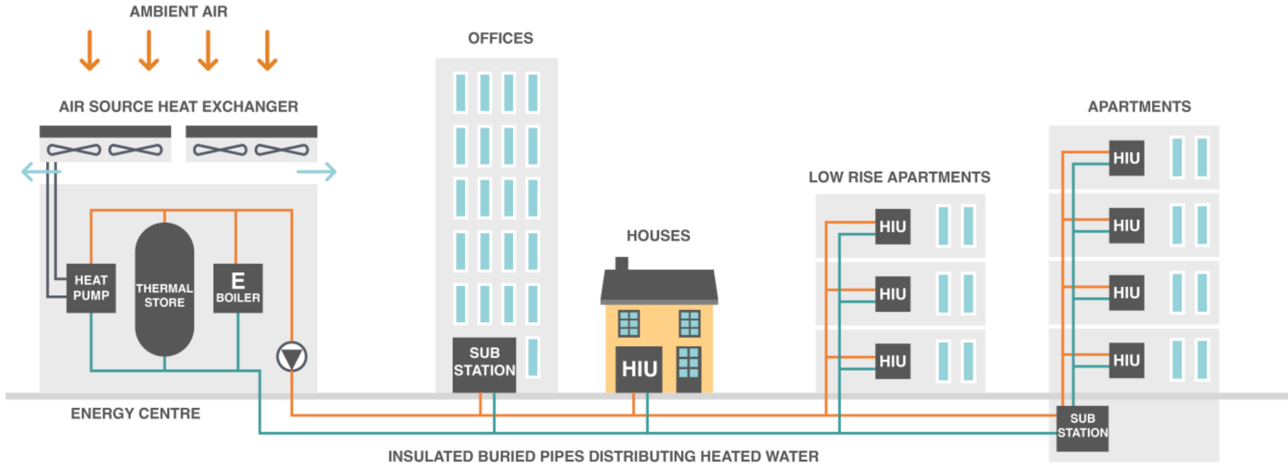

Figure 8: Indicative arrangement of an ASHP energy centre supplying a heat network

ASHPs can be beneficial in areas where there are no alternative, more efficient heat sources. ASHPs can also be a cost-effective solution as no drilling or abstraction equipment is required to supply the heat pumps.

A single centralised heat pump option (with larger heat pumps) has advantages over smaller heat pumps at the building level and these include:

- Potentially higher SPF than smaller heat pumps
- Economy of scale CAPEX and OPEX benefits
- Significantly reduced space requirements within planned development buildings
- Potential to purchase electricity more competitively
- Thermal storage, control strategy and multiple heat sources enable smart operation
- Potential for grant funding
- A more diversified heat demand and so the centralised heat pump capacity is far lower than at the building level
- It is more practical to utilise low or zero global warming potential (GWP) working fluids such as ammonia in large heat pumps

However, ASHPs will be less efficient than WSHPs, therefore operating temperatures will be important. The ASHP efficiency will vary with external air temperature; it will be less efficient in winter and have lower output. The lower seasonal performance factor (SPF) will impact project economics, CO_2e savings and potentially grant funding (where CO_2e savings are a key criterion). ASHPs can also have a cooling "cold plume" effect on their environment and nearby buildings as they extract heat from the air. Specific issues, risks, benefits, and disbenefits for an ASHP LTHW Network are detailed in Table 7.

Table 7: Specific issues, risks, benefits, and disbenefits for ASHP network solution

		Viability consideration	Risks	Benefits	Disbenefits	Prioritised solution?
ASHP LTHW Network	Technology selection	• ASHPs are less efficient than WSHPs • Operating temperatures will be important as efficiency varies with external air temperatures	Lower CoP will impact project economics, CO_2e savings and renewable heat during cold periods			Yes
	Heat resource	• Heat output and project economics will be negatively impacted by external air temperature in cold winter periods		Not dependent on accessing ground water or waste heat sources	ASHP will be less efficient in winter and have a lower output	
	Plant operation	• Heat generated from the ASHP will be prioritised with gas boilers only supplying peak demands and in times of ASHP maintenance/failure		~90% of network heat demand will be from renewable technology		
	Energy centre design	• Ground floor / basement of the development would need to be used as the energy centre • Air heat exchangers to be installed on the rooftop of the development	Acoustic attenuation will impact cost and efficiency		Multiple energy centre locations may be required for future expansion of the network	
	Impact on Ealing Town Centre	• Energy centre required at planned development • Strong economic case required to account for loss of development space on rooftop and basement / ground floor • Air heat exchangers may result in noise and cold plume impact on nearby buildings	Location of the energy centre within the development must be secured	Lower heat pump capacity required throughout the town centre due to diversity in heat loads	Significant capital cost required up front to build energy centre	

4.1.2.2 Individual ASHPs

Individual ASHPs at the building level are typically the preferred low-carbon heat source for buildings, where a heat network is not viable. As with centralised ASHPs, individual ASHPs can be beneficial in areas where there are no alternative, more efficient heat sources as they are not dependent on accessing a heat source such as groundwater. Figure 9 illustrates the individual ASHP arrangement in different building types.

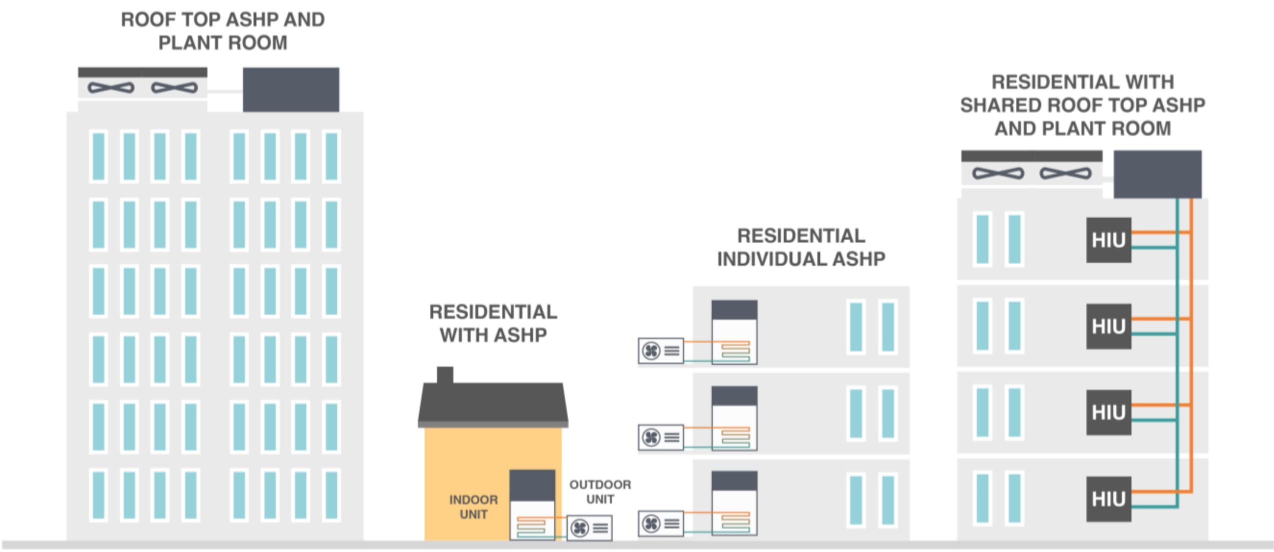

Figure 9: Indicative arrangement of ASHPs at each building

However, individual ASHPs are often less efficient than larger-scale heat pumps, resulting in higher operating costs. As individual ASHPs must be sized to meet the peak demand of each building, the overall installed heat pump capacity will be much higher than a centralised option. This will result in greater electricity grid connection requirements that could lead to expensive grid reinforcement. Individual ASHPs will also require rooftop plant rooms at each building to house the air heat exchangers and heat pumps.

Specific issues, risks, benefits, and disbenefits for an individual ASHPs are detailed in Table 8.

Table 8: Specific issues, risks, benefits and disbenefits for individual ASHPs

		Viability consideration	Risks	Benefits	Disbenefits	Prioritised solution?
ASHP in Each Building	Technology selection	• Low carbon counterfactual • Potentially lower-risk option • ASHPs efficiency will vary with external air temperature	Lower CoP will increase the cost of heat generation, CO_2e savings and renewable heat availability during cold periods	No disruption or CAPEX implications associated with heat network installation	Higher heat pump capacity required due to reduced diversity – higher grid capacity required	No, as counterfactual only
	Heat resource	• Heat output and project economics will be negatively impacted by external air temperature in cold winter periods		Not dependent on accessing boreholes	ASHP will be less efficient in winter due to a lower air temperature and therefore have a lower heat output	
	Plant operation	• Higher GWP refrigerants may be used in smaller heat pumps	May not be operated and maintained in most efficient manner	Potentially higher CO_2e savings if operated and maintained efficiently		
	Energy centre design	• Energy centre not required		No requirement for large energy centre		
	Impact on Ealing Town Centre	• Possibly higher heat cost to customers • Heat demand is not diversified, and significantly greater heat pump capacity required	Grid capacity in the area may be insufficient for ASHPs in each building	No requirement for large energy centre or underground distribution pipework	Roof and plant room space will be required at all buildings for heat exchangers and heat pumps	

4.2 Summary

A long list of heat sources was assessed to determine a short list of options. The short list consisted of an ASHP LTHW network and a low carbon counterfactual of individual ASHPs at the building level. Ambient air was identified as the prioritised heat source due to the limited resources and low land availability within/near Ealing Town Centre. An ASHP LTHW network has the potential to meet LBE's priorities and therefore will be further assessed throughout this report. A detailed assessment of the ASHP network is presented in chapter 8, Techno-Economic Modelling. There is an opportunity for waste heat from the planned data centres in Southall or from connection to the nearby OPDC heat network currently in development, in future phases.

A shortlist of potential energy centre locations has been identified including a number of planned development sites (including Perceval House Car Park, Sandringham Mews, and Arcadia Centre and Broadway Connection). The selection of a preferred site will be determined by land ownership as well as other technical and commercial risks, and discussions with developers. Ongoing engagement with the planning and regeneration teams at LBE will be required to ensure space is safeguarded for the energy centre and the timing of network development is not hindered. Further details of the risks and mitigation measures for the energy centre and heat sources are included in Chapter 11 - Risks and Issues.

A second energy centre may be required for future expansion of the network. The potential energy centres identified should be further assessed for later phases of network development.

5 NETWORK ROUTE ASSESSMENT

This section describes the methodology behind network routing and sizing and includes details of the linear heat density (LHD) assessment, potential constraints, and sizing techniques.

The network route assessment considered the information gathered from site visits and underground utility data searches. Further information on constrained sections of the network route can be found in Appendix 4: Network Constraints.

5.1 Potential Constraints

Information was gathered on any key potential constraints to the network route. Utility maps, shapefiles and plans provided by LBE and open-source maps on ArcGIS were used to identify potential barriers and risks to the network.

5.1.1 Infrastructure Constraints

Figure 10 shows the potential infrastructure constraints within the assessment area. The major constraints to the network are congested utilities along Uxbridge Road and the adjacent railway line.

Uxbridge Road is the main artery through Ealing Town Centre, along which the majority of the heat demand is concentrated, making it the likely spine of a future network. The main road going through Ealing Town Centre is wide and consists of two driving lanes, a bus lane, and a bike lane. However, these roads are congested with utilities, including three medium-pressure gas mains, low voltage electric cables, water mains, surface water and foul sewers. To avoid these utilities, higher capital costs would be required for pipe work installation. Detailed utilities maps for Ealing Town Centre are shown in Appendix 4: Network Constraints.

The railway line north of Uxbridge Road, would present a major challenge in expanding the network in that direction. However, there are several bridges which could be utilised to connect heat demands on the other side.

The number of crossings over these main roads has been minimised where possible. Additional capital costs have been included in the economic assessment for traffic management for key roads where crossings cannot be avoided. Further assessment of this area along with ground penetrating radar (GPR) survey of the network route will be required as the project progresses.

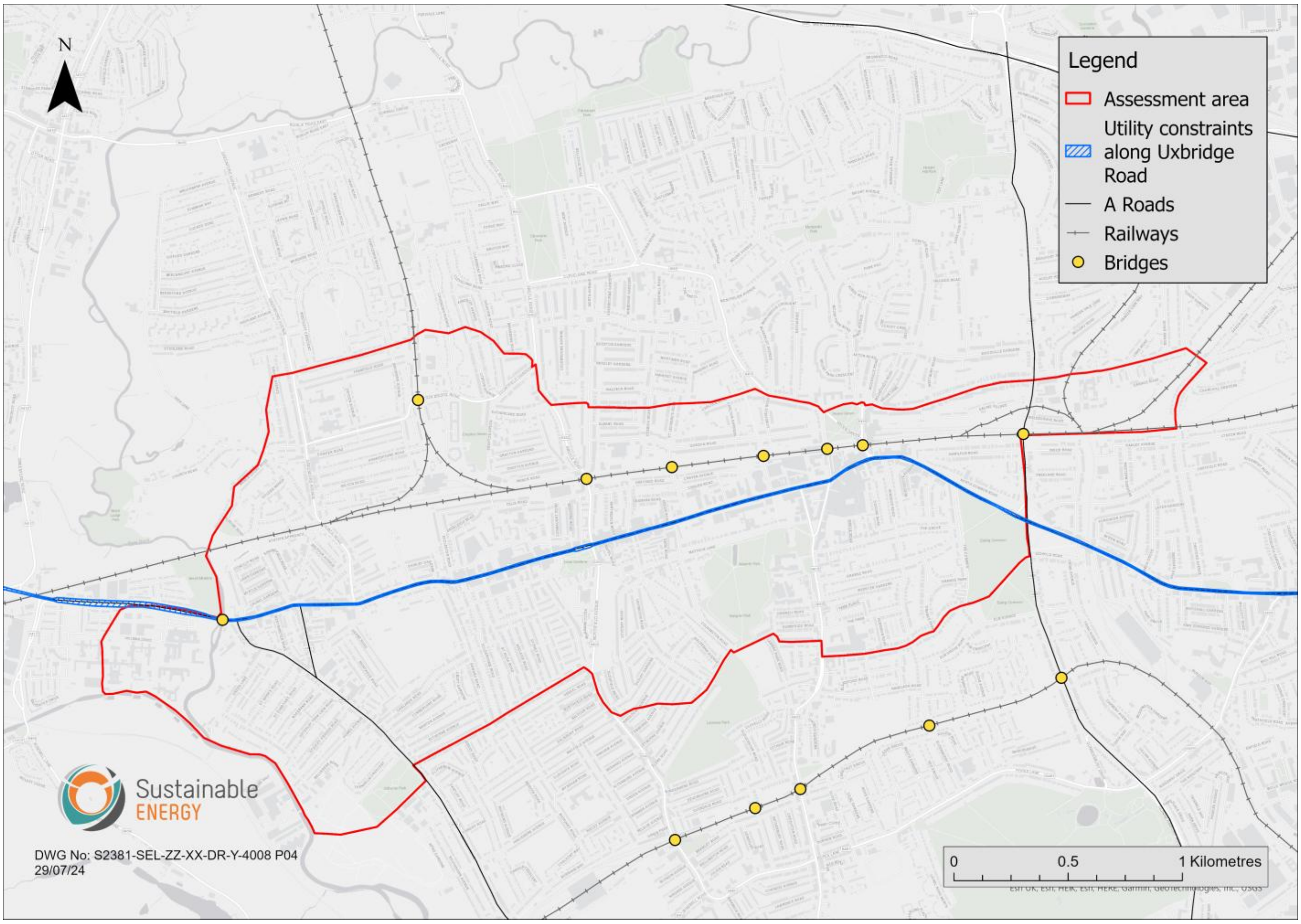

Figure 10: Potential infrastructure constraints

5.1.2 Natural Constraints

Figure 11 shows the high-level terrain for the assessment area. There is a height difference of less than 30 m within the assessment area. A gradient is unlikely to restrict the development of a heat network, as there is limited change of terrain within the assessment area.

Potential natural constraints are shown in Figure 12. Tree preservation orders are primarily located around the Ealing Broadway Shopping Centre, along Mattock Lane, and near Perceval House. Additionally, there are tree preservation orders in the west towards Ealing Hospital. These have been considered in the assessment but are unlikely to have any significant impact on the network route.

Connection to Ealing Hospital from the town centre would require the network route to cross the River Brent via the bridge at the west end of Uxbridge Road. This would likely increase the capital cost of the network.

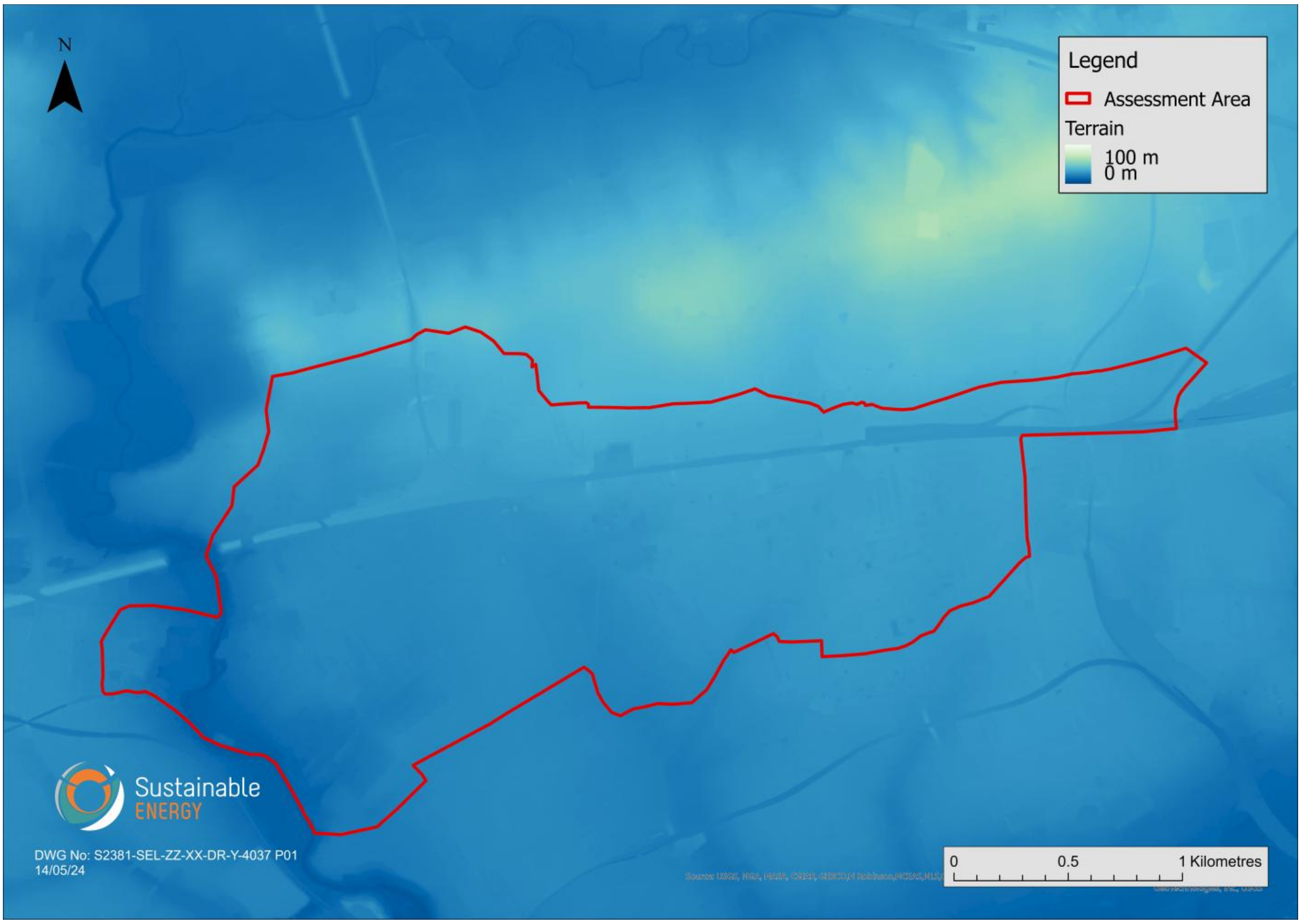

Figure 11: Ealing terrain map

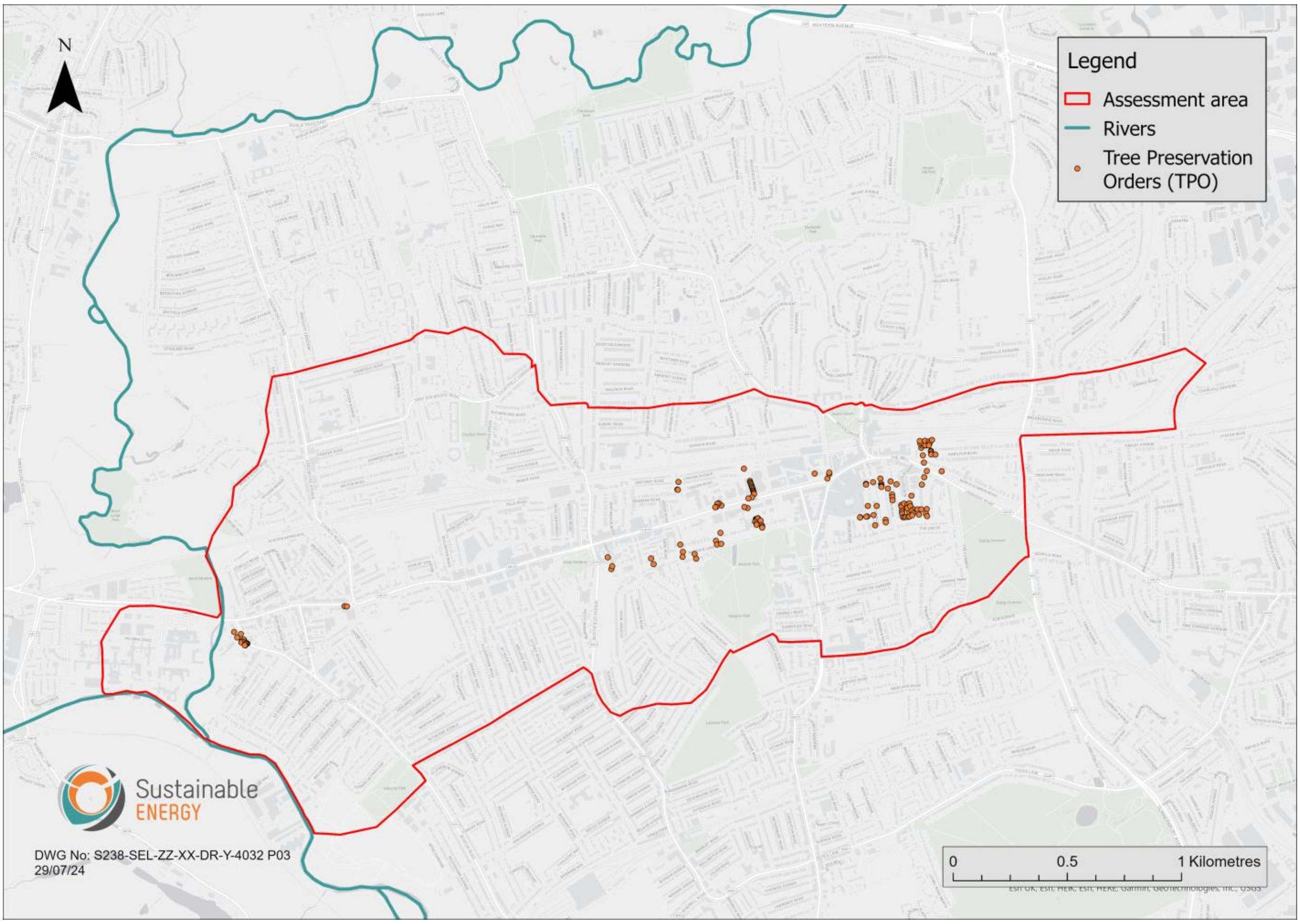

Figure 12: Potential natural constraints

5.1.3 Historic Constraints

Historic constraints are shown in Figure 13, these include a number of listed buildings and an area of archaeological interest around the town centre. Key potential network connections that are listed buildings include:

- Ealing Town Hall
- Christ the Saviour Church
- Ealing Studios
- St Bernard's Wing

While these designations were considered when deciding on a network route, their sparse positioning meant they did not have a significant impact on the network routing. For the connections that are listed, appropriate connection points were chosen to minimise the impact on the façades.

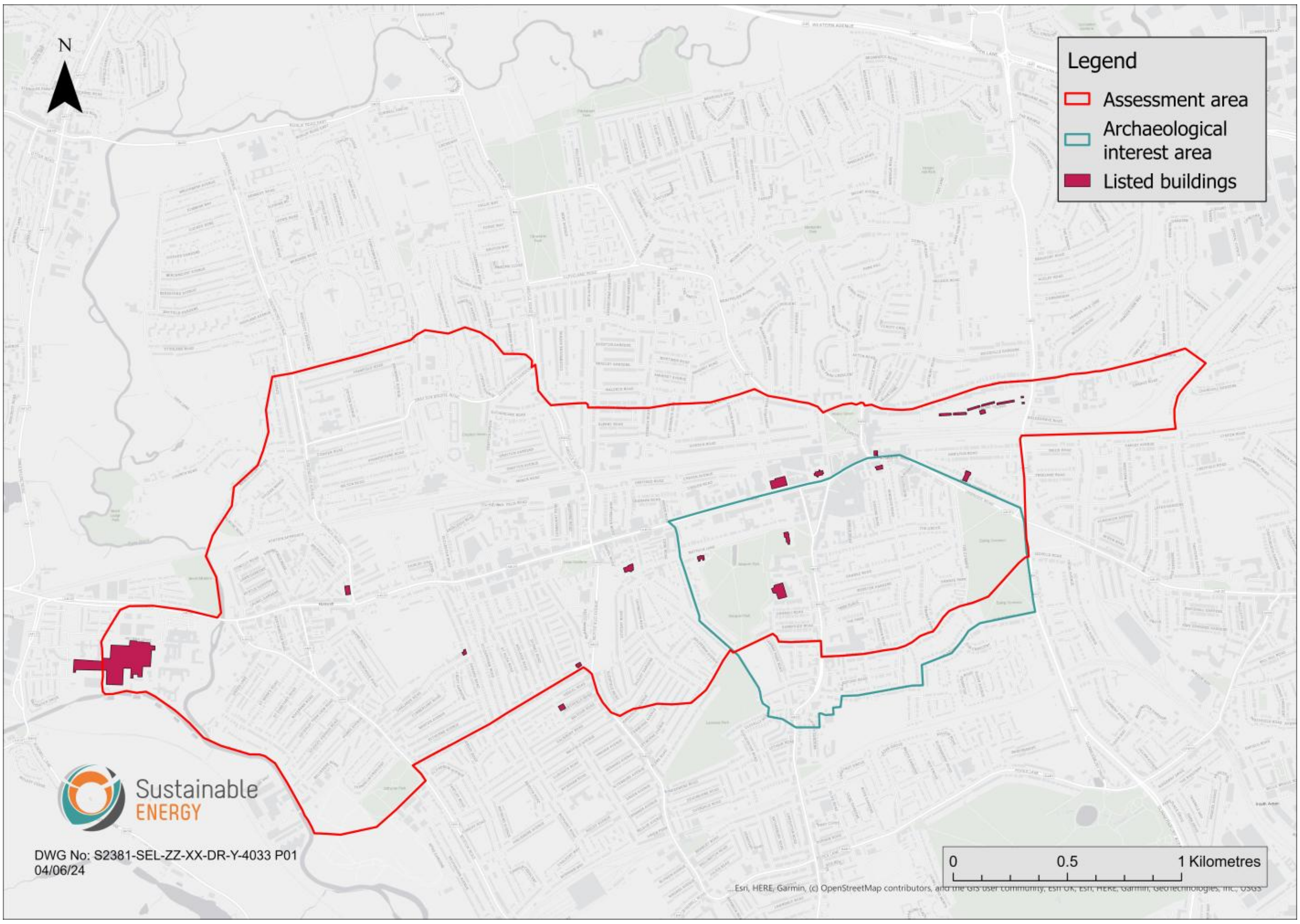

Figure 13: Potential historic constraints

5.2 Network Route

The network route was designed to minimise network length, cost, and risk. Where possible, for existing buildings, the location of plant rooms was identified, and development plans were assessed to identify the network connection points.

5.2.1 Linear Heat Density

Linear heat density (LHD) is a high-level method of assessing the economic viability of a section of heat network. The total quantity of heat energy that will flow through a given pipe section in one year (in MWh) is divided by the length of the network trench (in metres). In London, an LHD of less than 6 MWh/m is considered low and the network is unlikely to be economic due to increased capital costs and higher network losses. Connections that do not meet this 6 MWh/m threshold are removed from consideration at this stage, unless they have been identified as a key load due to their importance to LBE. Figure 14 shows the LHD for the initial network route.

The initial LHD assessment shows several sections of the network were identified as having an LHD lower than 6 MWh/m. The majority of these connections are offices and schools located north of the railway, at significant distances apart, making them uneconomical. Connections with low LHD include The Questors Theatre, Pitzhanger House, Ealing Fire Station, and a number of residential sites such as Walpole Close and Dean Gardens. These connections have been ruled out at this stage.

The Acton Sidings development site, located east of Ealing, was also removed during the assessment. However, if the connection between OPDC and the Ealing Town Centre network is viable in the future, the connection to Acton Sidings should be further assessed.

Once all pipe sections from the initial assessment with lower LHD than 6 MWh/m were removed, a new LHD was recalculated as additional sections of the route may also then drop below the 6 MWh/m threshold due to the reduced heat demand present at the end of a given length of pipe. The assessment was repeated until no sections were below the minimum threshold, except for the network section connecting to key loads, which in this case included the connection to Ealing Studios. The final network iteration is shown in Figure 15.

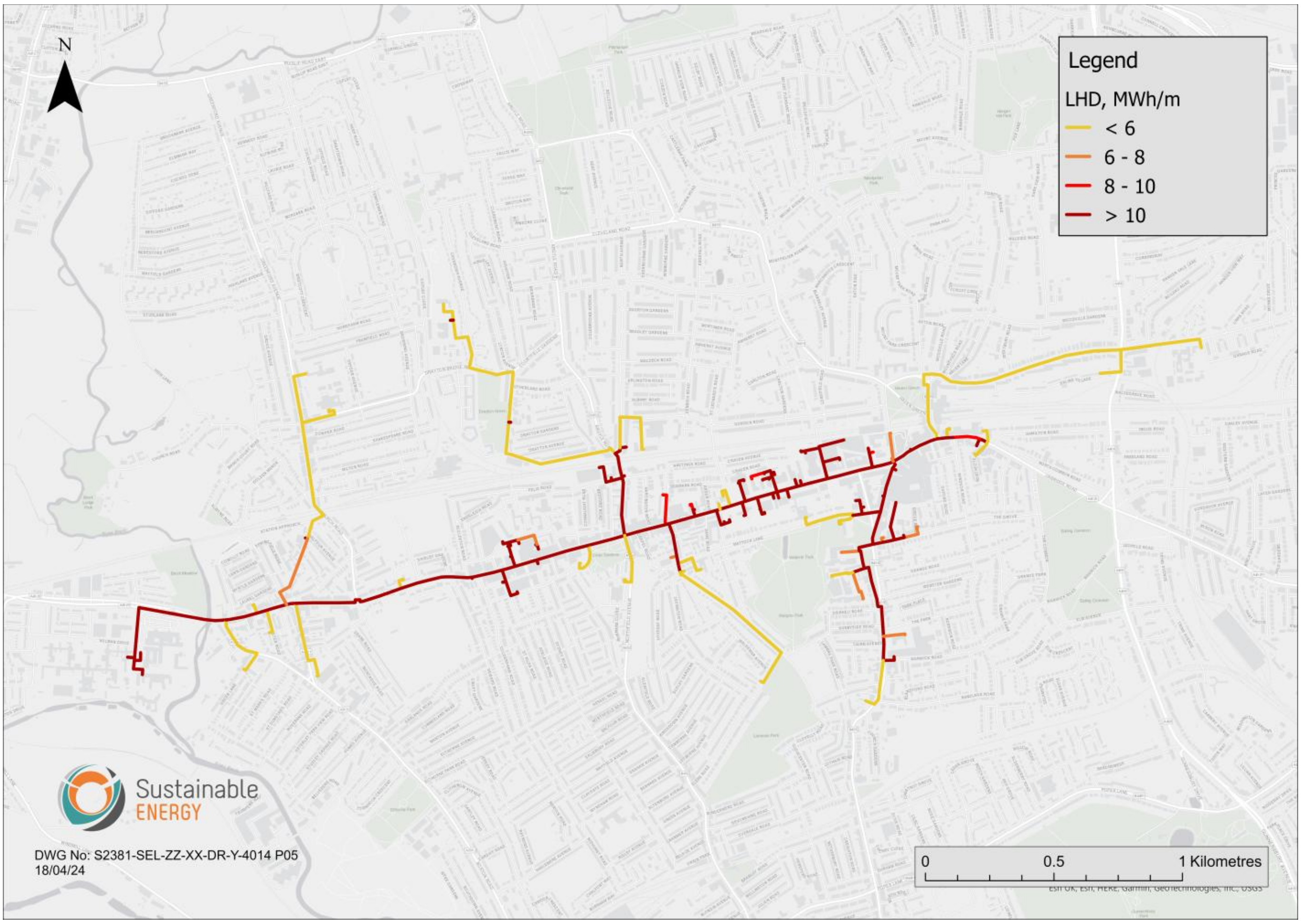

Figure 14: Initial linear heat density

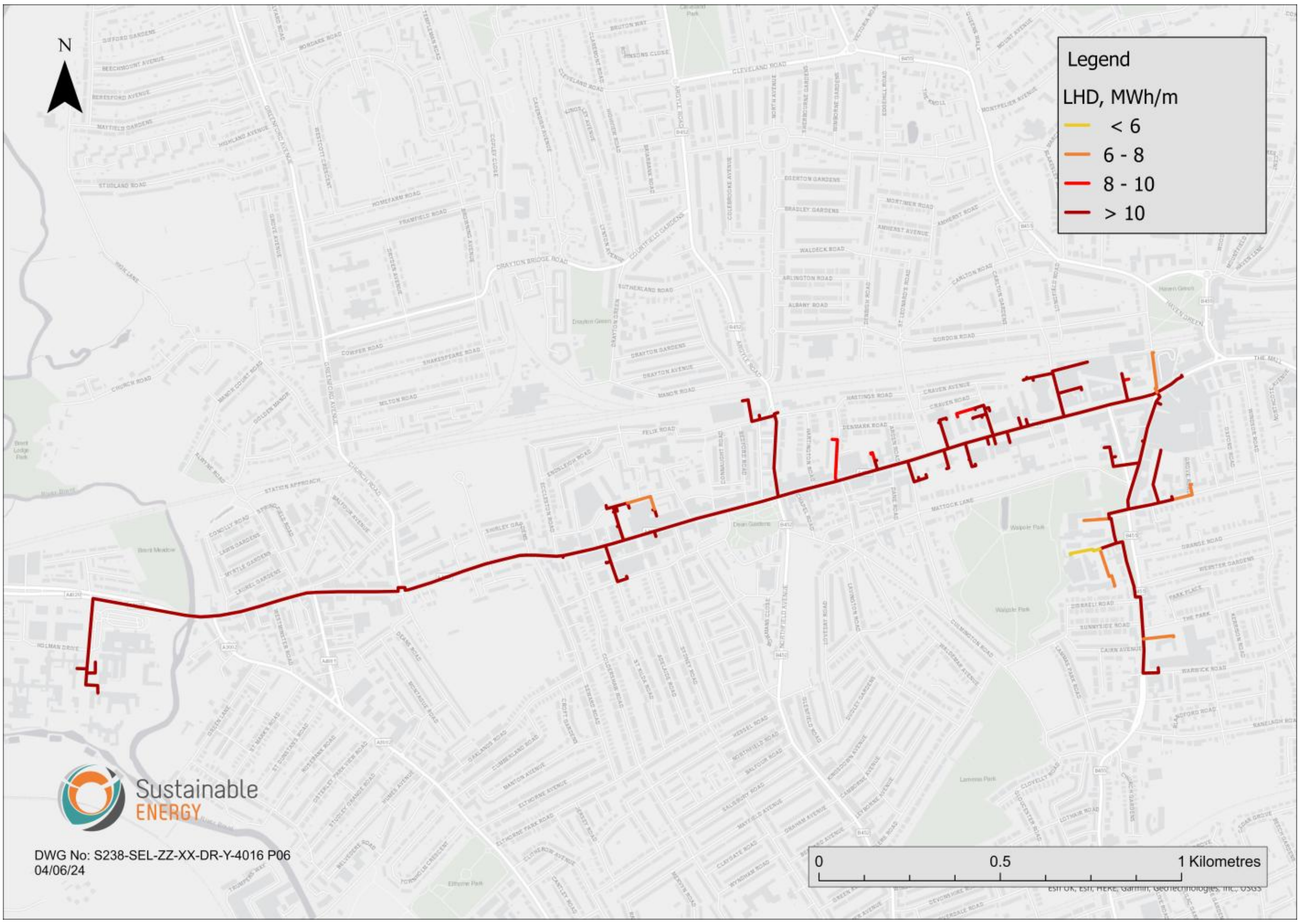

Figure 15: Final linear heat density

5.3 Network Sizing

The proposed network route is shown in Figure 16, whilst the connection to the Ealing Hospital site does have a sufficient LHD, it was ruled out as a connection to the initial network phases at this stage due to the distance from the town centre. The significant heat demand from hospital and distance from the core network area would result in the requirement for a very large diameter and lengthy pipe along the congested Uxbridge Road. This would lead to considerable network costs and heat losses, which would bring very little/no benefit to the hospital over on-site renewable heat generation.

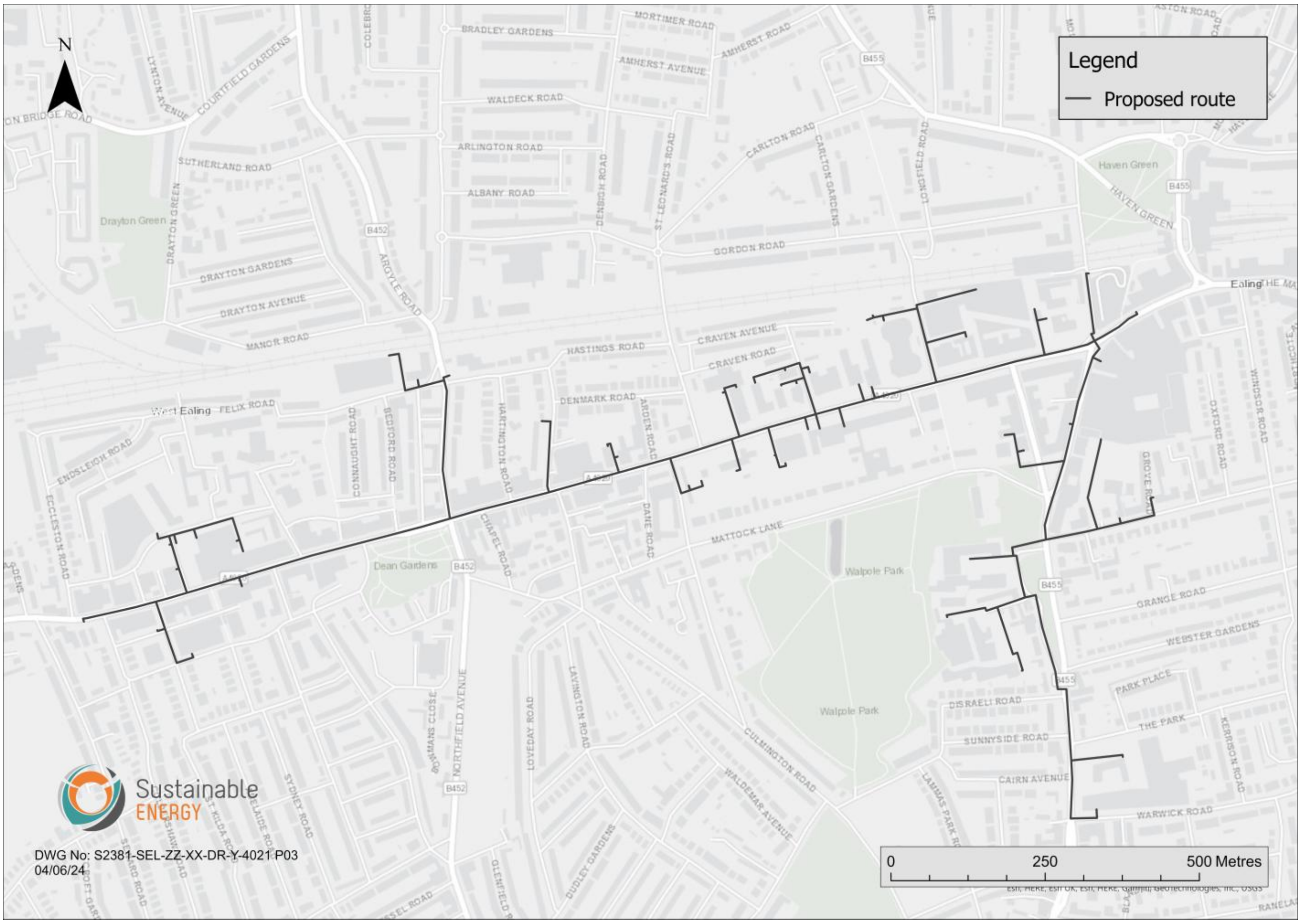

Figure 16: Proposed network route

The network was sized to optimise cost, balancing initial CAPEX against ongoing pumping and maintenance costs, whilst maintaining safe operation. The recommended maximum velocities quoted in CP1 for each pipe size were taken into consideration as well as the pressure loss along the pipes. It was ensured that sufficient pressure remained across heat exchangers at the connections.

The feeds to each connection were sized on the peak demand for that connection. Where these connections contained multiple dwellings, the Danish hot water diversity curve was used to find the peak instantaneous hot water demand the pipe would have to provide. The network pipe sizes and length can be found in Appendix 7: Key Parameters and Assumptions under Network Costs.

5.4 Summary

The selected network route considers:

- Minimising pipe length as much as possible
- Routing through publicly owned land and service areas of connected buildings as much as possible

- Physical constraints and site barriers including major utilities, main roads, high traffic areas and existing, future and historical building foundations and underground structures
- The outputs of hydraulic modelling exercises (including pipe lengths, diameter, insulation and materials)
- Calculated heat distribution losses throughout the network
- CIBSE / ADE Heat Networks Code of Practice (specifically Objective 2.5)
- Linear heat density
- Potential for co-location / multi-utilities approach
- Planned infrastructure projects

The key network route summary are shown in Table 9.

Table 9: Network route summary

Total heat demand, MWh	51,920
Total no. of connections	54
Linear Heat Density, MWh/m	6.6
Network length, m	7,826

Key potential constraints include:

- Congested utilities along Uxbridge Road including gas mains and foul sewers
- Traffic management requirements
- Impact of road closures and potential diversion routes

The key network constraint map is shown in Figure 17. A detailed network constraint summary can be found in Appendix 4: Network Constraints.

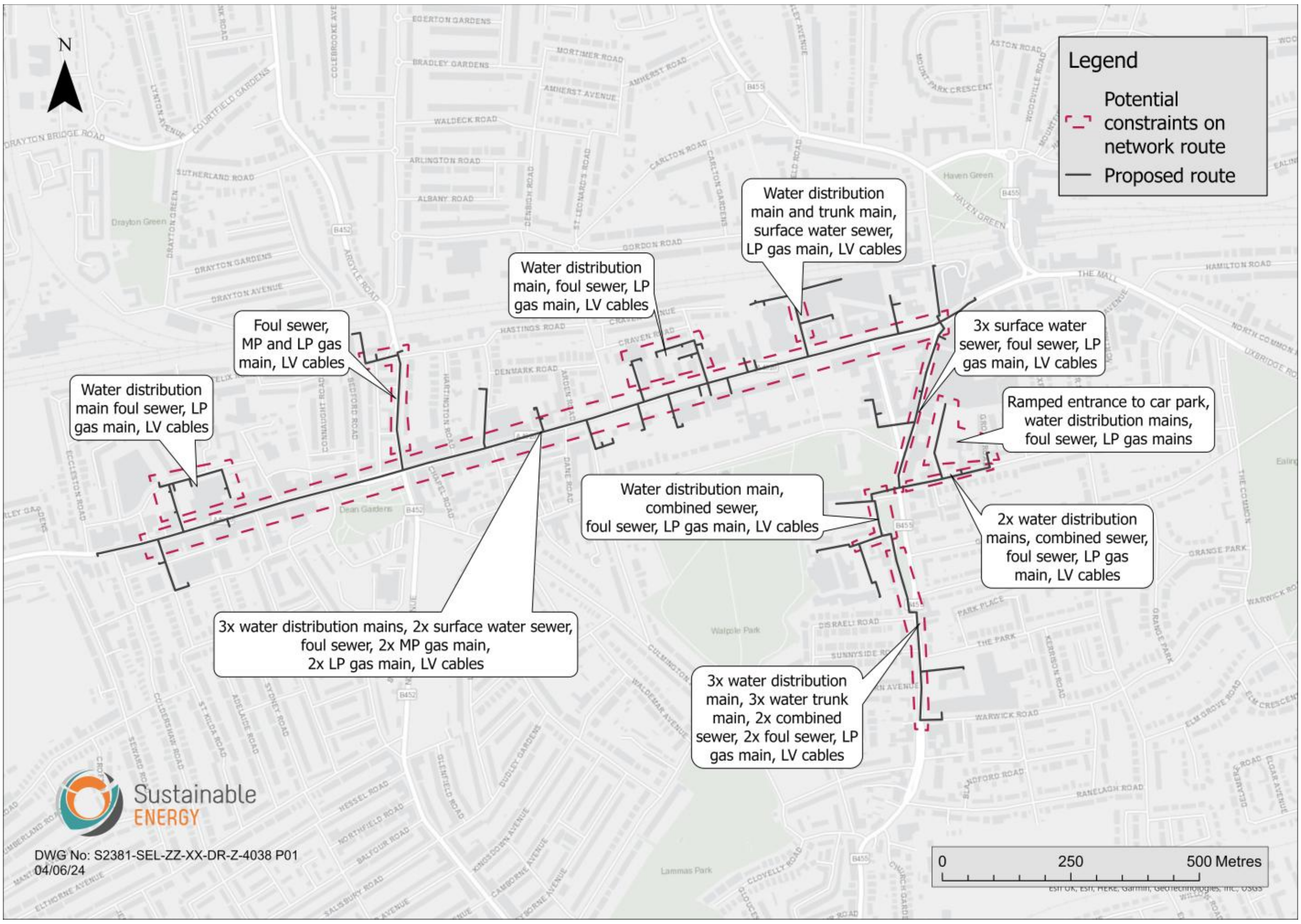

Figure 17: Summary of key network constraints in the town centre

6 SCHEME OPTIONS ASSESSMENT

A potential heat network has been identified for the Ealing Town Centre area, supplied by ASHPs at an energy centre located within a town centre planned development, with the potential for future low-carbon heat supply from the planned data centres in Southall and/or the OPDC network.

The ASHP sizing and subsequent phasing of the initial network were based on assumed land available for an energy centre and roof space available for heat exchangers at a town centre development site. This has been estimated based on very high-level information that is currently available for the development site, provided by LBE. This should be further assessed as additional information becomes available and development plans for the site are progressed.

The phasing of the network is discussed in further detail in section 6.1. The results of the economic assessment are shown in section 8.4.

6.1 Network Phasing

The proposed network includes three phases:

- Phase 1: Several key existing public sector buildings such as Perceval House, Bakers House and Wells House, Ealing Green College and Christ the Saviour School, as well as key private and planned developments such as Ealing Broadway shopping centre and Ealing Town Hall
- Phase 2: Extends to connect private sector demands including large offices, hotels and retail
- Phase 3: Extends to longer-term developments, buildings with recently installed low carbon plant, and other larger heating loads to the west and south, and will require additional heat supply from outside of the town centre

The phased network route and connection details are shown in Figure 18 and Table 10. The network phasing has been selected based on ownership, proximity to the town centre, technical barriers, economics, timing of developments and risks. It has been assumed that the phase 1 network could be progressed to supply heat by 2030 in line with the proposed timing for identified planned developments, phase 2 in 2033 and the timing of phase 3 is dependent on a heat source from outside the area such as the planned data centres in Southall. The phasing and timing of the network should be further assessed if additional details for the area become available.

Table 10: Network connections

Site ref.	Site name	Network phase	Site ref.	Site name	Network phase
1	CP House	1 (2030)	29	99-113 Broadway	3 (2036)
2	Perceval House Car Park		30	West London Islamic Centre	
3	Perceval House		31	Chignell Place	
4	Ealing Town Hall		32	Green Man Lane	
5	Ealing Green College		33	Freedom House	
6	Christ the Saviour CoE School		34	Sainsbury's	
7	Sandringham Mews		35	96-102 Broadway	
8	Christ the Saviour Church		36	Hyde House	
9	The Arcadia Centre		37	59-65 Broadway	
10	Marks and Spencers		38	St John's School	
11	Christ the Saviour CoE School – Groves Site		39	66-86 Broadway	
12	Ealing Broadway		40	Waitrose	
13	Broadway Connection		41	Luminosity Court	
14	Bakers House and Wells House		42	42 Hastings Road	

Site ref.	Site name	Network phase	Site ref.	Site name	Network phase
15	A2 Dominion		43	Broughton Court	
16	Hilton		44	Job Centre Plus	
17	Dawley House		45	84 Uxbridge Road	
18	Ibis Styles		46	Exchange Plaza	
19	Ealing Cross		47	Cavalier House	
20	Travelodge		48	Craven House	
21	Ealing Gateway	2 (2033)	49	Bruce Court	3 (2036)
22	Ealing Aurora		50	Arc Tower	
23	Premier Inn		51	49-69 Broadway	
24	Longfield House		52	Dickens Yard	
25	Ealing Studios		53	Filmworks	
26	Met Film School		54	South Ealing YMCA	
27	Hotel Xanadu		55	University of West London	
28	131 Broadway				

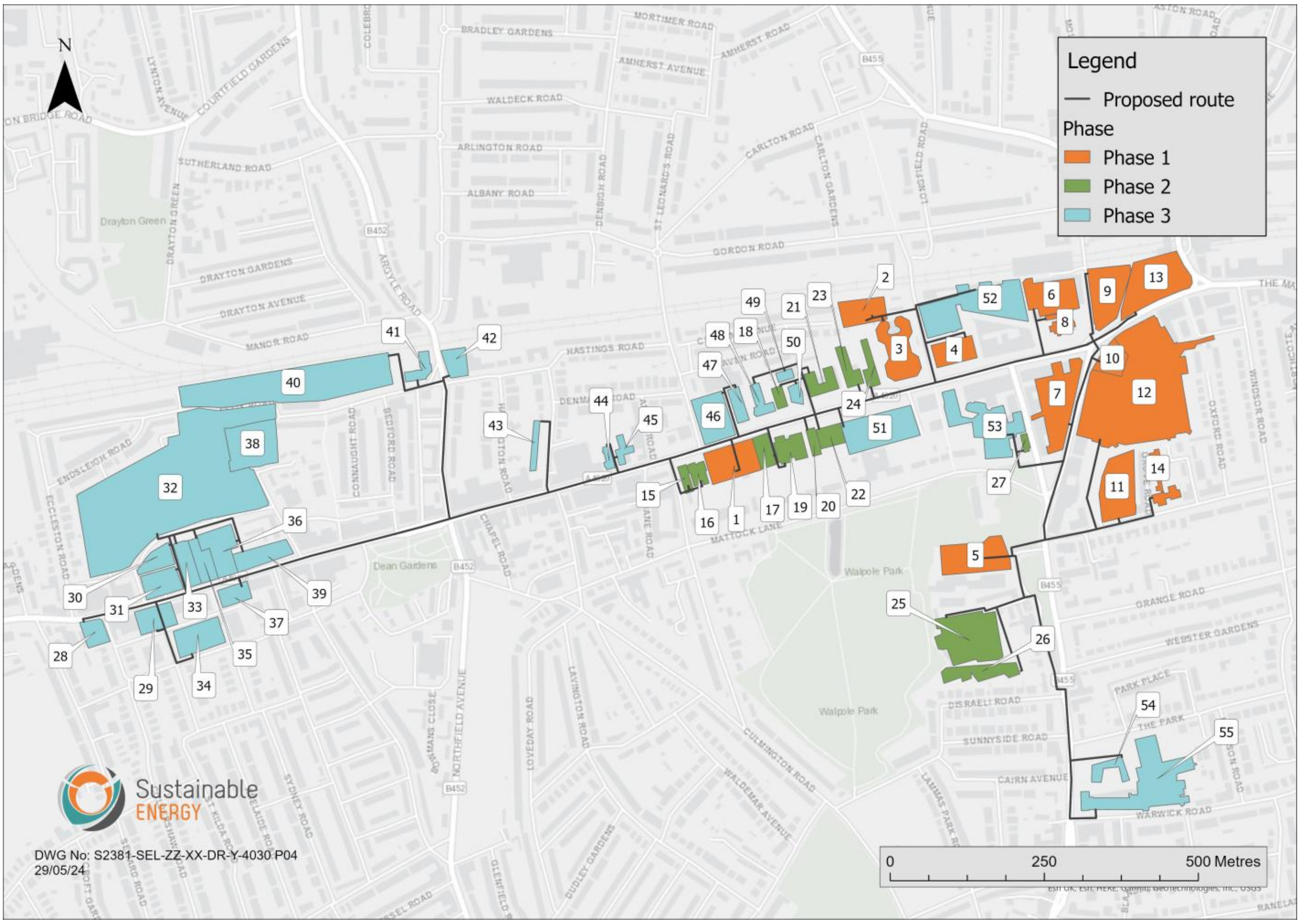

Figure 18: Ealing Town Centre district heating network

6.1.1 Phase 1

It has been assumed that phase 1 of the network could be brought forward for 2030 in line with the proposed timing for planned development sites which could house an energy centre. The timing of the phase 1 network is dependent on the progression of a suitable planned development to house the energy centre. If there is a delay in development timings, this will cause a delay in the heat on date for the heat network.

This phase mainly connects to low risk, key public sector sites and planned development sites. This includes Perceval House, Perceval House Car Park, Ealing Green College, Christ the Saviour CoE School and Church and social housing located nearby. Ealing Town Hall is undergoing development to be repurposed into a hotel while retaining part of the structure as council-owned property for use as a Town Hall. Further details on connected buildings are shown in Table 11 and Figure 19.

Table 11: Phase 1 network connections

Site ref.	Site name	Site ownership	Annual heat demand, MWh	Peak demand, kW
1	CP House	Planned development	2,088	1,349
2	Perceval House Car Park	Planned development	772	276
3	Perceval House	LBE	1,245	964
4	Ealing Town Hall	Planned development	1,136	640
5	Ealing Green College	Other / Public sector	380	243
6	Christ the Saviour CoE School		469	489
7	Sandringham Mews	Planned development	903	242
8	Christ the Saviour Church	Other / Public sector	156	158
9	The Arcadia Centre	Private sector	735	431
10	Marks and Spencers		614	355
11	Christ the Saviour CoE School – Groves Site	Other / Public sector	132	128
12	Ealing Broadway	Private sector Planned development	4,065	2,327
13	Broadway Connection		1,011	415
14	Bakers House and Wells House	LBE – Social housing	663	327

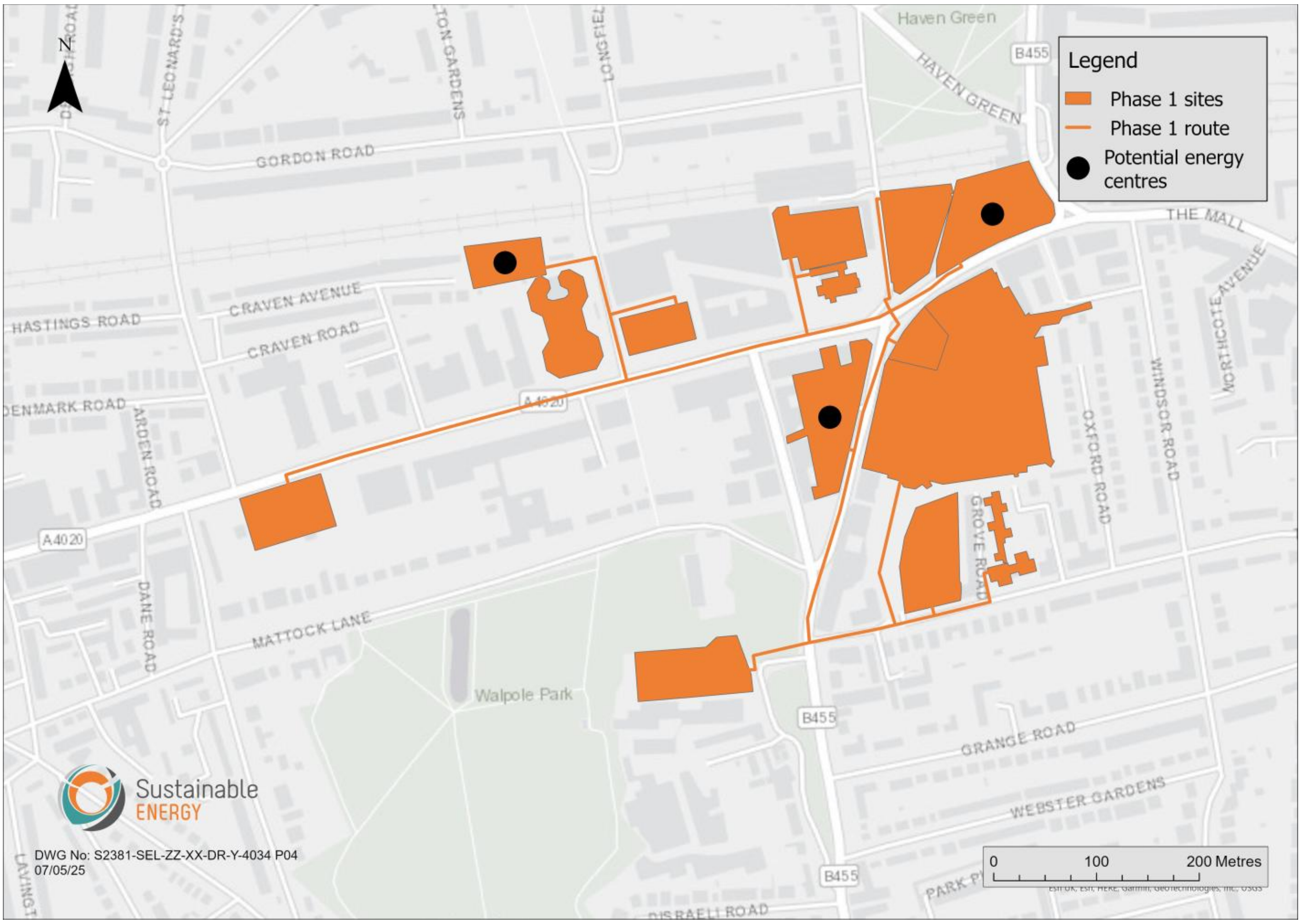

Figure 19: Phase 1 network

The Phase 1 energy centre proposed includes 2.8 MW of ASHPs, which would provide sufficient low-carbon heat to supply approximately 90% of the Phase 1 Ealing Town Centre Network. The ASHP capacity is determined based on the available footprints within planned developments identified as potential energy centre sites, considering structural constraints. The subsequent network phases will require additional sources of low-carbon heating. These heat sources could include additional ASHP energy centres within the town centre and/or heat from the planned data centres in Southall and/or the OPDC network.

6.1.2 Phase 2

In addition to phase 1 connections, 13 potential connections have been identified for the phase 2 heat network, which will be brought forward by 2033. The key phase 2 connections include private sector buildings in the city centre such as Dawley House, Ealing Aurora and Ealing Cross. Further details on connected buildings are shown in Table 12. An additional energy centre and low-carbon heat source will likely be required to serve the phase 2 network. This energy centre could be located in another planned development within the town centre, as shown in Figure 20 However, an additional energy centre within the town centre may not be required if heat from the planned data centres in Southall and/or the OPDC network connects to the town centre sooner than estimated during this assessment. For the base case assessment, it has been assumed that an additional energy centre would be located within the town centre.

Table 12: Phase 2 network connections

Site ref.	Site name	Site ownership	Annual heat demand, MWh	Peak demand, kW
15	A2 Dominion	Private sector	318	235
16	Hilton		881	369
17	Dawley House		1,370	573
18	Ibis Styles		505	217

Site ref.	Site name	Site ownership	Annual heat demand, MWh	Peak demand, kW
19	Ealing Cross		978	1,170
20	Travelodge		419	180
21	Ealing Gateway		846	863
22	Ealing Aurora		927	662
23	Premier Inn		775	334
24	Longfield House		473	250
25	Ealing Studios		467	450
26	Met Film School	Private sector	918	783
27	Hotel Xanadu		266	110

Figure 20: Phase 2 network

6.1.3 Phase 3

The phase 3 network has been assessed at a high level as it will require additional heat supply from outside of the assessment area. There is potential to utilise excess heat from the planned Southall data centres and/or the OPDC network; however, further engagement and assessment are required to confirm the heat available and the timing of this connection.

Southall Data Centres

The current plans for the two data centres in Southall indicate an electrical capacity of over 350 MW across both sites. This capacity is significantly large and would have more than enough heat to meet the Ealing Town Centre phase 3 network demand. The LBE planning team are currently assessing opportunities through planning policy to require the data centres to supply waste heat offtake to future heat networks in the borough.

OPDC Data Centres

Initial discussions have indicated an additional 10 MW of heat available from the planned OPDC data centres, beyond what has been designated under the previous zoning study (which does not include Ealing Town Centre). However, there are also a number of existing data centres located in the OPDC area, that could be utilised should more heat be required.

It should also be noted that a pipe size of approximately DN350 and a network length of 1 km and 2.5 km will be required to connect the Southall data centres and OPDC network respectively, to the Ealing Town Centre Network. Due to the uncertainties regarding the waste heat options at the time of this study, the phase 3 network has not been included in the techno-economic assessment and is provided as an indication of the potential expansion opportunity for the Town Centre Network. Further assessment is required to assess the heat availability and network constraints of the extension

Potential connections to the phase 3 network include an additional 27 buildings to the south and west of the city, along Uxbridge Road and B455 respectively. Several large private and public sites have the potential to be connected to the Ealing Town Centre Network during phase 3 including Green Man Lane, Dickens Yard, the University of West London and Filmworks. These connections are listed below in Table 13 and Figure 21. The Ealing Hospital sites to the west of the network area are not shown, as the significant heat demands would result in greater network pipe sizing and considerable additional network capital costs. However, there may be potential for additional heat to be supplied to the Town Centre Network from the west near the hospitals in future. Further details for this are shown in Table 13 and should be further assessed as the network progresses.

Table 13: Phase 3 network connections

Site ref.	Site name	Site ownership	Annual heat demand, MWh	Peak demand, kW
28	131 Broadway	Planned development	352	90
29	99-113 Broadway	Planned development	603	171
30	West London Islamic Centre	Other / Public sector	602	315
31	Chignell Place	Planned development	237	69
32	Green Man Lane	Private sector	2,446	883
33	Freedom House	Private sector	403	144
34	Sainsbury's	Planned development	1,576	544
35	96-102 Broadway	Planned development	568	181
36	Hyde House	Private sector	728	218
37	59-65 Broadway	Planned development	269	91
39	66-86 Broadway	Planned development	262	83
40	Waitrose	Planned development	2,340	839
41	Luminosity Court	Private sector	419	168
42	42 Hastings Road	Planned development	381	189
43	Broughton Court	LBE – Social housing	1,177	580
44	Job Centre Plus	Other / Public sector	257	307
45	84 Uxbridge Road	Private sector	303	519
46	Exchange Plaza	Planned development	1,814	1,187
47	Cavalier House	Private sector	691	265
48	Craven House	Planned development	597	444
49	Bruce Court	Private sector	196	67

Site ref.	Site name	Site ownership	Annual heat demand, MWh	Peak demand, kW
50	Arc Tower	Private sector	678	300
51	49-69 Broadway	Planned development	1,600	1,126
52	Dickens Yard	Private sector	4,260	1,570
53	Filmworks	Private sector	2,345	1,203
54	South Ealing YMCA	Private sector	611	187
55	University of West London	Other / Public sector	2,693	1,615

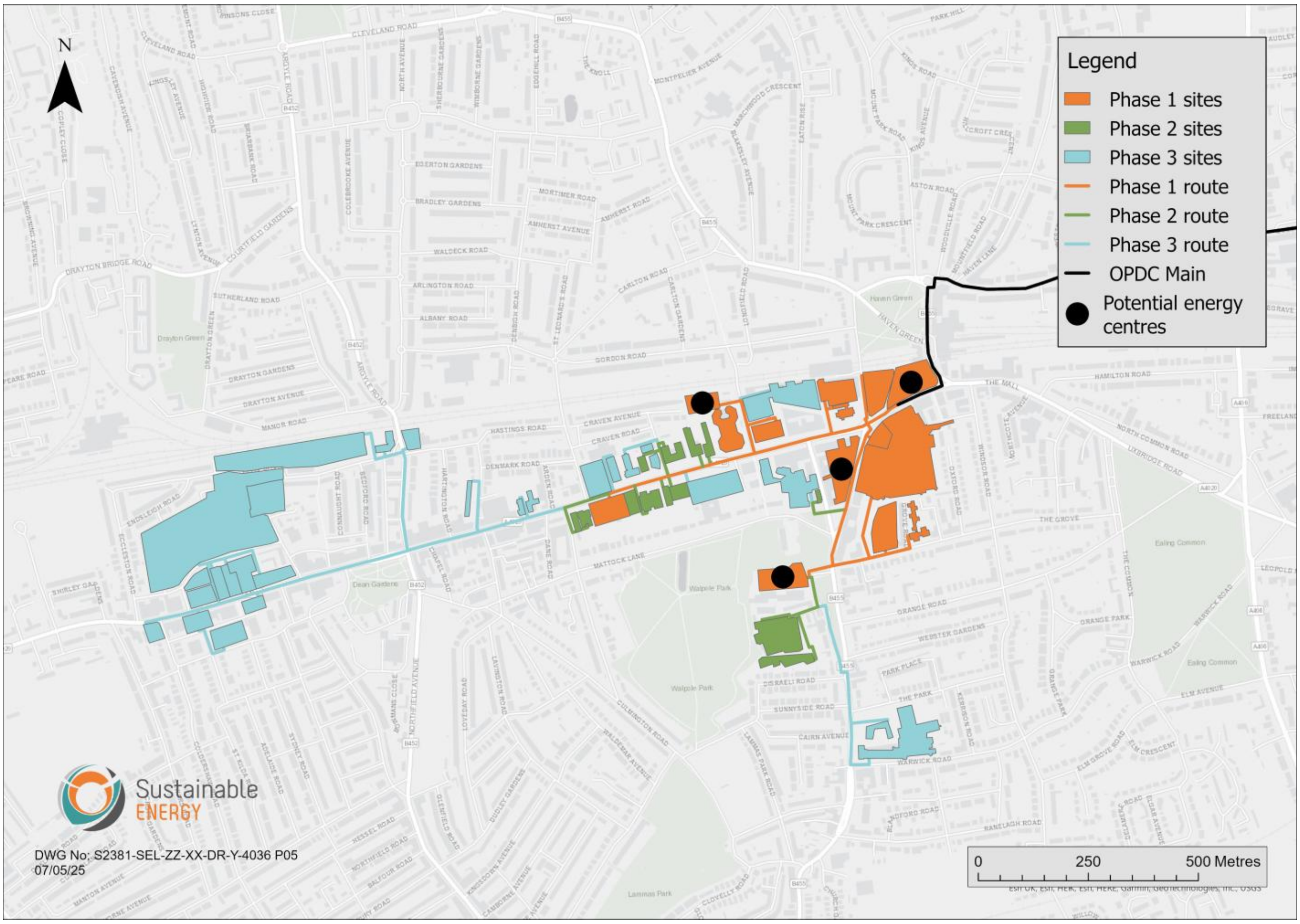

Figure 21: Phase 3 network

6.2 Network Summary

A summary of total network demands is shown in Figure 22, and the network heat generation and supply over 3 phases are shown in Table 14. Due to the significant heat demand in phase 3 and the limited availability of heat sources within Ealing Town Centre area, the viability of the network expansion to phase 3 is dependent on connecting to the planned data centres in Southall and/or the OPDC network (or other heat sources from outside the town centre). Therefore, indicative figures only have been included for the phase 3 network.

Table 14: Network summary

	Phase 1	Phase 2 (including previous phase)	Phase 3 (including previous phases)
Total heat demand (incl. losses), kWh	15,135,808	24,688,675	55,445,303
Peak heat demand, kW	7,190	13,065	25,198
Number of connections	14	27	54

	Phase 1	Phase 2 (including previous phase)	Phase 3 (including previous phases)
Low carbon capacity, kW	2,800	5,000	10,000
Gas boiler capacity, kW	3,600	5,800	11,000
Heat demand met by heat pumps	90%	92%	91%
Heat demand met by gas boilers	10%	8%	9%
% heat demand met by low carbon / renewable technology	90%	92%	91%

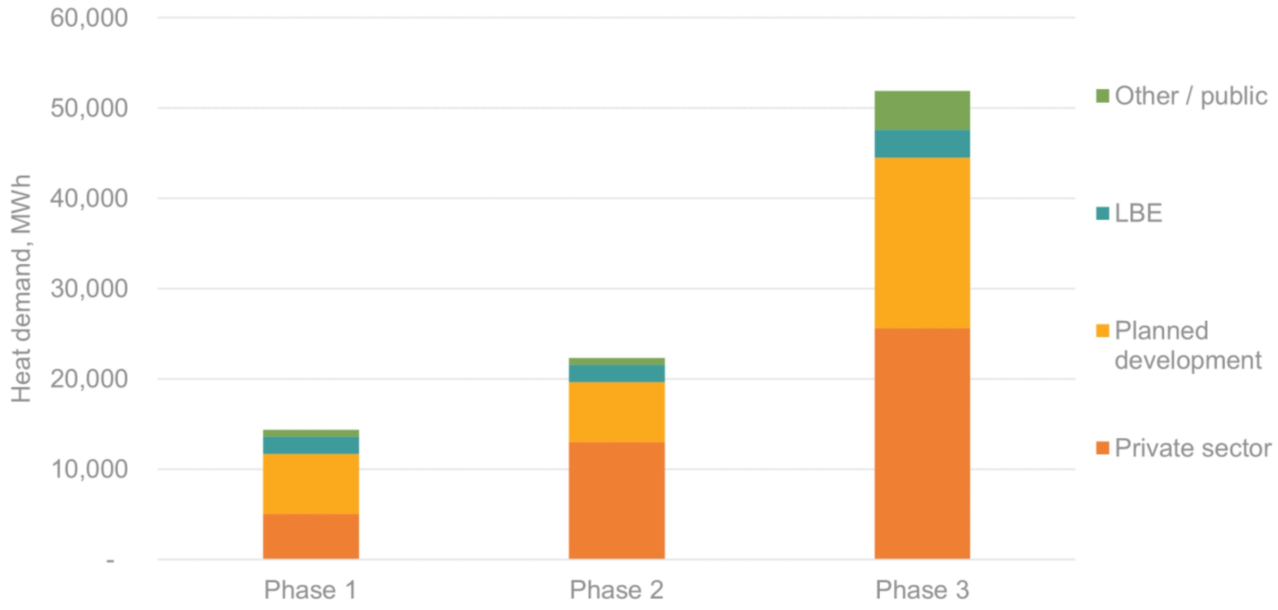

Figure 22: breakdown of heat demand by phase

Figure 23 shows the hourly network heat demand for the fully built network at phase 2, ordered from highest to lowest. Heat demand below the heat pump capacity line is met by the heat pumps. The heat demand above the lines is met by the thermal stores and peak and reserve boilers.

The heat from the low carbon technology will meet 92% of the Phase 2 heat demand, including heat losses in the network. The remaining 8% will be met by the gas peak and reserve boilers. The gas boilers are installed to meet peak network heat demands (e.g., during very cold periods) as well as the 2 weeks plant downtime a year included in the assessment for maintenance and repairs to the heat pump.

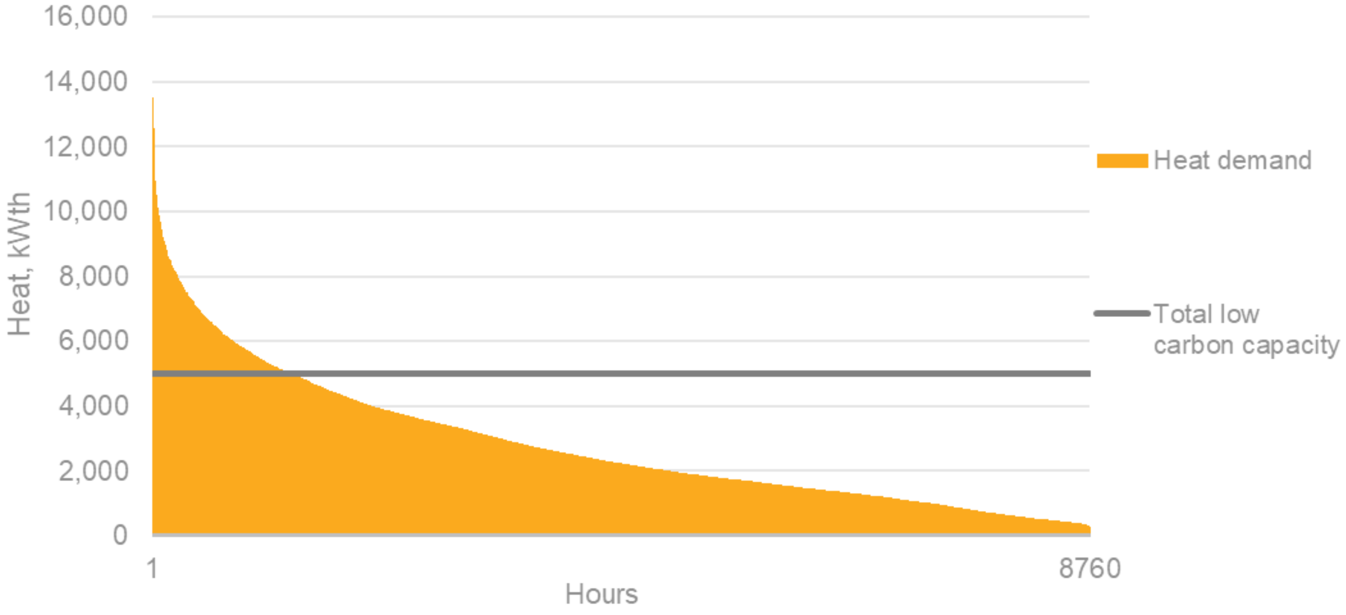

Figure 23: Load duration curve for phase 2

6.3 Energy Balance

The energy balance for the phase 1 and phase 2 network are shown in Figure 24 and Figure 25.

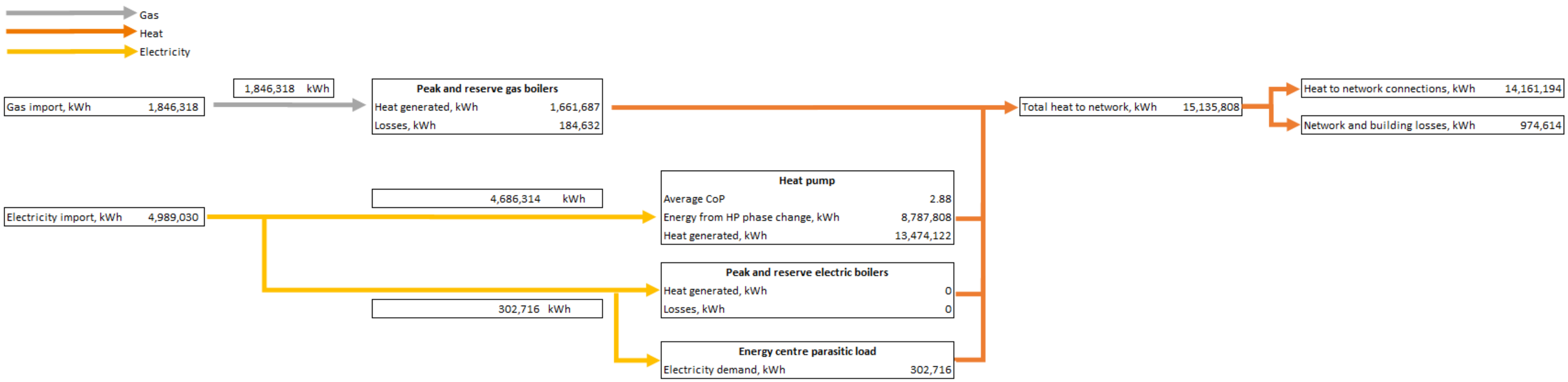

Figure 24: Phase 1 energy balance

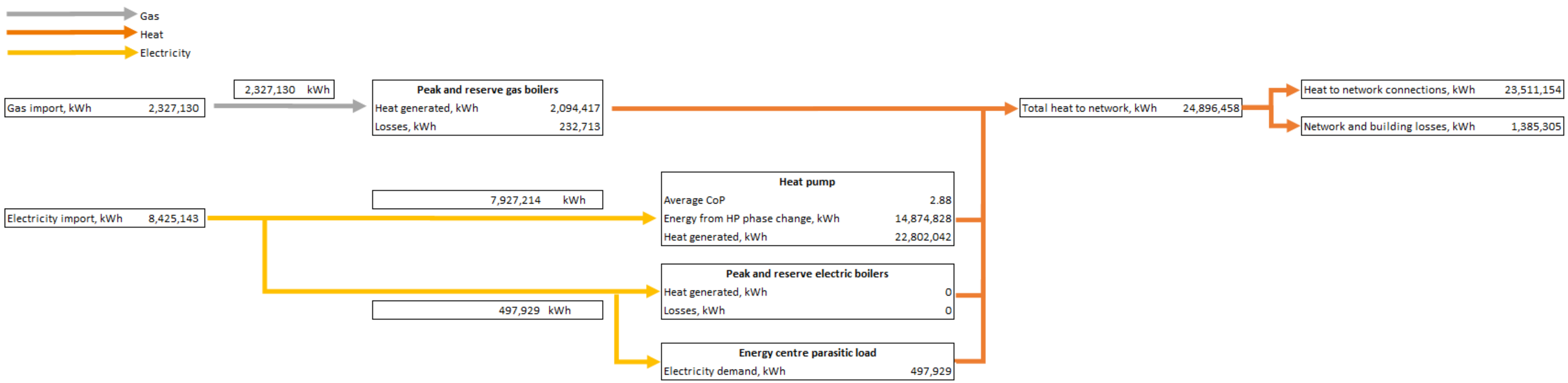

Figure 25: Phase 2 energy balance

7 CONCEPT DESIGN

This section describes the scheme concept design and includes details of the primary heat sources, peak and reserve boilers, other energy centre equipment (distribution pumps, expansion vessels, pressurisation units, and water treatment systems), utility connections and metering for the planned development energy centre. Required energy centre equipment and associated costs are shown in Appendix 7: Key Parameters and Assumptions. Network connections are discussed in section 7.3 and the heat network is discussed in section 7.4.

7.1 Futureproofing

Futureproofing measures have been considered throughout the concept design process for the network options. It has been estimated that there is only sufficient space in the phase 1 energy centre to accommodate 2.8 MW ASHPs (and supporting plant). However, additional heat sources to provide 2.2 MW of low-carbon heat will be required to extend to the phase 2 network, leading to the need for additional energy centre(s) or connection to the planned data centres in Southall and/or the OPDC heat main. The additional low-carbon energy centre(s) required for phase 2 could be located within planned development sites. However, a preferred site for the Phase 2 energy centre has not been identified at this stage.

The network has been futureproofed to allow for the connection of additional heat sources and expansion to wider town centre connections.

7.2 Energy Centre

The proposed energy centre would utilise the basement or ground floor of a planned development site located within the town centre (short list of energy centre locations identified in section 4.2). The proposed energy centre requires an internal floor area of 400 m^2 and an internal height of 5 metres. The space requirement for the energy centre and associated plant should be considered when development plans for the site are progressed.

The proposed phase 1 energy centre includes 2.8 MW of ASHPs, 3.6 MW of gas boilers and a 50,000 litre thermal store. The potential capacity of ASHPs for the energy centre and air heat exchangers on the roof was determined based on high-level plans for the planned developments identified as potential energy centres. The capacity of the ASHPs could potentially increase if the chosen building is designed with a greater rooftop footprint for the installation of more air heat exchangers.

The backup gas boilers will be used to provide heat at times of peak demand (if this exceeds the capacity of the heat pumps and thermal stores), or as a reserve heat source during times of heat pump maintenance or failure. The heat network control system will prioritise heat from the heat pumps and thermal stores over the peak and reserve boilers, to maximise the use of low-carbon plants. To reduce the network CO_2e intensity in the longer term, electric boilers could be installed in place of gas boilers. However, the use of electric boilers will increase the scheme OPEX as the price of electricity is higher than that of gas. The use of electric boilers will also increase the electrical capacity required at the energy centre, resulting in increased grid connection charges and potentially limited electric boiler capacity due to grid constraints. The impact of including electric boilers is shown in section 10.7.

A summary of the technology capacities for each phase at the proposed energy centre is shown in Table 15.

Table 15: Energy centre capacity summary

	Phase 1	Phase 2 (including previous phase)
Cumulative heat pump capacity, kW	2,800	5,000
Peak and reserve boiler capacity, kW	3,600	5,800
Thermal store capacity, L	50,000	80,000
Energy centre footprint, m^2	400	

Figure 26 shows process flow diagrams (PFDs) for the proposed energy centre. The fully built energy centre on a planned development site will require a land area of approximately 400 m^2. An overall ground floor footprint of 715 m^2 including the energy centre equipment, building reception, communal area and bin store is shown in Figure 27. A rooftop footprint of 450 m^2 will be required for the installation of air heat exchangers including maintenance access.

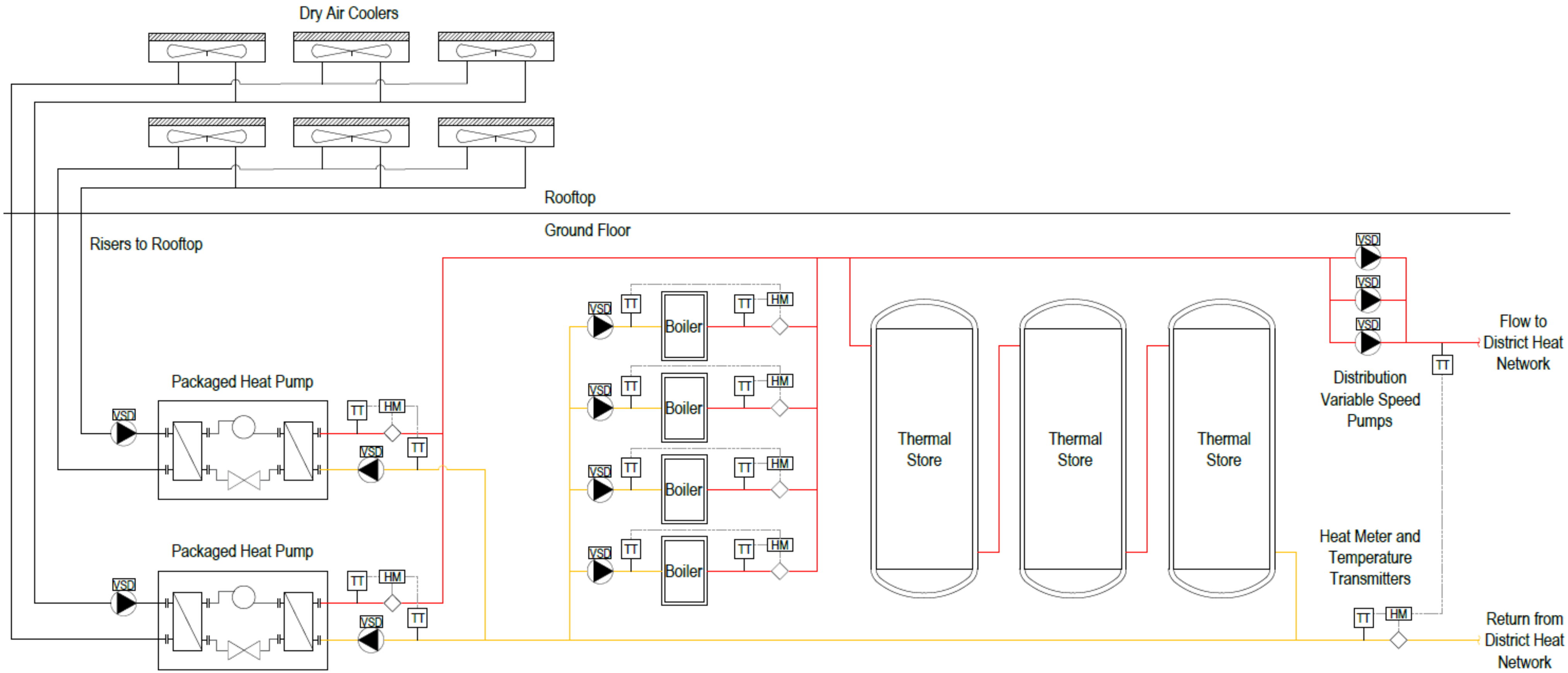

Figure 26: Town centre energy centre PFD

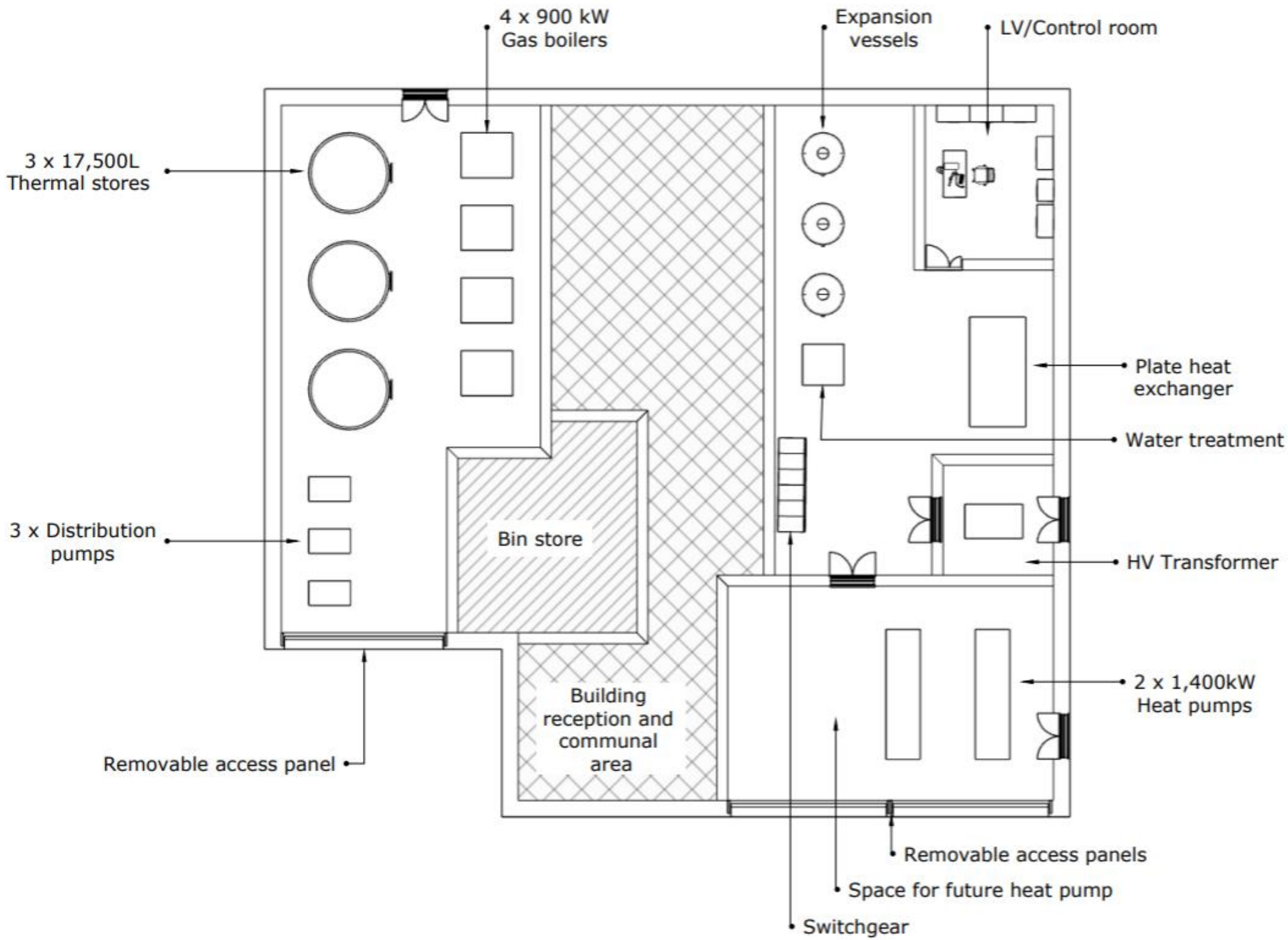

Figure 27: Town centre energy centre general arrangement

7.2.1 Technology Sizing

7.2.1.1 Heat Pumps

The heat pumps will be packaged units connected within the energy centre to two main circuits: the air heat exchanger source circuit and the primary heating circuit. The heat source circuit(s) operates by running a mix of water and glycol through a heat exchanger to extract the heat from the ambient air.

The refrigerant fluid 'absorbs' the heat from the circulating water and boils at low temperature with the resulting gas being compressed to increase the temperature, the gas is then passed through another heat exchanger, where it condenses, releasing its latent heat to the primary heating circuit.

The heat pump refrigerant circuit will be hermetically sealed and subject to the F-gas directive and the working fluid will be a refrigerant with GWP. More details on the advantages and disadvantages of different refrigerants can be found in Appendix 5: Heat Pump Refrigerants. Consideration has also been given to the optimum balance between heat generation capacity, capital cost, maintenance costs and physical size.

A detailed technology sizing exercise has been undertaken using SEL's heat pump and thermal store sizing tool. The tool analyses the hourly network heat demand, network losses, source temperature, heat pump capacity and modulation, and thermal store size on an hourly basis for a full year taking into account hourly, daily and seasonal variation as well as electricity tariffs. Further details of SEL's heat pump and thermal store sizing tool are included in Appendix 2: Borehole Assessment.

7.2.1.2 Peak and Reserve Boilers

Peak and reserve boilers have been sized to meet peak demand up to phase 1. Multiple boilers will allow modulation to meet heat demands as the phases are built out. The capacity installed includes n+1 to provide redundancy and enable the boilers to operate at their highest efficiency across the range.

The installed boiler redundancy ensures that the failure of any single unit will not prevent the peak heat demand of the network from being met. The economics and concept designs are based on gas boilers. The installation of electric boilers could also be considered in the future to decrease the network's carbon intensity or in the event of a gas boiler ban or increased gas prices. However, based on the current energy market and prices, the installation of electric boilers would negatively impact the network economics as it would result in higher operating costs due to increased electricity consumption at the energy centre and the requirement for a greater electricity connection capacity.

If gas boilers are selected, the design of the flues will achieve sufficient velocity of exhaust gas to achieve adequate dispersion, avoiding concentrations of harmful gasses such as nitrogen oxides (NOx).

Gas boilers are expected to only operate for short periods of time, although discussion with planning officers will be required. If required by local air quality officers, dispersion modelling can be conducted to ensure that any impact is within regulatory limits and meets local air quality objectives (and this information will be fed back into the flue design process).

7.2.2 Thermal Storage and Control

Thermal storage has been included to maximise the proportion of heat that can be provided from the heat pump and reduce the use of the peak and reserve boilers. The thermal storage comprises large cylindrical, insulated water tanks which will be connected in series with each other to maximise the stratification of the stored volume. The thermal storage will be connected in parallel with the heat pump so that a proportion of low carbon heat is always used to charge the thermal stores when they are below full capacity. The concept design includes a 50,000 litre thermal store. Three cylinder thermal store with 50,000 litre capacity with a diameter of approximately 3 meters and a height of 4.5 metres.

7.2.3 Operating Conditions

A detailed assessment of the proposed network has been undertaken and the proposed operating conditions reflect the optimal network efficiency. To ensure heat network losses are kept below 10%[3], and to effectively serve a combination of existing buildings with varying secondary systems, the heat network will operate at variable temperature conditions.

7.2.3.1 Primary Network Temperatures

The Ealing Town Centre Network will be a variable temperature network operating between 70°C and 65°C over a typical year, e.g. higher flow temperatures in peak winter periods and lower temperatures in summer outside the main heating season (heat demand is largely domestic hot water at buildings).

Given the mix of the connected buildings, the typical return temperature at the energy centre is 40°C. Future improvements to secondary side systems of connections (including the replacement of radiators) will lead to lower return temperatures, allowing lower flow temperatures from the energy centre.

The town centre energy centre has been designed with a maximum flow temperature of 70°C, to meet peak heat demands. The peak and reserve boilers will boost the network temperature to ensure a maximum network temperature of 70°C is reached during the coldest period of the year.

7.2.3.2 Secondary Side System Temperature

The proposed network comprises existing buildings mainly built/refurbished post the early 2000s and planned developments. Existing buildings will require upgrades to their secondary systems and controls to reduce the flow and return temperatures making them more efficient for a heat network connection. The best practice for replacing hot water systems and enhancing control in existing buildings' space heating systems involves targeting secondary side temperatures to be reduced to 65°C for flow and 40°C for return. Typically, the target return temperature for retrofitted existing buildings is 55°C.

For new developments connecting to the network, the flow and return temperature for heating systems should be designed at 55°C flow and 35°C.

Non-residential building hot water systems should be designed to operate with a primary flow temperature of 65°C and a secondary flow temperature of 60°C therefore if stored water is essential, the hot water heat exchangers should be installed on the primary system.

Hot water systems in commercial / non-residential buildings should consider systems and arrangements that always maintain return temperatures at less than 40°C including under part load and no load conditions such as instantaneous hot water via trace heating. Alternatively point of use hot water could be considered.

7.2.3.3 Operating Pressure

The operating pressures were calculated using two indicative energy centres for the phase 2 network, one at Perceval House Car Park and the other at Broadway Connection. These locations have been selected for this modelling as examples only, energy centre(s) could be located within any of the shortlisted development sites.

The highest point of the Ealing Town Centre Network is located at the Travelodge, at a height of 49 m above sea level and the lowest point is 28 m near the Perceval House. The design pressure at an energy centre at the Perceval House Car Park will be within a 6 bar rating and network pressure will be less than 3 bar.

The pumping pressure defines the maximum operating pressure when generating enough head to deliver the flow rate to all buildings. Hydraulic modelling was carried out to assess how the pressure in the network will vary

[3] The CIBSE/ADE HNCoP states that the calculated annual heat loss from the network up to the point of connection to each building when fully built out is typically expected to be less than 10 %

throughout the phasing and development of the network. The pressure difference of the network is 2.1 bar with a pressure difference index located at Ealing Broadway. The network pressure difference is shown in Figure 28.

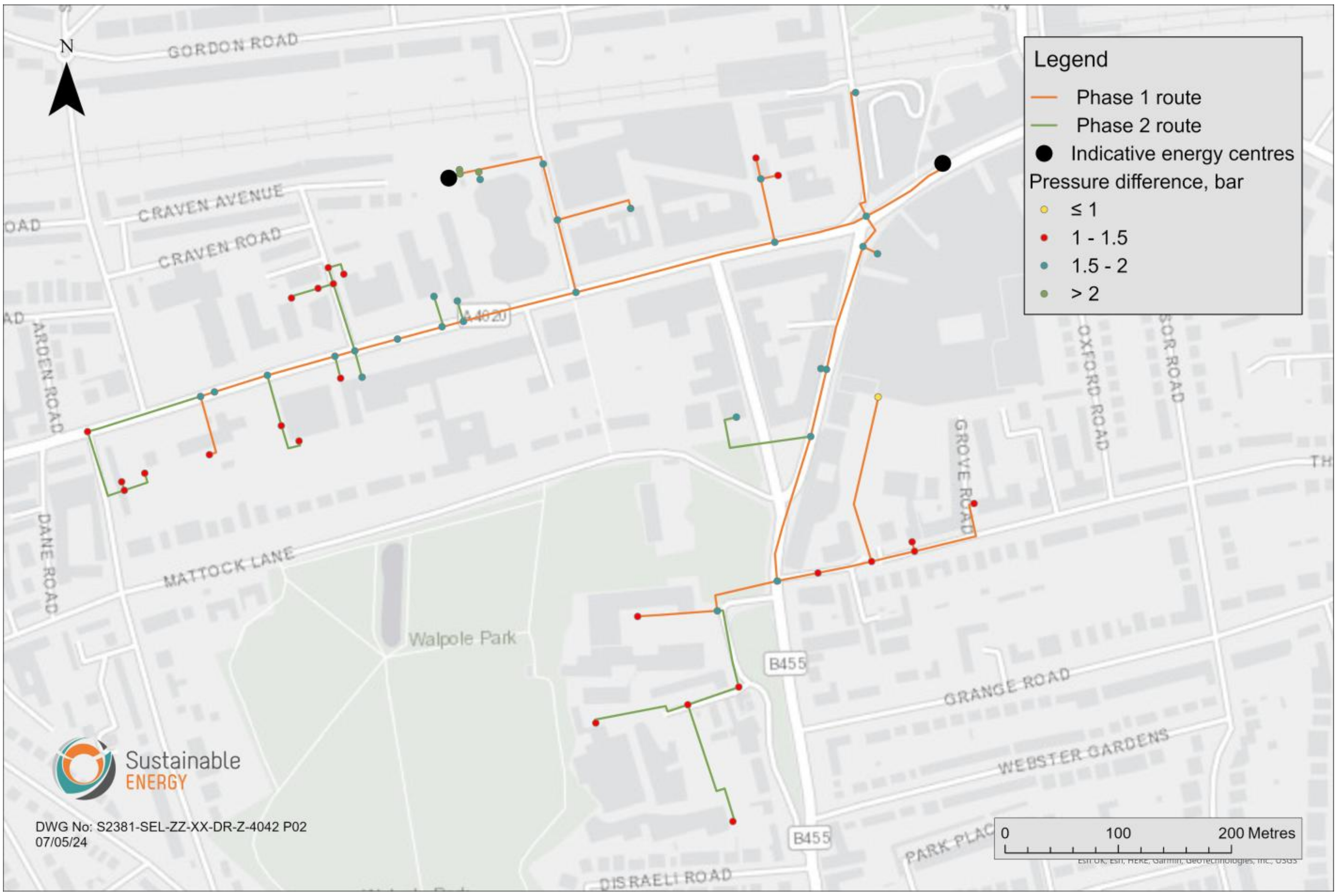

Figure 28: Network pressure difference

7.2.4 Variable Speed Pumps

The design utilises variable speed pumps in a multi-pump arrangement (3 pumps – 2no. duty and 1no. standby). They will be controlled to maintain a minimum pressure difference at specific locations using index differential pressure sensors within the network. The pump set will be sequenced, and speed controlled (on a demand basis) to maintain a differential pressure that is influenced by the pressure independent control valves controlling heat demand to ensure heat demands are satisfied and flow rates are minimised.

The benefits of the variable speed function will be realised as peak flow rate conditions will typically only occur for brief periods during a heating season, with average demands being much lower.

7.2.5 Utility Connections

The town centre energy centre will require a 2 MW electricity connection. A 3.6 MW gas connection will be required at the energy centre. A budget electricity quote from Scottish and Southern Energy and gas quote from Cadent Gas respectively was received for £87,000 and £230,000 respectively following the completion of the study. During the study, an estimate of £450,000 across both utilities was assumed. This lower costs received from the DNOs results a very minimal impact in economic returns (0.1% increase).

7.2.6 Energy Centre Acoustic

If the project progresses, an environmental noise survey and noise impact assessment will be conducted to assess the potential increase in noise levels from the installation of air heat exchangers. Relevant measures, including the installation of a noise screening structure, will be considered to maintain a noise level of at least 5.0 dB below the prevailing background sound level at the closest residential properties during the night.

The details of energy centre acoustic impacts are discussed in section 9.2.2.

7.2.6.1 Metering

All metering should be specified with suitable accuracy class in accordance with the Measurement Instrumentation Directive to satisfy the utility requirements for the purchase and sale of heat, gas, water and electricity for the energy centre.

Heat Metering

The energy centre will have heat meters installed across heat pumps, peak and reserve boilers and a combined export heat meter. The ultrasonic flow sensors measure flow and return temperatures and flow rates and the multi-function meters will calculate the heat energy exported. The heat meters will provide output signals (via mbus) for instantaneous measurements and cumulative measures of flow and energy. Data from all meters will be imported into the control system and used for control and monitoring of system performance.

Water Metering

There will be water meters to determine the cumulative use by each of the system pressurisation units, water treatment plant and the overall incoming mains water to each of the energy centres. All data will be collected by the control system.

Electricity Metering

Electricity meters will be fitted to measure the supply to the heat pumps and the imported electricity from the grid.

7.3 Building Connections

It has been assumed that all the network connections will be indirect (where a heat exchanger separates the heat network hydraulically from the building heating system or secondary network). An example of a typical arrangement for the thermal substation connections at a non-residential building is shown in Figure 29.

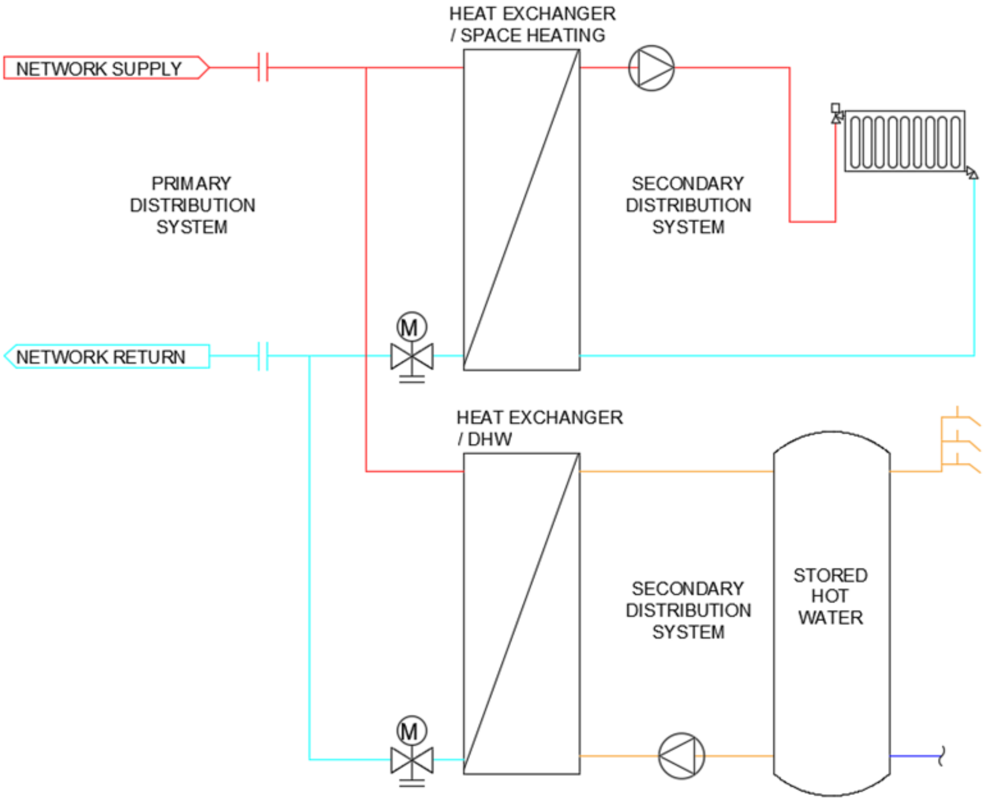

Figure 29: Example of a typical non-residential network connection

Some of the building connections will likely have ageing heating systems unlikely to be suitable for direct connection (e.g. are of adequate water quality and can tolerate the associated pressures). Private buildings will be connected indirectly due to their ownership, age of buildings and facilities management arrangements.

It has been assumed that the network operator will own the substations (the heat exchange equipment between the heat network and the secondary side equipment within a building). The substation includes heat exchangers, control valves and heat metering and will be maintained by the network operator. The substation can include one or more plate heat exchangers (PHEs), depending on the size, turn-down and redundancy required for each building. Typically, two PHEs are installed in parallel, each installed at 60% of peak load, providing a full thermal range, and some redundancy to permit service and maintenance periods. Larger substations may include more than two PHEs and additional clearance space for the network operators to access.

The substation package will include:

- Means of flow measurement and test points on both sides for commissioning purposes
- Filtration to protect the heat exchangers
- Flushing, filling and draining details
- Pressure relief, control and instrumentation to allow the supplier to control and monitor the supply of heat

7.4 Heat Network Design

7.4.1 Optimised Route

The pipe routes have been designed to consider pipe length and barriers such as existing utilities, bridges and construction limitations as outlined in Chapter 5. The network has been designed with futureproofing to allow for the expansion of the scheme up to 3 phases.

7.4.2 Pipe Sizing and Insulation

The pipe sizing has been carried out using FluidIt modelling software to determine the characteristics and sizing for each part of the network with the aim of minimising the pumping energy costs and heat losses in the network. The network has been designed with future proofing to allow expansion of the scheme.

The heat network has been designed as a pre-insulated rigid steel pipe system. The heat losses and size of trenches for the network have been based on Series 2 insulation thicknesses of polyurethane foam with a diffusion barrier.

Insulation will be CFC free rigid polyurethane foam homogenously filling the space between the service pipe and casing over the total length and in compliance with standard EN 253. The high-density polyethene (HDPE) pipe casing and all fittings and joints will be manufactured in compliance with EN 253 standards.

Pipework will include a pipe surveillance system in full compliance with BC EN 14419, suitable for both raising the alarm of a fault and detecting the location of a fault within all routes of the network. The alarm system will allow the provision of outputs to the energy centre control system.

8 TECHNO-ECONOMIC MODELLING

A TEM has been constructed to assess the economics of the prioritised heat pump network option. The key assumptions for the TEM and key parameters are shown in Appendix 7: Key Parameters and Assumptions.

The sensitivity of all key assumptions and energy tariffs has been assessed, see section 8.2. The TEM provided with this report allows key variables to be revised and the associated impact assessed.

8.1 Model Structure

Figure 30 shows an overview of the tabs included in the TEM. Tabs relevant to the standard user are shown in grey. These tabs include the key model inputs and variables and display the key results from the model. Tabs that involve technical inputs and calculations are shown in green. Inputs in these tabs have been input from the SEL technology sizing tool (see Appendix 3: Technology Sizing) and are set for each phase. The TEM covers all capital, replacement and operating costs of the network to UK plc and does not consider specific commercial delivery models. A user guide and full list of assumptions have also been included in the TEM.

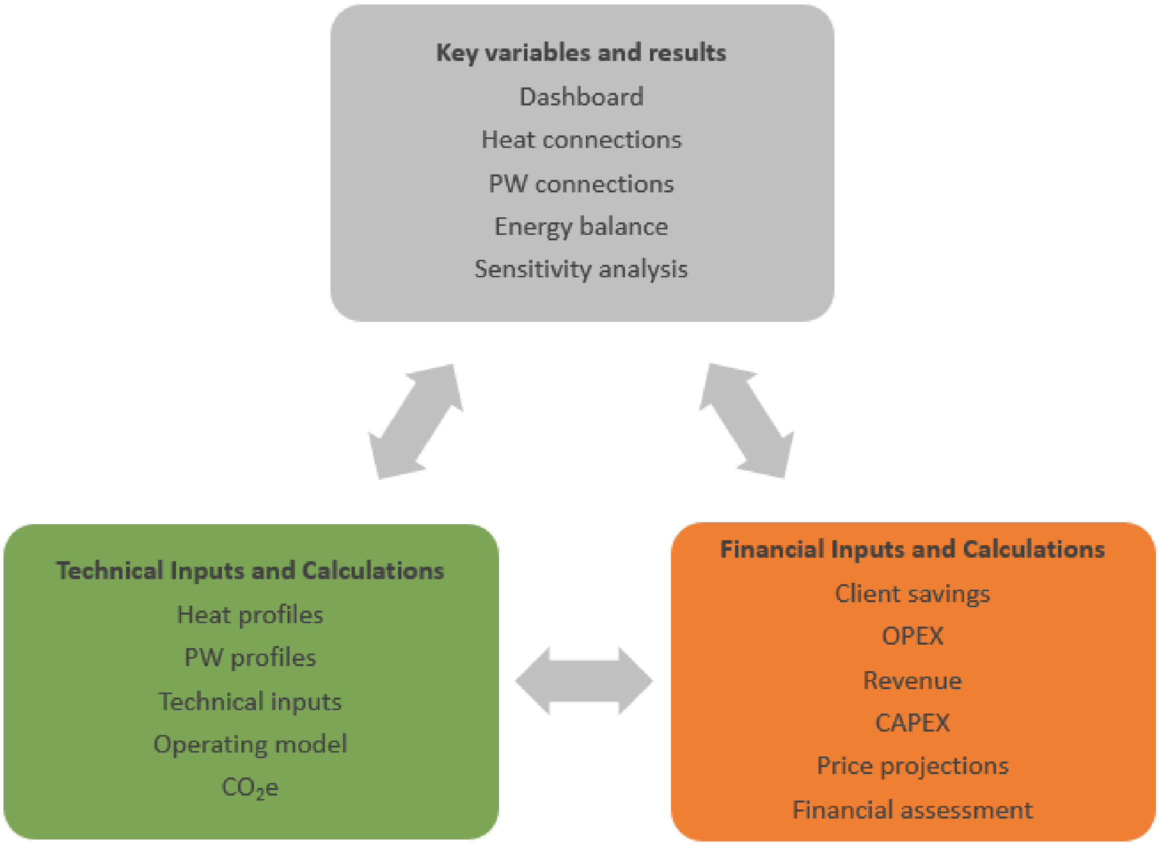

Figure 30: TEM tab structure

8.2 Key Assumptions

8.2.1 Energy Price Projections

To assess the impact of expected future price changes on the financial outputs, the 2023 DESNZ central scenario price projections for natural gas and electricity have been used. The projected changes in prices for electricity and natural gas for residential, services and industrial are illustrated in Figure 31. The projected price variations have been applied to the energy tariffs calculated.

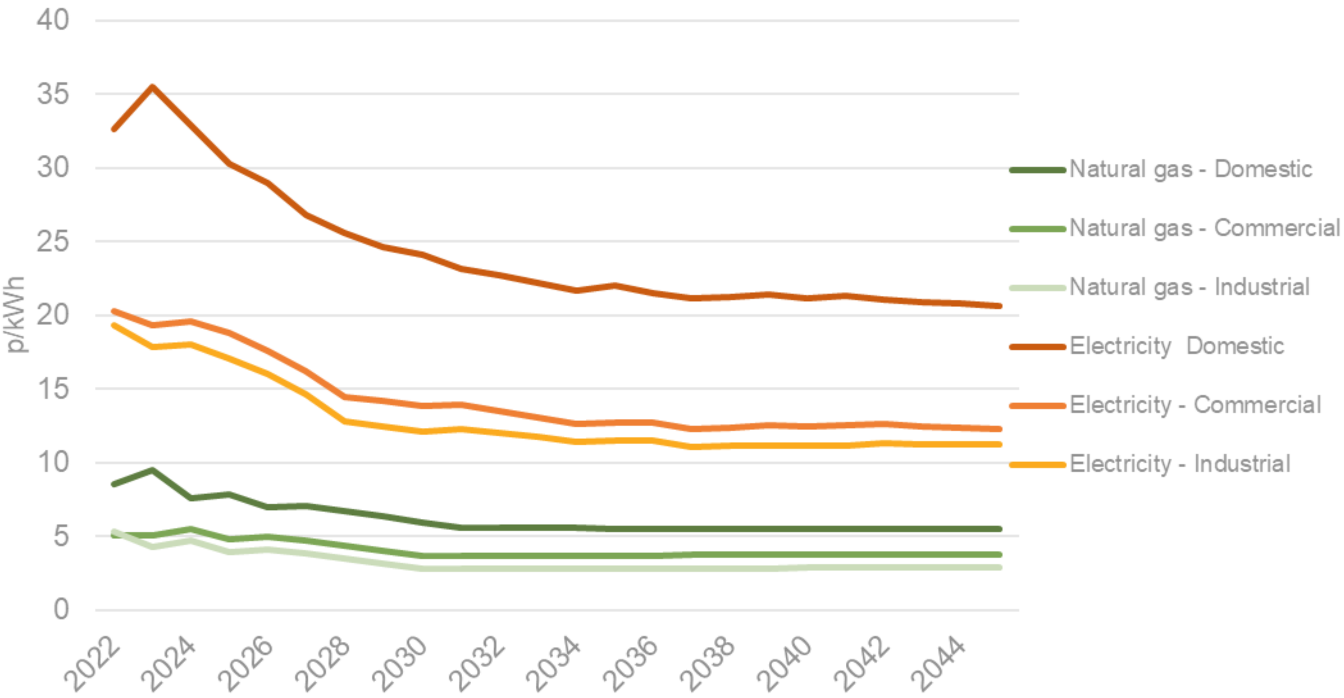

Figure 31: DESNZ[4] price projections – central scenario, updated 2023

The above projections indicate that, in the long term, energy prices will stabilise beyond 2026. The DESNZ low and high scenarios, as well as a fixed indexation rate, have also been assessed for the network option and their effect is shown in the sensitivity section. Additionally, the projected trend may be affected by policy changes over time, such as modifications to the electricity market from market balancing or the Review of the Electricity Market Arrangements (REMA) initiative.

8.2.2 Heat Sales Tariffs

The heat sale tariffs were developed for each network connection based on the cost of heat supply from the low carbon counterfactual of individual ASHPs. The heat sale tariffs comprise two elements - a variable tariff and a daily fixed charge. The DESNZ 'central scenario' energy price projections are applied to the variable heat tariffs to account for the variance in electricity prices over the project lifetime. The detailed heat sales tariffs used for the assessment are shown in Appendix 7: Key Parameters and Assumptions. This can be varied in the TEM.

8.2.3 Energy Centre Tariffs

Energy Centre Tariffs are used to calculate the cost of the fuels that the energy centre consumes to generate the required heat for the network. These fuels are often natural gas or electricity, depending on the systems. Electricity purchase tariffs used for the town centre energy centre have been based on existing energy tariffs at Perceval House. The DESNZ energy price projections are applied to the tariffs to account for variance in electricity and gas prices over the project lifetime. This can be varied in the TEM.

8.2.4 Other Energy Centre Operational Expenditure

The energy centre OPEX assessment includes the gas/electricity standing charge, energy system maintenance and service costs, heat network monitoring and maintenance (including pipework and HIUs/substations), staff costs, and insurance. All OPEX items have been calculated on an annual basis. Detailed energy centre OPEX can be found in Appendix 7: Key Parameters and Assumptions.

[4] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal - GOV.UK (www.gov.uk)

8.2.5 Initial Capital and Replacement Costs

Technology replacement costs are modelled on an annualised basis and consider the capital costs, expected lifetime, fractional repairs and the length of the business term. Details of expected equipment lifetime are shown in Appendix 7: Key Parameters and Assumptions.

Capital costs for the scheme are based on a combination of previous project experience, quotations for recent similar works and soft market testing and budget quotes. Soft market testing has previously been conducted with potential suppliers of key plants and equipment.

To develop an accurate estimate of the heat network costs, the proposed network has been broken down into constituent parts (i.e. straight pipe lengths, pipe bends, valves, valve chambers, welds, weld inspections, etc.) for each pipe section. These quantities have then been multiplied by the average rates taken from numerous quotations obtained for similar work. A complexity factor has been applied to account for the areas of lower implementation or construction complexity and areas of higher complexity such as main roads, key intersections and areas of congested utilities. This value was then assessed against the price provided via specific soft market testing.

Estimated capital costs for key plant items (such as heat pumps, thermal storage tanks, boilers, etc.) have been obtained from the respective suppliers.

Contingency has been applied to each element of capital expenditure as appropriate. A breakdown of capital costs and contingency values for each phase is shown in Appendix 7: Key Parameters and Assumptions.

8.2.6 Connection Costs and Connection Charges

It has been assumed that the network operator covers the connection cost, and customers will contribute through a connection charge when connecting to the network. Connection charges for all network connections have been included in the base case assessment and are assumed to be £600/kW based on previous project experience and existing schemes. This can be varied in the TEM.

8.3 Network Summary

A summary of the network is shown in Table 16. Figures shown for phase 2 are cumulative.

Table 16: Ealing Town Centre Network summary

	Phase 1	Phase 2
Total heat demand (excl. losses), kWh	14,161,194	23,303,370
Network trench length, m	2,148	3,165
Network linear heat density, MWh/m	6.6	7.4
Network losses, kWh	888,041	1,298,731
Building losses, kWh	86,573	86,573
Low carbon heat capacity, kW	2,800	5,000
Gas boiler capacity, kW	3,600	5,800
Heat demand met by heat pumps, kWh	13,474,122	22,357,260
Heat demand met by gas boilers, kWh	1,661,687	2,331,415
% heat demand met by low carbon / renewable technology	89%	91%
Estimated phase start year	2030	2033

The phase timing can be varied in the TEM to show the impact of a delay in network phases.

8.4 Economic Assessment

The 25 year, 30 year and 40-year economic assessments for two phases of the Ealing Town Centre Network are shown in Table 17.

Table 17: Economic assessment

		Phase 1	Phase 2
Capital costs for each phase (including contingency)		£21,635,190	£12,588,484
Total capital costs (including contingency)			£34,223,674
25 years	IRR	0.7%	0.8%
	NPV	-£4,665,985	-£6,637,992
	Simple payback	23 years	23 years
	Net income	£1,609,671	£2,514,127
30 years	IRR	1.6%	1.7%
	NPV	-£3,674,520	-£5,064,724
	Simple payback	24 years	24 years
	Net income	£4,590,392	£7,250,352
40 years	IRR	2.6%	2.7%
	NPV	-£2,249,115	-£2,826,142
	Simple payback	25 years	25 years
	Net income	£10,387,034	£16,408,918

The capital costs, operational expenditure, revenue and cumulative cash flow for the full network are shown in Figure 32 for 40 years.

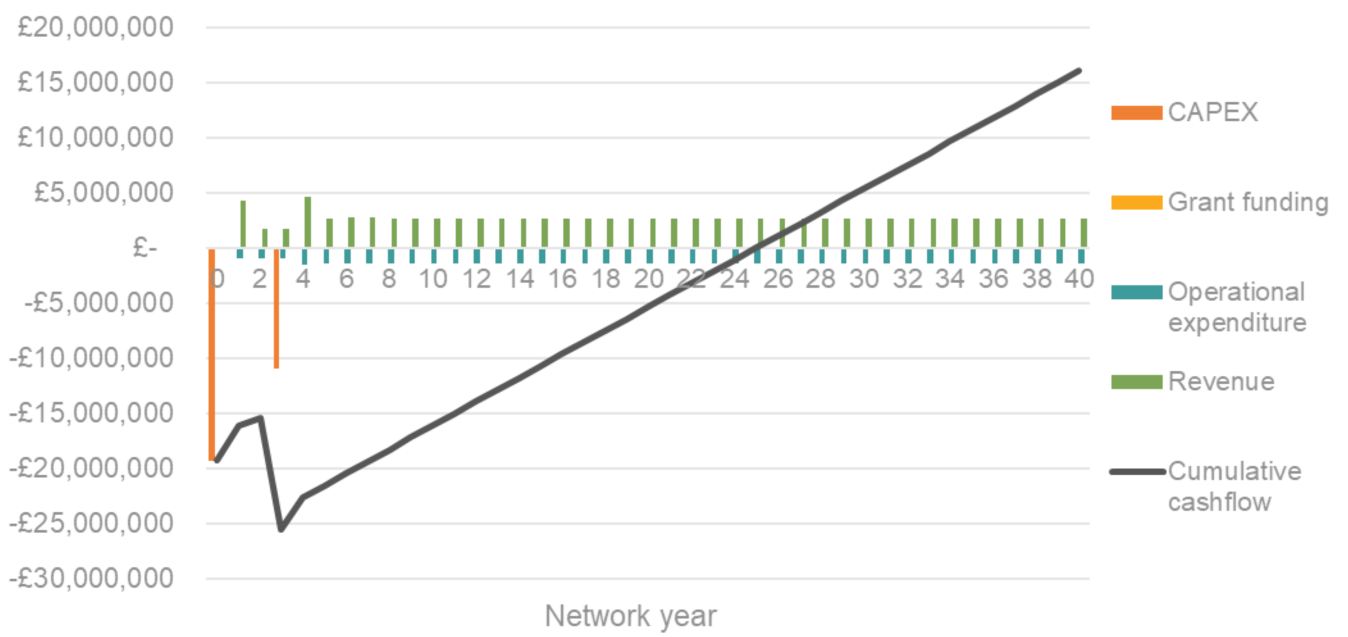

Figure 32: Ealing Town Centre Network cumulative cash flow - 40 years

8.4.1 Green Heat Network Fund

DESNZ provides capital support for the development of heat networks as they are seen as a key part of delivering the UK’s legally binding commitment to achieve net zero by 2050. As such they have made capital support available to projects via the Green Heat Network Fund (GHNF) which was launched in April 2022. GHNF is a £288m fund available to support heat network projects with capital grants up to but not including 50% of the project CAPEX. Certain key metrics must be met to apply for GHNF, and Table 18 shows the proposed phase 1 network's performance against these. It is possible to apply for GHNF for both phase 1 and 2, however, as the phase 2 network has a significant number of unknowns and risks including the location of a second energy centre or whether an additional energy centre is required at all, it is unlikely that GHNF would be secured for this phase.

Table 18: Green Heat Network Fund core metrics

Metric	Minimum score	Proposed option
Carbon gate	100 gCO_2e/kWh thermal energy delivered	The carbon intensity of the network is 56 gCO_2e/kWh for year 1.
Customer detriment	Domestic and micro-businesses must not be offered a price of heat greater than a low carbon counterfactual for new buildings and a gas/oil counterfactual for existing buildings	Heat sales tariffs have been calculated based on the cost of a low carbon counterfactual. There are no domestic or micro-businesses connected to the network.
Social IRR	Projects must demonstrate a social IRR of 3.5% or greater over a 40-year period	The 40-year social IRR is 9.2% for the phase 1 network.
Minimum demand	For urban networks, a minimum end customer demand of 2 GWh/year. For rural networks, a minimum number of 100 dwellings connected	End customer demand is 14.2 GWh/year for the phase 1 network.
Maximum CAPEX	Grant award requested up to but not including 50% of the combined total CAPEX + commercialisation costs (with an upper limit of £1 million for commercialisation)	The maximum grant funding available according to this metric is £10.8m (phase 1).
Capped award	The total 15-year kWh of heat/cooling forecast to be delivered will not exceed 4.5 pence of grant per kWh delivered (subject to review by GHNF)	Projects with a cap below 3.5 p/kWh are more likely to receive grant funding. Grant funding requested for this network should therefore be kept below 3.5 p/kWh. This corresponds to 34% grant funding for phase 1.
Non-heat/cooling cost inclusion	For projects including wider energy infrastructure in their application, the value of income generated/costs saved/wider subsidy obtained should be greater than or equal to the costs included.	No non-heat/cooling infrastructure included.

8.4.2 Effect of Grant Funding

The Ealing Town Centre Network could be eligible for grant funding for 34% of the Phase 1 project CAPEX (£7,390,906). Table 19 shows the impact of 34% of grant funding for Phase 1 on the project economics. The network IRR has increased from 2.7% to 5.1% over the 40-year business case for the full phase network. However, private investors are likely to require a greater return than 5.1% IRR.

Table 19: Economics assessment with 34% grant in Phase 1

		Phase 1	Phase 2
Capital costs for each phase (including contingency)		£21,635,190	£12,588,484
Total capital costs (including contingency)			£34,223,674
Total grant funding (additional)		£7,335,195	-
25 years	IRR	5.9%	3.9%
	NPV	£2,669,210	£697,203
	Simple payback	13 years	17 years
	Net income	£8,944,866	£9,849,322
30 years	IRR	6.3%	4.5%
	NPV	£3,660,674	£2,270,470

		Phase 1	Phase 2
	Simple payback	14 years	18 years
	Net income	£11,925,587	£14,585,546
40 years	IRR	6.6%	5.1%
	NPV	£5,086,080	£4,509,053
	Simple payback	14 years	18 years
	Net income	£17,722,228	£23,744,113

The capital costs, operational expenditure, revenue, and cumulative cash flow for the full network with 34% grant funding in all phases is shown in Figure 33.

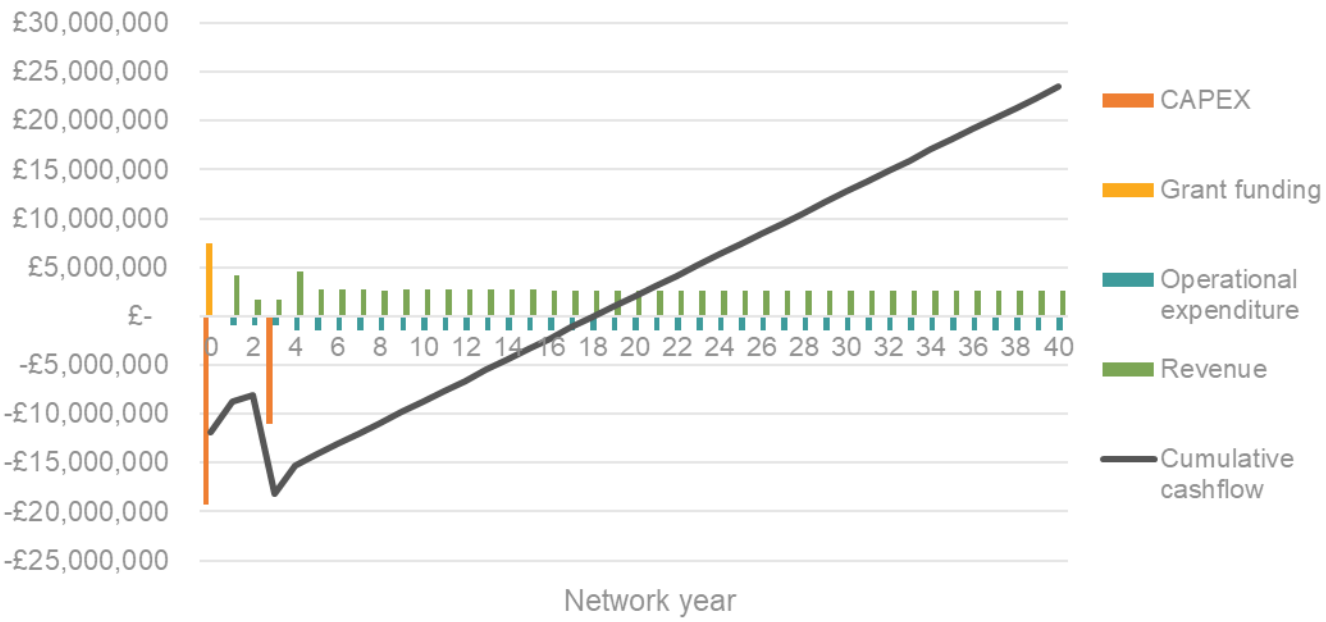

Figure 33: Ealing Town Centre Network cumulative cash flow with GHNF - 40 years

9 ENVIRONMENTAL BENEFITS AND IMPACTS

CO_2e intensity projections for grid electricity and natural gas are shown in Figure 34. The CO_2e emissions for the electricity grid are expected to reduce over time due to the increase in wind, solar and nuclear power and the closure of coal power stations.

Two CO_2e projections for grid electricity have been used in the TEM[5]:

- Long run marginal figure (commercial)
- Long run marginal figures (residential)

The long run marginal emissions factors consider the marginal plant for electricity generation. The projections are based on assumptions of future economic growth, fossil fuel prices, electricity generation costs, UK population and other key variables which are regularly updated. They also give an indication of the impact of the uncertainty around some of these input assumptions. Each set of projections takes account of climate change policies where funding has been agreed and where decisions on policy design are sufficiently advanced to allow robust estimates of policy impacts to be made.

These figures have been used for all electricity imported from the grid (i.e., for heat pump and energy centre electricity demand).

The long run marginal figures for grid electricity and the natural gas figure[6] have been used for the counterfactual CO_2e emissions.

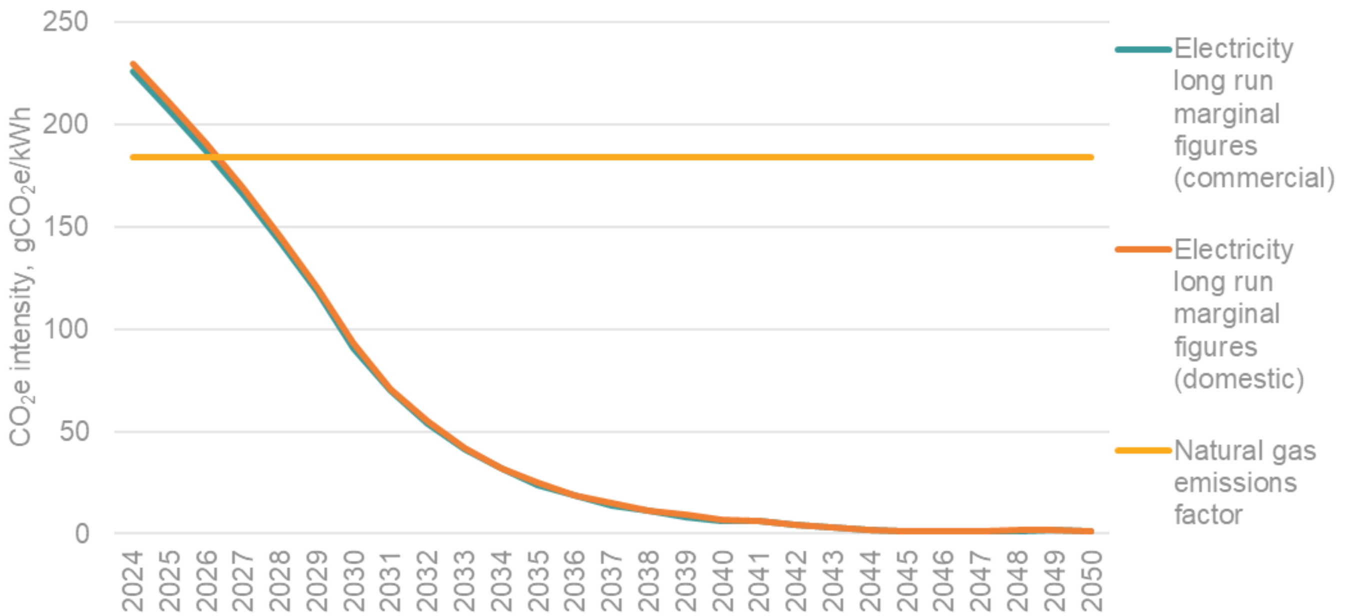

Figure 34: CO_2e intensity projections for grid electricity and natural gas

9.1 CO_2e Assessment

Individual gas boilers for existing buildings and individual ASHPs for planned developments have been assessed as the carbon emissions base case (BAU) for the Ealing Town Centre Network. BAU CO_2e emissions, network CO_2e emissions and CO_2e savings for the Ealing Town Centre Network are shown in Figure 35 and Table 20. The shaded area shows the difference between CO_2e emissions in the BAU and the Ealing Town Centre Network emissions. The BAU emissions remain constant due to the natural gas emissions factor used in the assessments. The network emissions reduce marginally over time as the grid decarbonises. Further decarbonisation of the network could be

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[5] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

[6] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022

achieved through the replacement of gas peak and reserve boilers with electric boilers as well as through the installation of additional low carbon capacity during future network expansions.

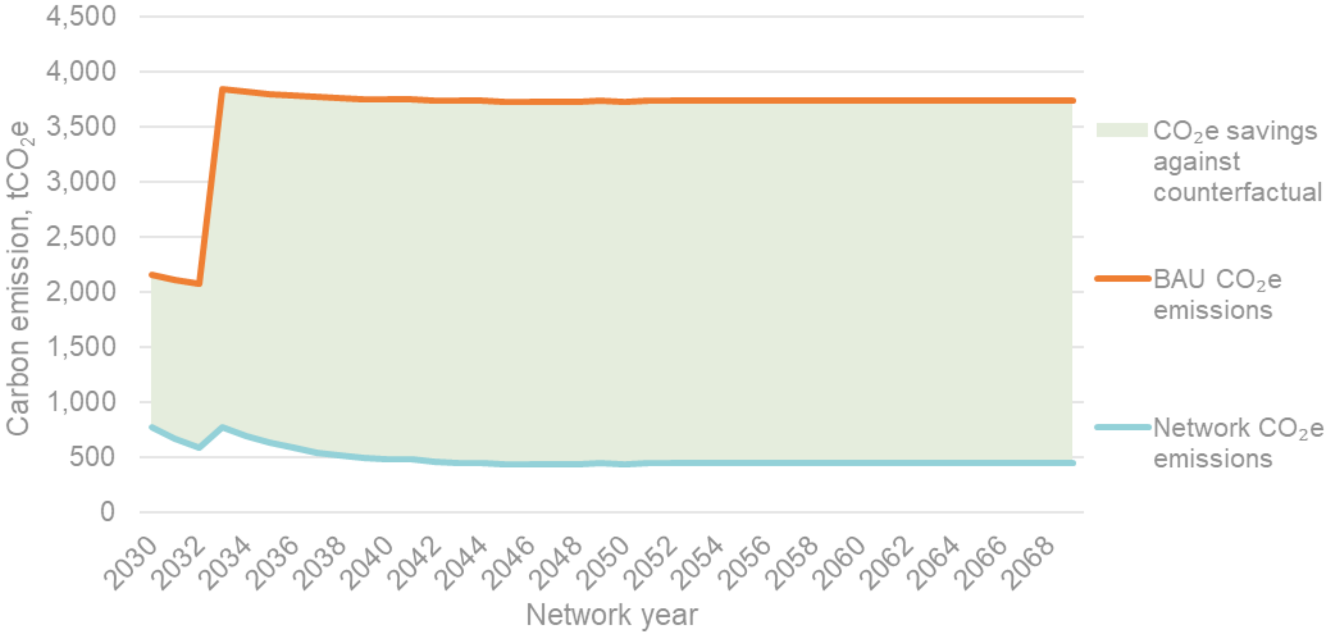

Figure 35: 40-years network CO_2e savings and emissions

Table 20: Network CO_2e emissions and savings over 25, 30 and 40 years

CO_2e emissions and savings		
25 years	Network CO_2e emissions, tCO_2e	14,103
	BAU CO_2e emissions, tCO_2e	88,923
	CO_2e savings against BAU, tCO_2e	74,821
30 years	Network CO_2e emissions, tCO_2e	16,567
	BAU CO_2e emissions, tCO_2e	107,607
	CO_2e savings against BAU, tCO_2e	91,040
40 years	Network CO_2e emissions, tCO_2e	21,496
	BAU CO_2e emissions, tCO_2e	144,974
	CO_2e savings against BAU, tCO_2e	123,478
First year CO_2e savings, tCO_2e		1,359
First year CO_2e intensity of delivered heat, g/kWh		56
CO_2e intensity of heat delivered (40-year average), gCO_2e/kWh		25

The CO_2e intensity of the Ealing Town Centre Network is compared with various industry standards. The CO_2e intensity of heat delivered in the first year of network operation (56 gCO_2e/kWh) is significantly lower than the SBEM/SAP (2012) figure for a notional building connected to a district heat network of 190 $g/CO_2e/kWh$, the proposed 350 gCO_2e/kWh threshold for an existing network in the Part L 2023 uplift and the GHNF criteria of 100 gCO_2e/kWh.

9.2 Cold Plumes, Visual Impact, Noise, and Air Quality

9.2.1 Cold Plume

The air from ASHPs is normally emitted at a temperature 3°C colder than the ambient air at the point of emission, this can form a dense cold air plume which can impact the surrounding area. Due to the large number of heat exchangers required for the town centre energy centre, there should also be consideration for the dispersion of cold air plumes to minimise the recirculation back into the heat exchangers. A cold plume assessment may be needed to ensure this is minimised as well as to assess the impact on buildings.

9.2.2 Noise

The ASHPs will require the installation of external air heat exchangers on the roof of the proposed development, above the energy centre. There is an associated noise impact from this external equipment, which will likely present the greatest noise impact from the new energy centre to the surrounding area. A noise impact assessment may be needed to understand the impacts on the site and possible mitigation measures needed, such as acoustic screening around the rooftop evaporators, although screening should not limit air flow around the coolers.

The impact of noise should be further assessed as the project progresses and heat pumps and heat exchangers are selected.

9.2.3 Visual Impact

The town centre energy centre has been designed to be incorporated into the ground floor or basement of a proposed development. The visual impact of the energy centre is therefore unlikely to be significant. Access to the energy centre is yet to be determined but is likely to be to the north of the development site away from the key areas for active frontage and near to the railway and SSE substation.

The visual impact of the heat exchangers on the roof will require further assessment as the development plans for the identified energy centre sites progress. Louvres across the top of the heat exchangers may be required to reduce the visual impact on nearby high-rises, however, this could affect the performance of the heat exchangers. This should be further assessed as the project progresses, more detailed development plans become available, and the heat exchangers are selected. The screening around the heat exchangers will increase the building height by approximately 4 m.

The visual impact should be further assessed as the project progresses and discussed with LBE Planners and the developers of development sites.

9.2.4 Air Quality

Gas boilers have been included in the base case and they should be compliant with the Medium Combustion Plant Directive. Gas boilers will be low NOx versions and will run only at peak heat demands and when the heat pumps are not operating.

Ealing town centre is within an Air Quality Management Area and dispersion modelling should be conducted at the next stage of project development, if a district heating project is progressed with gas boilers, to ensure that any impact is within regulatory limits and meets local air quality objectives (and this information will be fed back into the flue design process). Air dispersion analysis simulates the exhaust gases for each hour and models the dispersion of gases and, where appropriate, particulate emissions (although these are considered negligible for natural gas fuelled plants) over a wide geographical area. The output of the analysis provides concentration levels of particulates and NOx at specified locations.

9.3 Social IRR and NPV

The social IRR and social NPV help to identify the wider benefits of the scheme for the community and are a vital consideration for local authorities. The social IRR and NPV are shown in Table 21 and are determined by monetising the CO_2e savings and the improvements in air quality against the use of individual gas boilers. The economic value of the carbon and air quality improvements are included in the project cash flow and are based on DESNZ projections[7]. These account for the reduction in future costs of mitigating the effects of climate change, and the reduction in healthcare costs associated with the improved air quality by removing gas boilers across the city.

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[7] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal - GOV.UK (www.gov.uk) – Data tables 3 and 15

Social IRR is a key eligibility metric for GHNF applications. Projects must demonstrate a social IRR of 3.5% or higher over a 40-year period. In this case, both Phase 1 and 2 of the network have achieved a 40-year social IRR above 3.5%.

Table 21: Social IRR and NPV

		IRR	Social IRR	NPV	Social NPV
Phase 1	25 years	0.7%	8.5%	-£4,665,985	£10,914,286
	30 years	1.6%	8.9%	-£3,674,520	£14,061,284
	40 years	2.6%	9.2%	-£2,249,115	£18,843,335
Phase 2	25 years	0.8%	9.1%	-£6,637,992	£18,038,093
	30 years	1.7%	9.5%	-£5,064,724	£23,219,935
	40 years	2.7%	9.8%	-£2,826,142	£31,077,986

10 SENSITIVITY ANALYSIS

Sensitivity analysis has been undertaken for the Ealing Town Centre Network based on the key network risks and key parameters and variables. The base case 40-year IRRs are shown in dark grey cells in tables.

Key risks for the network include:

- Capital cost
- Network heat demand
- Energy tariffs including heat sales tariffs, energy centre fuel purchase tariffs and indexation of energy tariffs
- Heat pump SPF

10.1 Interpreting Sensitivity Graphs

In the majority of the graphs presented below, the x-axis represents the percentage variation of the parameter being varied. The 0% variation is therefore the base case and is typically in either the centre of the graph or at one of the extremes.

From the base case, the parameter is varied by a fixed percentage (usually -30%, -15%, +15% and +30%), and the effect on the project IRR is displayed.

If a graph were to display a horizontal line, this would indicate that the parameter being varied does not affect the project. A very steep line on the other hand would indicate that the project is very sensitive to small changes in the parameter being varied, indicating a high risk.

10.2 Capital Costs

A total cost of £1,800,000 (£2,070,000 with contingency) has been used for the energy centre building construction at a development site. Should the energy centre be designed to a higher specification with additional architectural design, the costs could increase further. This would increase the overall CAPEX and result in a reduced 40-year IRR. Figure 36 shows the effect of a variance in capital costs over the 40-year IRR for each network phase.

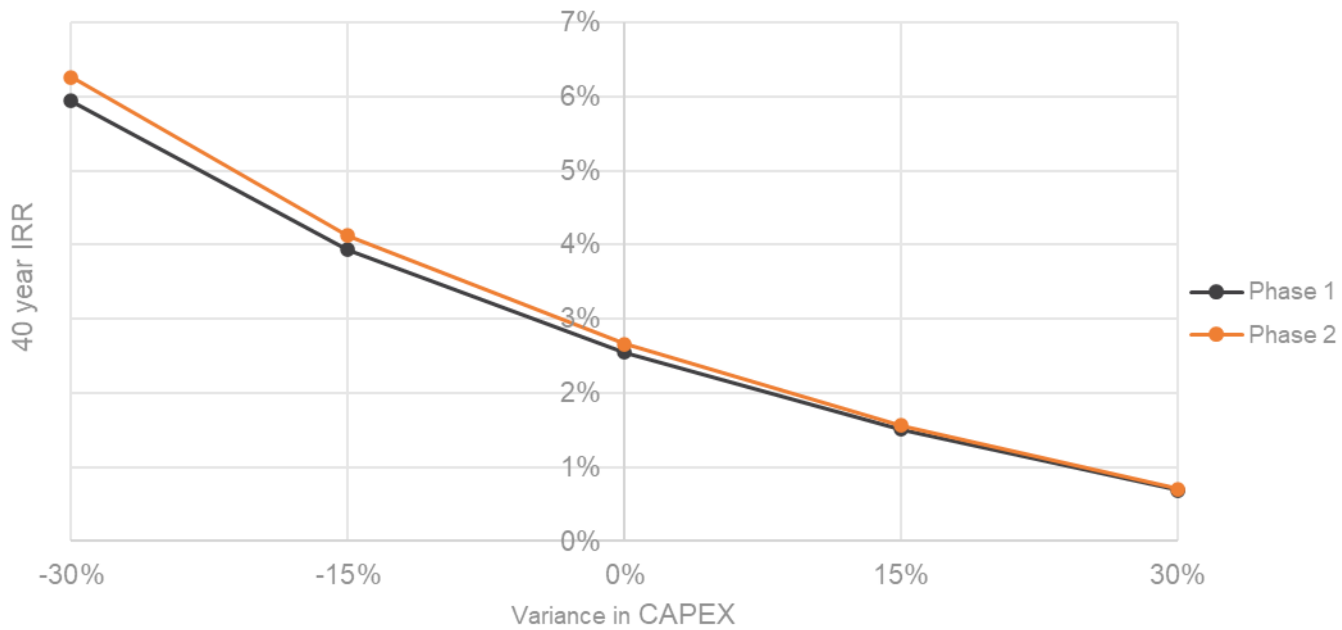

Figure 36: Effect of variance in capital costs

Table 22 shows the 40-year IRR for the fully built out network if the capital costs did not include contingency.

Table 22: Contingency applied to capital costs

	Phase 2
Capital costs including contingency (including previous phases)	£34,223,674
40-year IRR including contingency	2.7%
Capital costs not including contingency (including previous phases)	£25,560,383
40-year IRR not including contingency	4.1%

10.3 Heat Demand

Figure 37 shows the effect of a variance in the total network heat demand, with all other parameters remaining constant. An increase in heat demand results in an increase in the 40-year IRR, as the increased heat sales revenue generated through the additional heat demand outweighs the OPEX of additional heat generation. The analysis does not consider the installation of additional or larger capacity heat pumps.

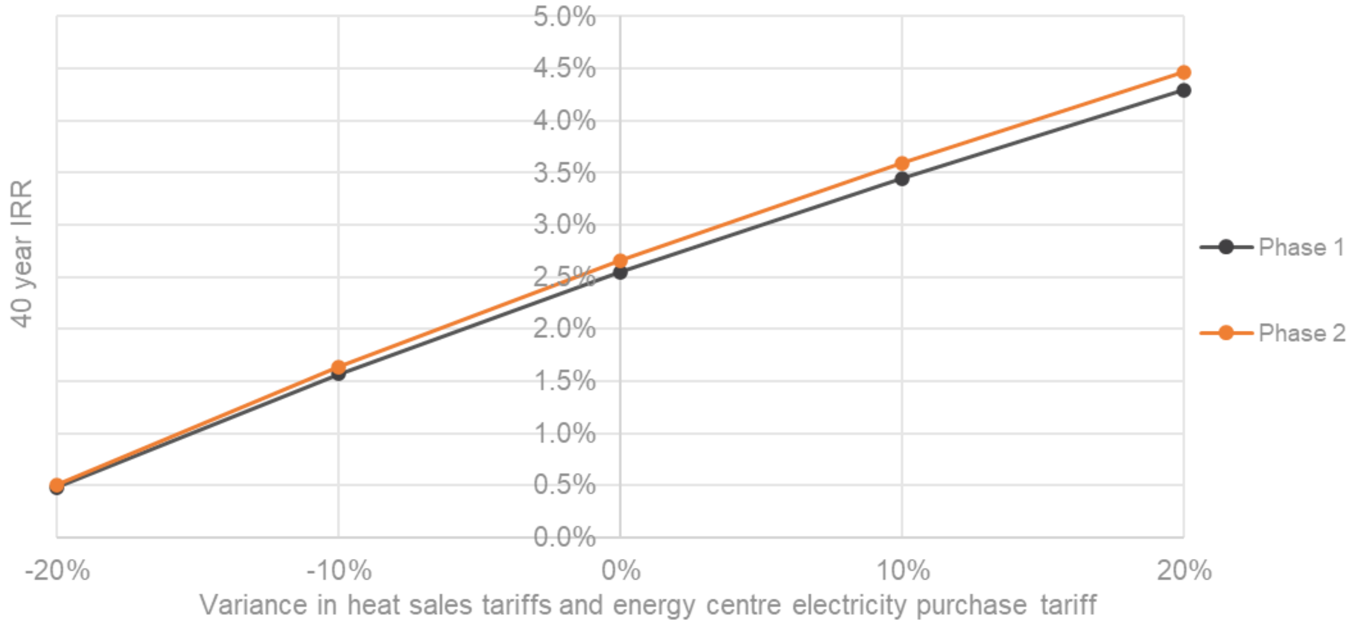

Figure 37: Effect of variance in heat demand

Table 23 shows the impact of the key buildings not connecting to the heat network. If these buildings do not connect, the network's economic performance will be impacted significantly.

Not connecting planned development has a major impact on IRR across all phases as the heat demand of the planned development accounts for a large portion of the overall heat demand within phases 1 and 2. The reduction of IRR is mainly due to the assumed heat connection fee and heat sales being lost. The sensitivity of the 3 largest non-council connections not connecting to the network was assessed and shown below.

Table 23: Impact of buildings not connecting to the network

Heat demand scenarios	Phase 1 40-year IRR	Phase 2 40-year IRR
Base case	2.6%	2.7%
Perceval House	1.8%	2.1%
Ealing Broadway	0.1%	1.1%
CP House	1.4%	1.9%
Dawley House	2.5%	2.2%
Planned developments	-2.8%	-1.0%

According to Table 23, the network economics will be significantly impacted if key heat loads do not connect to the network. Ealing Broadway is a key phase 1 connection and early stakeholder engagement is required to ensure site is connected. The network economics are also reliant on the connection of the phase 1 planned developments. Robust planning policy should be developed to require all new developments to connect to the heat network.

10.4 Energy Tariffs

The impact of a variance in the energy centre electricity tariff is shown in Figure 38. For the base case assessment, an electricity supply tariff of 18 p/kWh was used. This has a significant impact on the 40-year IRR as a large portion of the heat network operational costs relate to electricity consumption.

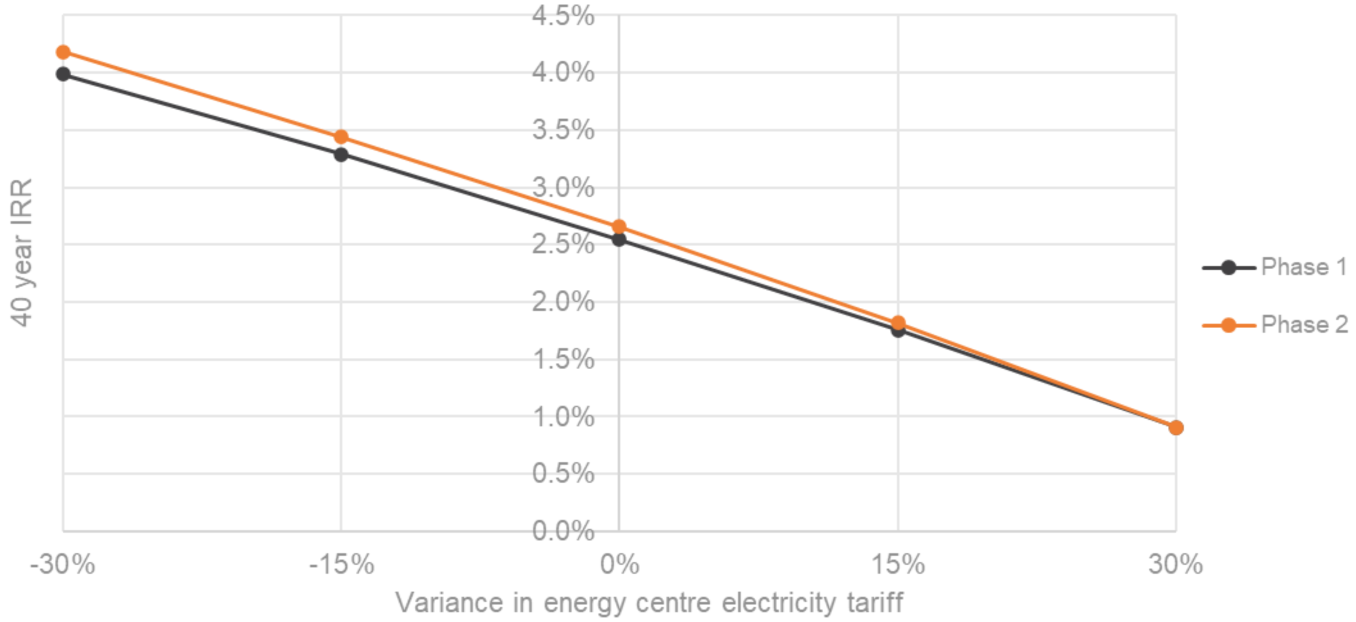

Figure 38: Effect of variance in energy centre electricity purchase tariff

The variance in energy centre electricity tariff used in the sensitivity analysis is summarised in Table 24.

Table 24: Variance in energy centre electricity tariff

Sensitivity	Energy centre electricity tariff after variation (day), p/kWh
30% decrease	12.6
15% decrease	15.3
Base case	18.0
15% increase	20.8
30% increase	23.5

The impact of variance in heat sale tariff and energy centre electricity purchase tariff is shown in Figure 39. The figure shows that a variance in both the heat sales tariff and the energy centre electricity purchase tariff at the same rate will have a significant impact on network economics. This figure shows that the network's economics are more sensitive to changes in the heat sales tariff than energy centre electricity purchase tariff.

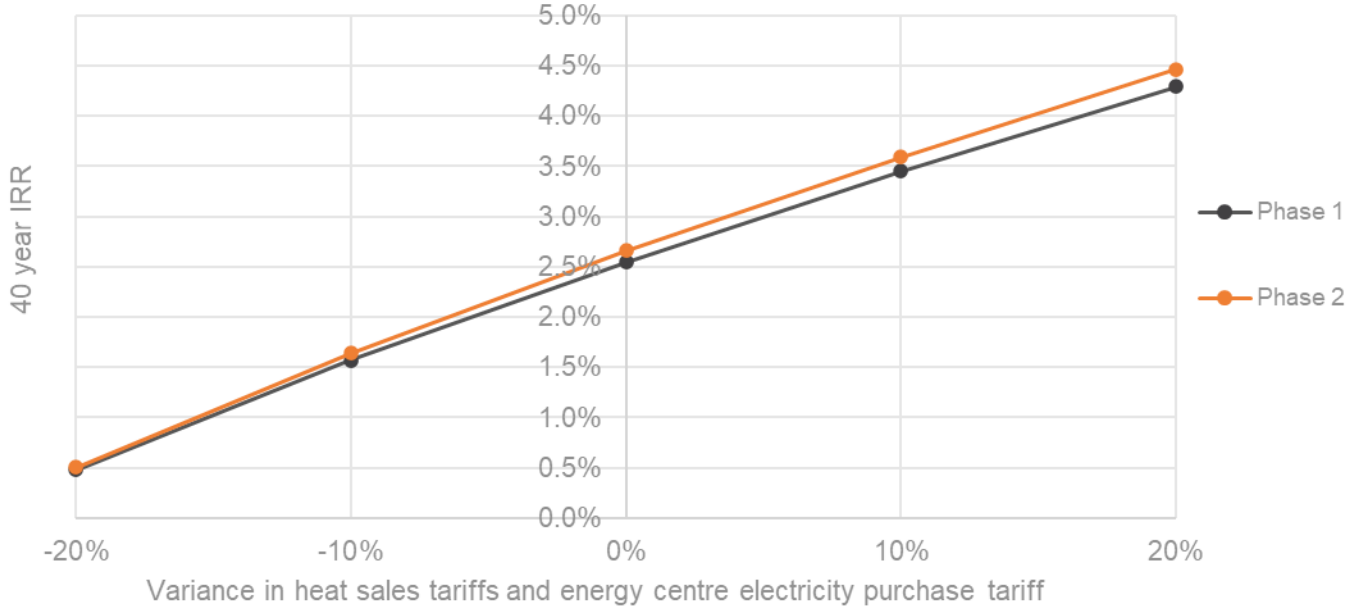

Figure 39: Effect of variance in variable heat sales tariff and electricity purchase tariff

10.5 Energy Price Indexing

The impact of price indexing on all energy tariffs is shown in Table 25. The 40-year IRR remains constant with different DESNZ scenarios, suggesting the network is resilient against changes in energy prices.

Table 25: Impact of indexing of all energy tariffs

Index for energy tariffs	Phase 1	Phase 2
DESNZ central scenario	2.6%	2.7%
DESNZ low scenario	2.7%	2.7%
DESNZ high scenario	2.3%	2.5%
Fixed rate: 0%	3.7%	3.9%
Fixed rate: 2.5%	3.7%	3.9%

10.6 Heat Pump SPF_{H4}

The impact of variance in the SPF_{H4} of the heat pumps is shown in Figure 40. SPF_{H4} includes the electrical consumption related to the heat pumps. If the electricity consumption related to the heat pump increases, the project IRR will decrease.

Figure 40: Impact of variance in heat pump SPF_{H4}

10.7 Electric Peak and Reserve Boilers

If electric peak and reserve boilers were used, the network IRR would decrease due to the increased cost of fuel for heat generation. However, the 40-year network carbon emissions would be reduced if electric peak and reserve boilers were used, as shown in Table 26.

Table 26: Electric peak and reserve boilers sensitivity analysis results

Sensitivity	Phase 1	Phase 2
40 years IRR with gas peak and reserve	2.6%	2.7%
40 years IRR with electric peak and reserve	1.5%	1.7%
Network emission with gas peak and reserve, tCO_2e	15,725	21,496
Network emission with electric peak and reserve, tCO_2e	2,867	3,721

10.8 Connection Charge

The impact of changing the connection charge for network customers on the project's 40-year IRR is shown in Figure 41 and Table 27. As can be seen an increase in connection charge will result in an increase in the 40-year IRR.

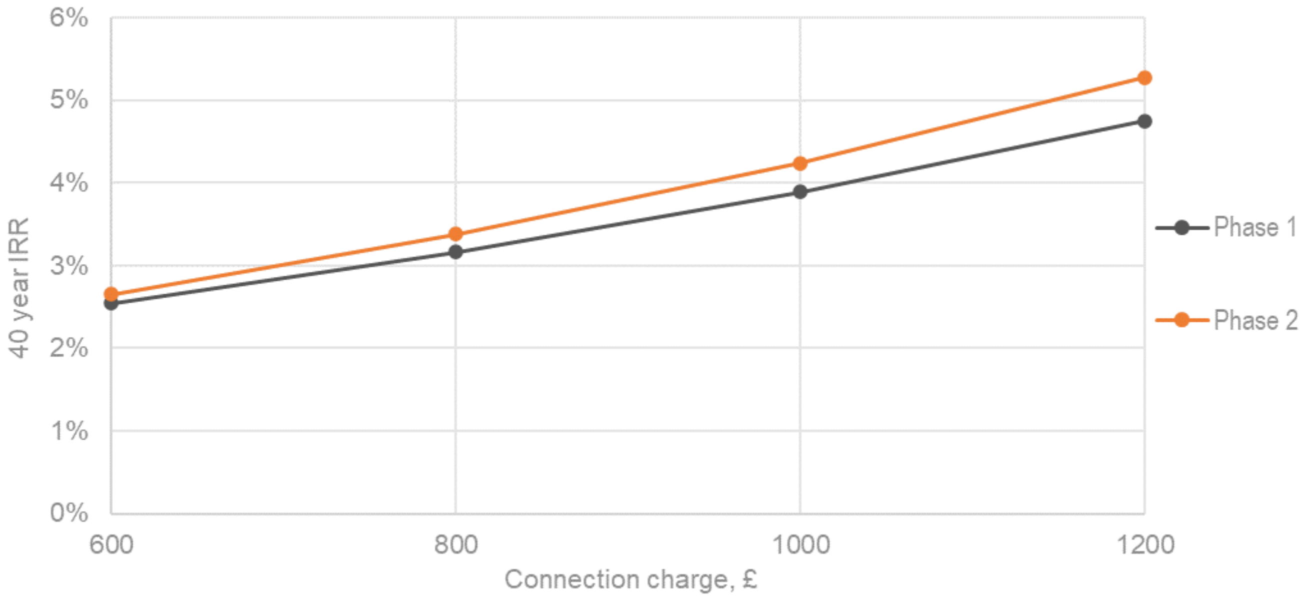

Figure 41: Impact of variance of connection charge

Table 27: 40-year IRR change for different connection charges

Connection charge, £/kW	Phase 1	Phase 2
£600	2.6%	2.7%
£800	3.2%	3.4%
£1,000	3.9%	4.2%
£1,200	4.7%	5.3%

11 RISKS AND ISSUES

The main risks and issues for the shortlisted options have been considered and assessed. Table 29 outlines key potential risks and issues that apply to the network, including both current risk and re-scored values.

Risk ratings are the product of impact and likelihood. The impact measures the effect of the risk being realised, and the likelihood measures the probability of the risk being realised. The current risk rating is the level of risk present if no further action is taken, and the re-scored risk rating is a measure of the risk present following mitigating measures.

A key showing the level of risk is shown in Table 28.

Table 28: Risk key level

Impact	1	Insignificant
	2	Minor
	3	Moderate
	4	Major
	5	Catastrophic
Likelihood	1	Highly unlikely, but may occur in exceptional circumstances
	2	Not expected, but a slight possibility it may occur
	3	Might occur at some time
	4	There is a strong possibility of occurrence
	5	Very likely, expected to occur
Risk rating	0-5	**Low risk**
	6-14	**Medium risk**
	15-25	**High risk**

Table 29: Risk register

	Risk / issue	Risk rating			Rationale	Mitigating measure / action
		Impact	Likelihood	Rating		
Energy demand	**ED1** Energy demands for some planned developments based on information that may change.	Risk rating: 3	4	12	Energy demands for some planned developments have been based on very high level information that is likely to change as development plans are progressed.	Energy demands for all planned developments have been estimated based on the most recent information available. Energy demands should be re-assessed as development plans progress and if development plans change.
		Mitigated risk rating: 3	3	9		
Energy demand	**ED2** Where organisations were unresponsive, or not open to consultation, actual heat demands have not been obtained.	Risk rating: 2	4	8	Obtaining robust energy demands for expected key heat loads is important in providing accurate conclusions on project viability and the extent of the network. The majority of the heat demand arises from planned developments where metered energy data is not yet available.	Where energy data was not obtained, heat demands have been estimated using SE's extensive database of energy demands for similar sites. These have been calculated based on building footprint, number of storeys, building use and age of building.
		Mitigated risk rating: 2	3	6		
Energy demand	**ED3** Half hourly gas data not available for most connections.	Risk rating: 3	4	12	Building peak loads determine network pipe diameter requirements and heat demand profiles have a significant impact on technical and economic viability assessments of the proposed network.	The hourly, daily and annual heat demand of buildings has been modelled based on building use, occupancy / heating patterns and local temperature data. The consultant team has a database of hourly annual demand profiles for a wide range of building types, and these are used to provide and estimated heat demand profiles for buildings where half hourly data has not been obtained.
		Mitigated risk rating: 3	3	9		
Energy demand	**ED4** Potential heat connections do not connect / planned developments are not brought forward. This can cause network demands to change from those assessed.	Risk rating: 4	4	16	Volume risk is likely to sit with the network operator. Heat demand significantly impacts on network viability. If key existing buildings do not connect, or key planned developments are either not built out or are built out but do not connect, then this will reduce the viability of network options.	Engagement with key heat demand stakeholders should continue as the project progresses. LBE should continue to work with developers to convey the benefits of network connection and ensure planning requirements continue to drive network development, futureproofing, and connection through GLA's heat hierarchy. This is particularly important for the developers of the potential energy centre sites.
		Mitigated risk rating: 4	3	12		

	Risk / issue	Risk rating			Rationale	Mitigating measure / action
		Impact	Likelihood	Rating		
Energy demand	**ED5** Engagement with developers is not achieved and developments do not connect to network	Risk rating			If planned developments do not connect this would lead to a reduction in heat sales from the network. Key planned developments are the Perceval House Car Park and CP House planned developments which make up a significant proportion of the network heat demand.	Effective, continued engagement with developers is essential and the benefits of connecting new buildings to a network need to be made clear.
		2	3	6		
		Mitigated risk rating				
		2	2	4		
Energy centre	**EC1** Not securing suitable energy centre locations.	Risk rating			Networks are reliant on sufficient space for energy generation being available near key heat loads. Limited suitable alternative sites have been identified. A single town centre planned development energy centre is unlikely to have sufficient space for technologies to supply the phase 2 heat demand, as such an alternative or additional energy centre location will have to be identified.	Potential energy centre locations have been assessed and selected based on discussions with LBE. Potential alternative energy centre sites should continue to be assessed including other privately owned sites and development areas.
		5	4	20		
		Mitigated risk rating				
		5	4	20		
	EC2 A planned development energy centre is not brought forward in time.	Risk rating			If a suitable planned development energy centre is not brought forward in time to supply shorter term planned developments with heat then either additional temporary energy centres will be required or developers will install alternative heating plant. This could significantly impact network economics.	The construction of a planned development energy centre is dependent on the overbuild development being brought forward at the same time so the heat exchangers for the ASHPs can be located on the roof. Alternative energy centre sites should be further assessed that may be able to be brought forward sooner including other development plots within the town centre.
		5	4	20		
		Mitigated risk rating				
		5	4	20		
	EC3 Energy centre design does not allow for connection of potential future heat sources, meaning there is little futureproofing.	Risk rating			Consideration should be given to futureproofing to ensure the energy centre could connect to a large low carbon heat source, such as the planned data centres in Southall and/or the OPDC transmission main.	The current energy centre and network options include futureproofing to allow for connection to a future wider heat network with heat supplied from outside the town centre e.g. planned data centres in Southall.
		4	4	16		
		Mitigated risk rating				
		4	2	8		

	Risk / issue	Risk rating			Rationale	Mitigating measure / action
		Impact	Likelihood	Rating		
Energy centre	**EC4** The visual impact of the energy centres or heat exchangers is deemed significant.	Risk rating			If the visual impact was deemed significant, this could potentially increase design costs or limit the energy centre size.	Visual impact of the planned development energy centre is likely to be low as it proposed it is located within the ground floor or basement of the development. The visual impact of the heat exchangers on the roof is likely to be more significant depending on the height and proximity of surround development buildings. The visual impact of an additional or alternative energy centre location should be considered as sites are further assessment. The visual impact and any active frontage requirements should be further assessed and discussed with LBE as the project progresses and as development plans for potential energy centre sites are progressed.
		5	4	20		
		Mitigated risk rating				
		5	3	15		
	EC5 Heat pump working fluids require consideration.	Risk rating			R134a has a high GWP (global warming potential) and may increase in cost because of the Kigali amendment. If ammonia or HFOs are used, then there is a safety risk that needs to be mitigated through design and operation.	Refrigerant choice needs to be considered in design measures and risk assessments as the project progresses and specific heat pumps are selected.
		4	3	12		
		Mitigated risk rating				
		4	2	8		
Network	**N1** Network options presented do not allow connection of additional heat demands.	Risk rating			Network options should, where possible, include futureproofing to allow additional heat demands to connect in the future, otherwise long-term success of the network may be damaged. Consideration should therefore be given to futureproofing to ensure the network has the capacity to serve future network phases and planned developments.	Future potential energy loads have been identified and local plans considered to identify long term planned developments. Careful consideration has been given to futureproofing and efficient operation in the short and medium term. Planned developments should be continuously monitored as the project progresses. An extended phase 3 network has been identified but will required connection to an additional heat source from outside of the town centre area, such as the planned data centres in Southall and/or the OPDC transmission main.
		4	4	16		
		Mitigated risk rating				
		4	2	8		
	N2 Connections may be made up of multiple buildings with numerous decentralised plant rooms that may increase project	Risk rating			Multiple plant rooms can increase network length and significantly increase project CAPEX and network losses.	Where sites include multiple plant rooms, the network may need to be split between the primary networks and smaller secondary networks (buried, above ground or internal to buildings) that connect between a substation and groups of smaller buildings. The number of plant rooms for several of the existing buildings is unknown.
		4	4	16		
		Mitigated risk rating				
		4	3	12		

	Risk / issue	Risk rating			Rationale	Mitigating measure / action
		Impact	Likelihood	Rating		
	CAPEX and network losses.					
Network	**N3** Existing buildings are not district heat ready.	Risk rating			High return temperatures can significantly impact on the performance of networks, particularly for networks served by heat pumps. Heating system upgrades may be required for existing buildings, to ensure lower network return temperatures.	In the base case, it has been assumed that connections would cover the cost of any secondary side upgrades as these would be required (and more critical) for the installation of low carbon heating systems at the building level. Secondary side improvements and specific building return temperatures for existing sites should be further assessed as the project progresses.
		4	4	**16**		
		Mitigated risk rating				
		4	3	**12**		
	N4 Phase 3 connection to heat sources outside of the town centre.	Risk rating			The Phase 3 network will require an additional heat supply from outside of Ealing. Currently, the viable heat supply for Ealing Phase 3 would have to come from the planned data centres in Southall and/or the OPDC heat network.	The Southall heat network and OPDC design teams and potential network operators should be engaged as early as possible to allow them to identify the potential opportunities available in Ealing. Early engagement may also reduce the impact of the technical challenges associated with connecting Southall data centres and/or OPDC and Ealing Town Centre, providing more time for planning and engagement with relevant authorities.
		5	5	**25**		
		Mitigated risk rating				
		5	4	**20**		
Economic assessment	**EA1** Capital costs are significantly higher than estimated.	Risk rating			Higher capital costs can have a significant impact on the viability of all network phases. If the economic assessment does not include robust project CAPEX, the likely financial benefits or does not provide sufficient information to secure funding, then the network plan will not progress.	All project costs have been based on a combination of previous project experience and recent quotes for similar projects. The consultant team have a large database of actual costs of installing district energy schemes including costs for equipment supply and installation, distribution pipework supply and installation, trench excavation and re-instatement. Sensitivity analysis has been undertaken for network options to show the effect of a variance in capital costs, shown in section 10.2. Contingency has been applied to all CAPEX items.
		5	4	**20**		
		Mitigated risk rating				
		5	2	**10**		
	EA2 Variation in heat sales tariffs	Risk rating			A variation in the heat sales tariffs has a significant impact on the viability of all network options.	Heat sales tariffs have been based on the cost of the low carbon counterfactual i.e. ASHPs at each building connection.
		5	4	**20**		
		Mitigated risk rating				

	Risk / issue	Risk rating			Rationale	Mitigating measure / action
		Impact	Likelihood	Rating		
	significantly affects economics.	5	2	10		Sensitivity analysis has been undertaken to show the effect of heat sale tariff variation, shown in section 10.4.
	EA3 Variation in electricity import tariffs significantly affects economic viability.	Risk rating			Variation in electricity import tariffs have a significant impact on the viability of network options.	Import tariffs have been based on DESNZ price projections for the network start year (2030). Sensitivity analysis has been undertaken to show the effect of electricity import tariff variation, shown in section 10.4.
		5	4	20		
		Mitigated risk rating				
		5	3	15		
General	**G1** LBE senior stakeholders do not support the scheme and / or the scheme is not linked to corporate priorities.	Risk rating			There is a risk that LBE senior management and elected members will not fully support the project. If this is the case, then the whole project viability could be affected. Senior management and elected member engagement are key to advance the project further.	Meetings, and presentations have been delivered to discuss the objectives for the project to the LBE Town Centre Board. Further stakeholder engagement will be needed as the project progresses with more senior stakeholders within LBE.
		5	4	20		
		Mitigated risk rating				
		5	3	15		
	G2 Planned developments are brought forward prior to network development.	Risk rating			Developers may install alternative heating systems within planned developments if DHNs are not in place prior to construction.	The timing of planned developments has been estimated at a high level. Further discussions with LBE Planning and Regen teams and developers will be required as the project progresses to establish development timescales and to ensure the network is available for a day 1 connection.
		4	4	16		
		Mitigated risk rating				
		4	3	12		
	G3 Liaison between departments within LBE is critical for network development.	Risk rating			Engagement with departments within LBE, (including Highways, Property, Planning, Regen, etc.) is critical for network development to ensure energy centre locations and network routes are secured and safeguarded, to inform network design and to enable coordination of works.	Initial discussions have been undertaken with LBE regarding energy centre locations and planned development details. Ongoing engagement is critical as the project progressed and to feedback the results of this study.
		4	4	16		
		Mitigated risk rating				
		4	3	12		

12 CONCLUSIONS

The conclusions for the Ealing Town Centre Feasibility Study are outlined below.

Energy Demand Assessment

An energy demand assessment for Ealing has identified that Ealing Town Centre is a heat-dense area. Most of the proposed network connections in the first phase are privately owned commercial buildings. The largest heat demand identified from phase 1 connections is Ealing Broadway. Later phases will connect to a significant number of privately owned sites, including several planned development sites. For the full phase 2 network, 87% of the Ealing Town Centre heat demand is from private sector buildings, and therefore significant stakeholder engagement will be required to connect these sites to the network.

Energy Supply Assessment

As a result of a long list appraisal, two potentially viable low-carbon solutions were shortlisted for further consideration. The shortlist consisted of a centralised ASHP LTHW network and a low-carbon counterfactual of individual ASHPs at the building level. The LTHW network was identified as the prioritised option with a gas boiler for peak and reserve. Heat supply opportunities within the town centre are limited. However, several low carbon heat sources have been identified outside of the assessment area, including two data centres planned in the Southall area, to the west, as well as numerous data centres supplying the Old Oak and Park Royal Development Corporation (OPDC) heat network to the east that could expand in future to connect to the town centre. Future connection to the data centres to utilise the waste heat could lead to wider scale decarbonisation throughout the borough.

Potential energy centre locations have been assessed and selected based on discussions with LBE. A number of town centre development sites were identified as the potential energy centre locations for the LTHW Network based on proximity to heat demands, the final selection of which will depend on technical and commercial risks such as development timings. The energy centre has been designed for a 2.8 MW ASHP to supply the Ealing town centre network from phase 1. An additional energy centre from the Ealing planned development sites or heat supply outside Ealing Town Centre will be required for Phase 2 network expansion.

Network Assessment

Potential network barriers and constraints were assessed, and network route selection methodology also involved consideration of linear heat density (heat demand divided by pipe trench length). Key network constraints include road congestion along New Broadway/Uxbridge road, bridge crossings, and areas of congested utilities. The proposed LTHW Network includes two phases as shown in Table 30.

Table 30: Network summary

	Phase 1	Phase 2	Total
Heat network length, m	2,148	1,017	3,165
Total heat demand, MWh	14,161	9,142	23,303
Peak heat demand (diversified), MW	7.2	5.9	13.1
Assumed network date	2030	2033	
Total no. connections	14	13	27
Network linear heat density, MWh/m	6.6	9.0	7.4

Concept Design

Numerous technology sizing scenarios were assessed to determine the optimal heat pump and thermal store for each network phase. The optimised solution includes a 2,800 kW ASHP and 50,000 litres of thermal storage for phase 1, and an additional 2,200 kW ASHP and 30,000 litres of thermal storage for phase 2. The phase 1 energy centre will require a footprint of 400 m² and will be located in one of the town centre development sites. The scheme will also require peak and reserve boilers for times of peak demand (e.g., during the coldest weather) or when the heat pump is not operational. The phase 2 energy centre is assumed to be built within another of the planned development connections, but could be incorporated within the phase 1 energy centre, if sufficient space is available at the energy centre location.

Future network expansion will likely require additional energy centres and low carbon technology from outside of town centre e.g. the planned data centres in Southall and/or the OPDC network.

A separate study high level heat mapping study has been undertaken for the Southall area. The purpose of this study was to provide the LBE planning team with an evidence base to justify the requirement for heat offtake from the planned data centres in Southall. The results of the study indicate that there is sufficient heat demand in Southall and neighbouring areas (including the town centre) that could benefit from connection to a heat network supplied by heat offtake from data centres. However, further assessment of the heat offtake connection and potential for a heat network in Southall is required. This work is provided in Appendix 9: Southall Data Centre Planning Note.

If the timeframe permits and the solution is proven economically viable, the Southall data centres / OPDC network could potentially connect to the Ealing Town Centre Network from phase 2. This should be further assessed as the project progresses. Electric peak and reserve boilers could replace the gas boilers in the future to further decarbonise the network.

To ensure heat network losses are kept below 10%, and to effectively serve a combination of new build developments and existing buildings with varying secondary systems, the heat network will need to operate in variable temperature conditions. The primary heat network will provide heat via plate heat exchangers which means the flow temperature from the energy centre into the primary network will be circa 70°C during the majority of operation.

Pipe sizing has been carried out to determine the characteristics and sizing for each part of the network with the aim of minimising the pumping energy costs and heat losses in the network. The heat network has been designed as a pre-insulated rigid steel pipe system.

Economics

A TEM was constructed to assess the economics of Phase 1 and 2 of the Ealing Town Centre Network. The model allows key variables to be revised and the associated impact assessed. The 40-year economics and CO_2e savings for each network phase are summarised in Table 30. A conservative connection charge of £600/kW has been included in the base case assessment. However, during a short soft market testing exercise it was suggested connection charges for the Ealing Town Centre Network could be £1,000/kW. The 40-year IRR for this higher connection charge has also been included in the table below. Figures shown include previous phases. There is potential for the scheme to be supported through GHNF.

Table 31: Economic and carbon saving summary of network

	Phase 1	Phase 2
Cumulative capital costs (incl. contingency), £	£21,635,190	£34,223,674
40-year IRR	2.6%	2.7%
40-year NPV	-£2,249,115	-£2,826,142
40-year social IRR	9.2%	9.8%
Lifetime carbon savings (40 years), tCO_2e	63,038	123,478
40-year IRR (£1,000/kW connection charge)	3.9%	4.2%
40-year IRR with grant funding	16.0%	14.3%

Sensitivity and Risk

Key sensitivity parameters for the prioritised network areas include:

- Capital costs
- Network heat demand and key sites not connecting and key developments not being brought forward
- Energy tariffs including heat sales tariffs, energy centre electricity purchase tariffs and energy tariff indexing
- Heat pump SPF

Key risks for the networks include:

- Securing the energy centre location in Ealing town centre
- Requirement for additional heat sources/supply for phase 2 expansion
- Coordination of network timing with planned developments

Summary and Next Steps

It is likely that this scheme will be economic if GHNF can be secured and will deliver the required project benefits. The network will offer benefits to the Ealing Town Centre area including significant reductions in CO_2e emissions, reduction in electricity capacity and grid infrastructure upgrades for new developments compared to the counterfactual of individual ASHPs, potential for lower cost decarbonsiation, potential to utilise waste heat sources such as from data centres, and education opportunities. However, the network is reliant on securing a suitable energy centre site and coordination with planned developments. Future expansion and widespread decarbonisation of the town centre and wider borough can be achieved through connection to waste heat offtake from data centres in the Southall area.

If the project is to be progressed, the key next steps include:

- Present the findings of the report to relevant stakeholders including LBE senior staff and elected members
- Undertake detailed techno-economic feasibility study for the Southall area assessing the potential to utilise waste heat from the planned data centres in the area and potential expansion to serve the Ealing Town Centre heat network in the longer term
- Undertake soft market testing with a selection of investors in the heat networks market, to provide LBE with useful feedback on the viability of the scheme from a private sector perspective and provide insight on how investible and deliverable the project is in its current proposed structure and solution
- Undertake a commercial workshop with commercial advisors and senior staff within LBE to identify the preferred delivery vehicle and procurement route for an Ealing heat network scheme, along with the associated levels of control, risks, and a mitigation plan if needed
- Continue discussions with developers to secure a development site energy centre

Ongoing next steps include:

- Continued engagement with the planning officers and developers to coordinate with planned development sites and safeguard land for network route
- Consider applying to GHNF for commercialisation and construction funding
- Continued engagement with building owners to ensure connection to the network

13 NEXT STEPS AND RECOMMENDATIONS

Table 32: Next steps and recommendations

	Action	Responsibility	Timing		
			<6m	6m-2yr	>2yr
General	Ensure the technical and economic work undertaken in this study will provide an evidence base for planning policy	Project team			
	Present the findings of the report to relevant stakeholders including LBE senior staff and elected members. Consider the conclusions to determine whether to progress study to next stage				
	Undertake soft market testing with investors in the heat networks market, to provide the Council with useful feedback on the viability of the scheme from a private sector perspective				
	Hold commercial workshop with senior stakeholders within LBE to identify preferred delivery structure and procurement routes for the scheme				
	Consider applying to GHNF for commercialisation funding, including engaging with GHNF fund team to fully understand requirements and ensure a robust grant funding bid is submitted				
	Ensure LBE planners are equipped to guide developers and maximise benefits of connecting to the network and ensure early engagement				
Heat demand	Update energy assessment if actual energy data is available for any additional existing sites details become available or if development plans change				
	Update energy assessment if further details become available for new developments in the Ealing town centre area				
	Further assessment of network timing in line with planned developments and connection of existing buildings				
	Continued engagement with developers to secure day 1 connection				
EC / heat source	Work with Local Authority planners to safeguard energy centre site within Ealing town centre				
	Work with Planning and Regen teams to ensure network is developed in coordination with a planned development energy centre				
	Further assess heat resource at Redwire data centre, Southall data centres, and OPDC heat network to deliver heat to the town centre network in later phases				
	Engage with developers and LBE planners to explore the potential for additional energy centres to be located within developments to allow for expansion of the network in phase 2				

	Action	Responsibility	Timing		
			<6m	6m-2yr	>2yr
	Engage with planning officers to identify requirements for dispersion modelling for the gas boilers and identify any potential visual impact of the energy centre				
Network					
	Liaise with local highways, structures, and planning and utilities companies to assess any changes and refine network route				
	Engage with network connections to communicate potential requirements for heating system upgrades for Ambient Network.				
	Continued engagement with Planning and Regen teams to ensure any new developments are DH ready, including safeguarding network routes and potential energy centre locations	Project team			
	Confirmation of network design and installation strategy				
	Once project timeline established, further investigate technology sizing and phasing strategy				
Economics	Engage with utilities companies to obtain quoted import tariffs for gas and electricity				
	Engage with DNOs to obtain gas and electricity connection costs for the energy centre				

APPENDIX 1: ENERGY DEMAND ASSESSMENT

Table 33: Summary of all energy loads

Site name	Ownership	Building use	Annual heat demand, MWh	Source of heat data	Annual cooling demand, MWh	Source of cooling data, MWh
Perceval House	LBE	Offices	1,244,900	Actual metered data	430,920	Estimated using Cooling Demand Model
Westside Young Peoples Centre	LBE	Sports and recreation	85,855	Estimated using data from similar sites	25,998	
Ealing Alternative Provision	Other public sector	Education	116,134		-	
Carmelita House	LBE	Offices	122,890	Actual metered data	44,388	
Hanwell Children's Centre	LBE	Education	123,179		-	
Ealing Central Library	LBE	Public buildings	198,268	Estimated using data from similar sites	-	
Bakers House + Wells House	Social housing	Residential	662,711	Actual metered data	-	
Broughton Court	Social housing	Residential	1,176,580		-	
University of West London	Other public sector	Education	2,692,991	Actual DEC data	-	
Premier Inn	Private sector	Hospitality and entertainment	774,977	Estimated using data from similar sites	131,766	
Ibis Styles	Private sector	Hospitality and entertainment	504,641		85,802	
Travelodge	Private sector	Hospitality and entertainment	418,553		70,980	
Marks and Spencer	Private sector	Retail	613,825		270,102	
Hilton	Private sector	Hospitality and entertainment	881,449		149,885	
Ealing Gateway	Private sector	Offices	845,661		205,049	
Arc Tower	Private sector	Residential	677,787		-	
The Arcadia Centre	Planned development	Retail	734,622		179,485	
Ealing Studios	Private sector	Offices	466,919		136,728	
Ealing Broadway	Private sector	Retail	4,065,122		1,570,416	
Ealing Cross	Private sector	Offices	978,032		311,191	
Craven House	Private sector	Offices	597,059	Estimated using data from similar sites	112,536	

Site name	Ownership	Building use	Annual heat demand, MWh	Source of heat data	Annual cooling demand, MWh	Source of cooling data, MWh
Cavalier House	Private sector	Residential	690,989	Estimated using data from similar sites	-	Estimated using Cooling Demand Model
CP House	Planned development	Offices	1,964,451	Estimated using data from similar sites	103,680	Estimated using Cooling Demand Model
84 Uxbridge Road	Private sector	Offices	302,956	Estimated using data from similar sites	56,894	Estimated using Cooling Demand Model
Freedom House	Private sector	Residential	402,868	Estimated using data from similar sites	-	Estimated using Cooling Demand Model
Filmworks	Private sector	Mixed use	2,345,812	Estimated using data from similar sites	-	Estimated using Cooling Demand Model
Christ the Saviour CoE School	Other public sector	Education	469,269	Actual DEC data	-	Estimated using Cooling Demand Model
Ealing Aurora	Private sector	Offices	926,774	Estimated using data from similar sites	155,844	Estimated using Cooling Demand Model
Waitrose	Planned development	Mixed use	2,340,337	Estimated using data from similar sites	-	Estimated using Cooling Demand Model
Luminosity Court	Private sector	Residential	419,127	Estimated using data from similar sites	-	Estimated using Cooling Demand Model
Jobplus Centre	Other public sector	Offices	257,421	Estimated using data from similar sites	43,157	Estimated using Cooling Demand Model
A2 Dominion	Private sector	Offices	318,383	Estimated using data from similar sites	58,903	Estimated using Cooling Demand Model
Hotel Xanadu	Private sector	Hospitality and entertainment	265,522	Estimated using data from similar sites	44,912	Estimated using Cooling Demand Model
Mattock Lane Health Centre	NHS	Healthcare	259,890	Actual DEC data	31,990	Estimated using Cooling Demand Model
Dickens Yard	Private sector	Mixed use	4,260,383	Estimated using data from similar sites	-	Estimated using Cooling Demand Model
Ealing Fire Station	Other public sector	Offices	201,993	Actual DEC data	15,142	Estimated using Cooling Demand Model
Ealing National Spiritualist Church	Other public sector	Public buildings	63,180	Estimated using data from similar sites	-	Estimated using Cooling Demand Model
Ealing Village	Social housing	Residential	1,003,162	Estimated using data from similar sites	-	Estimated using Cooling Demand Model
Ellen Wilkinson School	Other public sector	Education	1,193,380	Actual DEC data	-	Estimated using Cooling Demand Model
Ealing Police Station	Other public sector	Public buildings	1,600,000	Actual DEC data	-	Estimated using Cooling Demand Model
The Questors Theatre	Private sector	Hospitality and entertainment	321,000	Estimated using data from similar sites	70,138	Estimated using Cooling Demand Model
Green Man Lane	Private sector	Mixed use	2,446,203	Estimated using data from similar sites	-	Estimated using Cooling Demand Model
Drayton Green Primary School	LBE	Education	400,000	Actual DEC data	-	Estimated using Cooling Demand Model
Christ the Saviour CoE School - Grove Site	Other public sector	Education	131,716	Actual DEC data	-	Estimated using Cooling Demand Model
Ealing Green College	Other public sector	Education	380,207	Actual DEC data	-	Estimated using Cooling Demand Model
Pizhanger Manor House and Gallery	Other public sector	Hospitality and entertainment	299,608	Estimated using data from similar sites	47,585	Estimated using Cooling Demand Model

Site name	Ownership	Building use	Annual heat demand, MWh	Source of heat data	Annual cooling demand, MWh	Source of cooling data, MWh
Drayton Manor High School	Other public sector	Education	714,610	Actual DEC data	-	Estimated using Cooling Demand Model
Hobbayne Primary School	LBE	Education	400,513		-	
Springhallow School	LBE	Education	325,473		-	
St Joseph's Catholic Primary School	Other public sector	Education	252,912		-	
St Ann's School	Other public sector	Education	227,540		-	
St Mark's Primary School	LBE	Education	296,591		-	
Central Studios - Homes for Students	Private sector	Education	149,169	Estimated using data from similar sites	-	
Hyde House	Private sector	Residential	727,602		-	
Dean Gardens	Private sector	Residential	161,617		-	
Broadway Connection	Planned development	Offices	989,639	Estimated using Heat Demand Model	372,133	
1A The Mall	Planned development	Residential	109,900	Estimated using data from similar sites	-	
Ealing Town Hall	Planned development	Hospitality and entertainment	1,073,279	Estimated using Heat Demand Model	214,085	
Perceval House Car Park	Planned development	Residential	771,926	Estimated using data from similar sites	-	
Exchange Plaza	Planned development	Offices	1,711,793	Estimated using Heat Demand Model	194,545	
Dawley House	Planned development	Hospitality and entertainment	1,370,121	Estimated using data from similar sites	97,870	
42 Hastings Road	Planned development	Residential	381,036		-	
96-102 Broadway	Planned development	Residential	568,487	Estimated using data from similar sites	-	
99-113 Broadway	Planned development	Residential	602,670		-	
131 Broadway	Planned development	Residential	352,185		-	
75 Boston Road	Private sector	Residential	1,334,865		-	
Northcote Avenue	Social housing	Residential	308,788		-	
Hawthorne Court	Social housing	Residential	195,470		-	
Gardenia Court	Social housing	Residential	219,814		-	
Benjamin Court	Social housing	Residential	368,846	Actual metered data	-	
Walpole Close	Social housing	Residential	407,937		-	

Site name	Ownership	Building use	Annual heat demand, MWh	Source of heat data	Annual cooling demand, MWh	Source of cooling data, MWh
St Marys Court	Social housing	Residential	150,932	Estimated using data from similar sites	-	Estimated using Cooling Demand Model
Sherwood Close	Planned development	Residential	540,384		-	
Rome/Castle House	Private sector	Residential	975,306		-	
Dominion/Sinclair House	Private sector	Residential	541,127		-	
Sainsburys	Planned development	Mixed use	1,575,881		-	
Chignell Place	Planned development	Residential	237,341		-	
Longfield House	Private sector	Residential	473,327		-	
Christ the Saviour Church	Other public sector	Public buildings	156,160		-	
St Johns Church	Other public sector	Public buildings	189,688		-	
West London Islamic Centre	Other public sector	Public buildings	601,699		-	
Sandringham Mews	Planned development	Residential	903,369		-	
66-86 Broadway	Planned development	Residential	261,946		-	
Ealing Hospital Main Building	NHS	Healthcare	11,553,186	Actual DEC data	1,103,544	
Bruce Court	Private sector	Residential	196,436	Estimated using data from similar sites	-	
Met Film School	Private sector	Education	917,816		-	
South Ealing YMCA	Private sector	Hospitality and entertainment	610,603		-	
Eastern Gateway	Planned development	Residential	471,420		-	
59-65 Broadway	Planned development	Residential	204,352		-	
Three Bridges Medium Secure Unit	NHS	Healthcare	1,511,946	Actual DEC data	159,862	
St Bernard's Wing (Ealing Hospital)	NHS	Healthcare	4,138,263		989,193	
Acton Sidings	Planned development	Residential	19,580,000	Estimated using data from similar sites	-	
West Acton Primary School	LBE	Education	420,168	Actual DEC data	-	
Horn Lane	Planned development	Residential	540,384	Estimated using data from similar sites	-	

APPENDIX 2: BOREHOLE ASSESSMENT

A summary of the borehole assessment for the network area is shown in Table 34 and Figure 42.

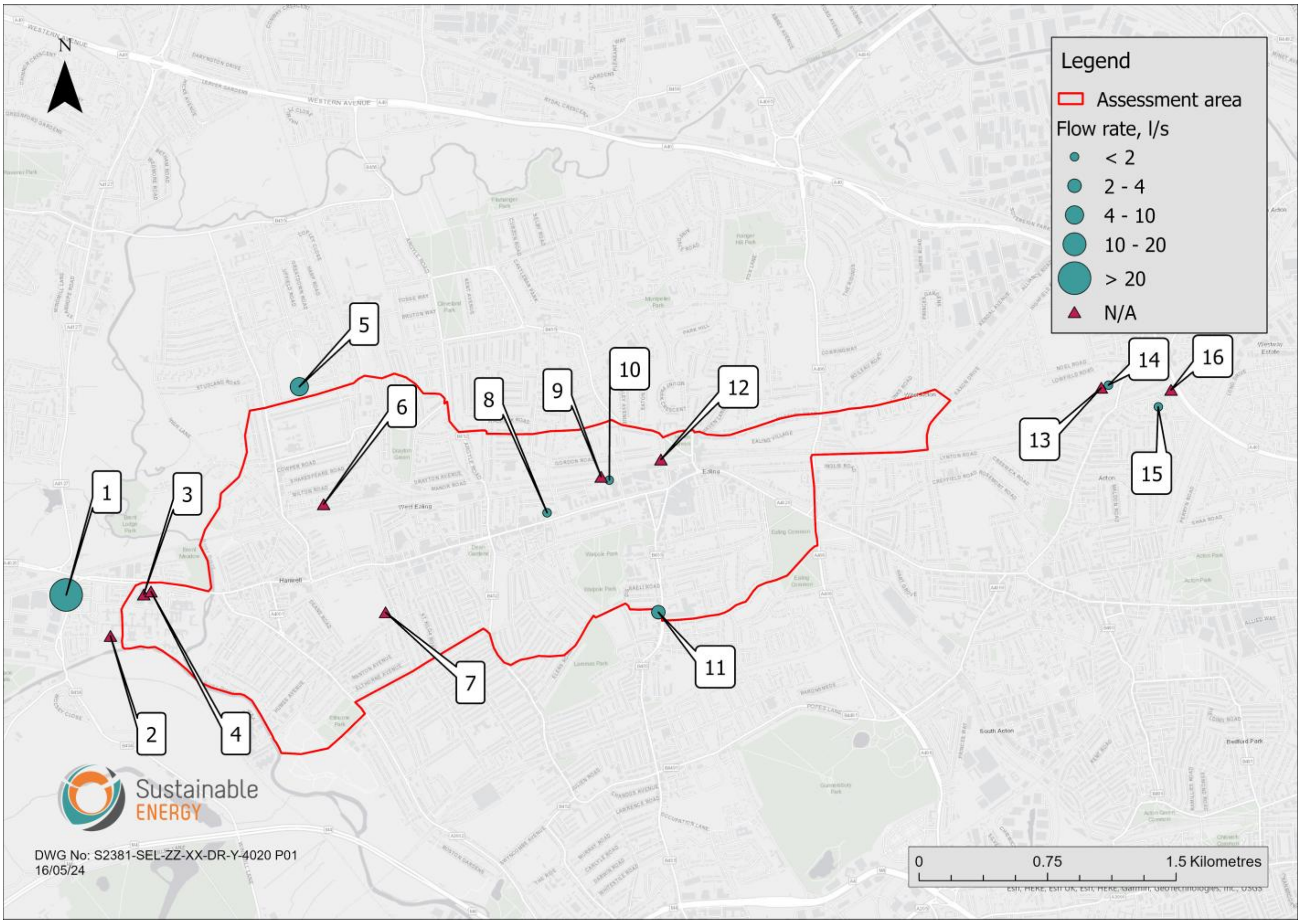

Figure 42: Borehole assessment

Table 34: Ealing borehole records

Map Ref.	Borehole name	Depth, m	Water depth, m	Flowrate, l/s	Dates
1	TQ18SW33 – WINDMILL LANE	182.89	48.15	22.19	1946
2	TQ17NW138 – HANWELL HOSPITAL	97.54	N/A	N/A	1842
3	TQ18SW146 - KING EDWARD MEMORIAL HOSPITAL 28	12.19	N/A	N/A	1964
4	TQ18SW143 - KING EDWARD MEMORIAL HOSPITAL 25	21.33	N/A	N/A	1964
5	TQ18SE1 - CENTRAL LONDON DISTRICT SCHOOL EALING	79.24	N/A	7.58	1856
6	TQ18SE31 - G.L.C. TENNYSON ROAD EALING BH4	15.24	N/A	N/A	1969
7	TQ18SE83 - MESSRS OSBOURNE LAUNDRY	121.92	10.06	N/A	1914
8	TQ18SE2 - WEST EALING LAUNDRY	129.54	18.29	0.12	1909

Map Ref.	Borehole name	Depth, m	Water depth, m	Flowrate, l/s	Dates
9	TQ18SE224 - UXBRIDGE RD EALING BH6	25	N/A	N/A	1979
10	TQ18SE147 - LONGFIELD AVENUE, EALING	183.25	10.97	0.06	1882
11	TQ17NE8 - RAINES & CO ST MARYS ROAD	137.16	23.47	3.16	1910
12	TQ18SE25 - EALING BROADWAY CAR PARK BH2	10.66	N/A	N/A	1961
13	TQ28SW662 - HORN LANE	170	47.53	N/A	2006
14	TQ28SW646 - ACTON CONCRETE PLANT	174	N/A	0.56	2005
15	TQ28SW320 - WALLS SAUSAGES THE FRIARY ACTON	180.75	N/A	0.88	1928
16	TQ28SW519 - FRIARS PLACE, EAST ACTON	106.68	N/A	N/A	1889

APPENDIX 3: TECHNOLOGY SIZING

Energy generation technologies are assessed using in house software that has been developed to allow detailed sizing of plant and thermal storage, modelling of operating parameters and conditions, financial assessment, and sensitivity analysis. The software utilises hourly network demands for each day of the year and considers hourly energy outputs from low carbon technologies, thermal storage and peak and reserve plant considering modulation limits, efficiencies and plant down time for maintenance. A range of plant and thermal store sizes and number of units are assessed and optimised to ensure key operating and financial/investment criteria are met.

The tools consider:

- Heat demand that can be served by the plant
- Thermal storage – used to supply heat loads below modulation limits or peaks above plant capacity and minimise plant firing e.g. for heat pump, store size will be modelled, optimised and cost/benefit analysis conducted to consider the optimum operating strategy for heat generation
- Supply strategy – consideration of issues such as varying seasonal or diurnal operation, continuous operation, modulated or full output, primary energy source or base load only and peak and reserve plant requirement
- Peak and reserve boiler sizing – according to the diversified peak demand of the various network phases, predicted operating requirements and redundancy
- Peak supply and minimum load – this will consider plant modulation limits and the number of units
- Carbon savings – these will be calculated against the 'business as usual' case and include annual and lifetime savings based on the most up to date DESNZ carbon emissions projections

Where heat pumps have been included, these have been sized based on network heat demand and have been maximised to provide the greatest economic and CO_2e savings for the network option and to provide the optimum balance between heat generation capacity, capital cost, maintenance costs and physical size.

The heat pumps and thermal stores have been sized with consideration of the hourly annual network heat demand. Peak and reserve boilers will meet any remaining demand. Technology sizing is based on an iterative process within the technical model to identify the optimal balance of the priorities.

Figure 43 shows the output from our technology sizing tool for the phase 2 network served by 5 MW heat pumps. The load duration curve shows the heat demand for every hour of a year, ordered from highest to lowest. The grey line shows the total low carbon and renewable capacity installed in the energy centre. The heat demand above the grey line is met by thermal storage and peak and reserve boilers.

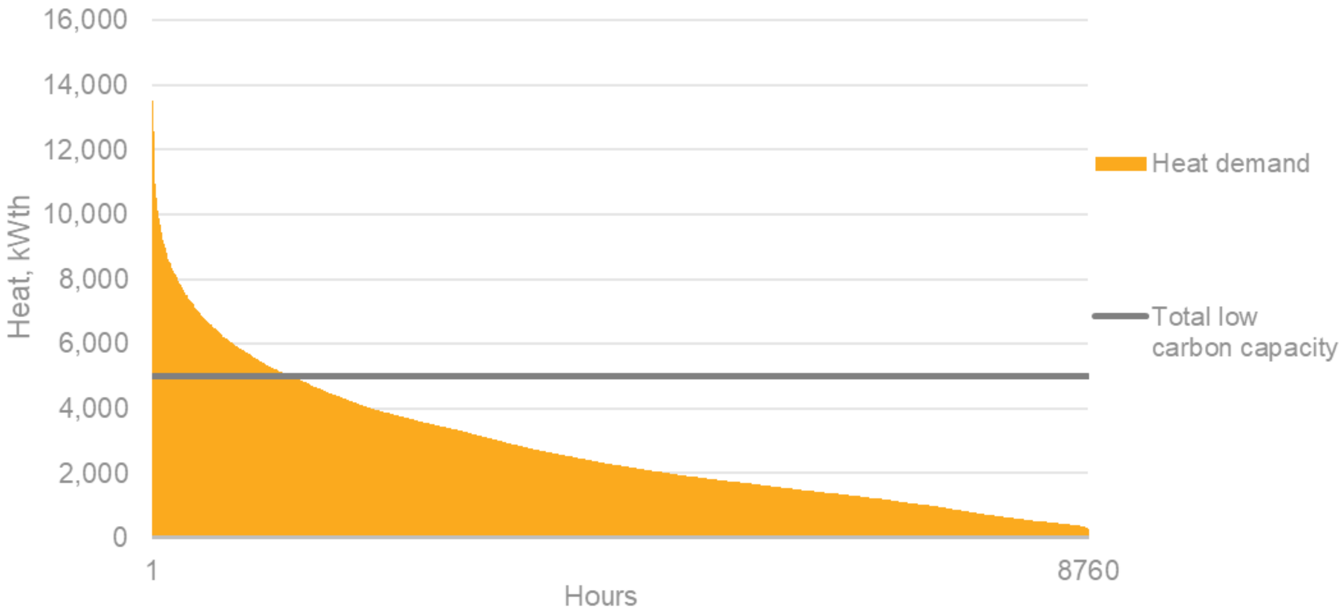

Figure 43: Load duration curve for example network

Figure 44 shows the proportion of the heat demand supplied by the heat pump, charge and depletion of the thermal store and heat demand supplied by peak and reserve boilers for the fully built network for 1st and 2nd Jan. The heat pump and thermal stores meet the majority of the baseload heat demand with a small proportion of the demand met by peak and reserve boilers. When possible, the thermal store is charged when the heat demand of the network is lower than the heat pump capacity, as shown in Figure 44.

Thermal stores have been sized based on hourly network heat demand, heat pump capacities, modulation limits and capital costs. The thermal store provides significant benefits at times of peak network demand and when heat generation is restricted by modulation limits.

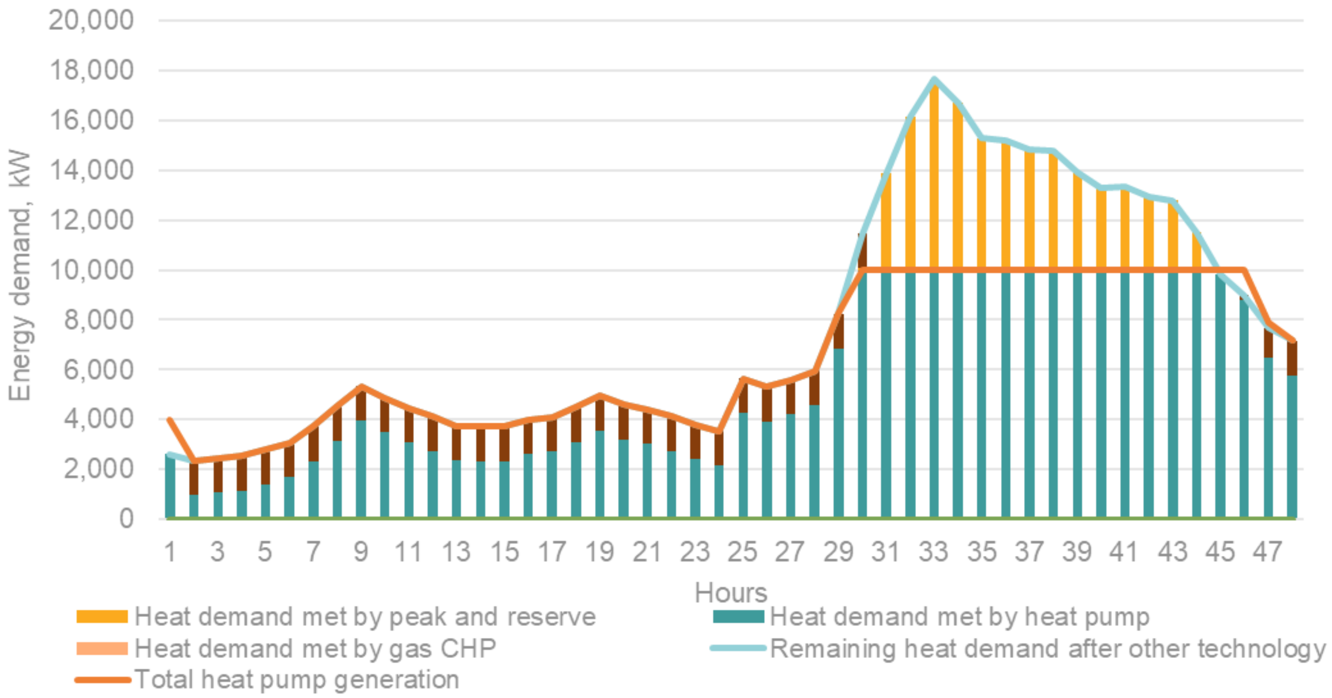

Figure 44: Heat generation 1st and 2nd Jan

APPENDIX 4: NETWORK CONSTRAINTS

A summary of network constraints are shown in Table 50 and Table 35. The utilities map for the Town Centre is shown in Figure 45.

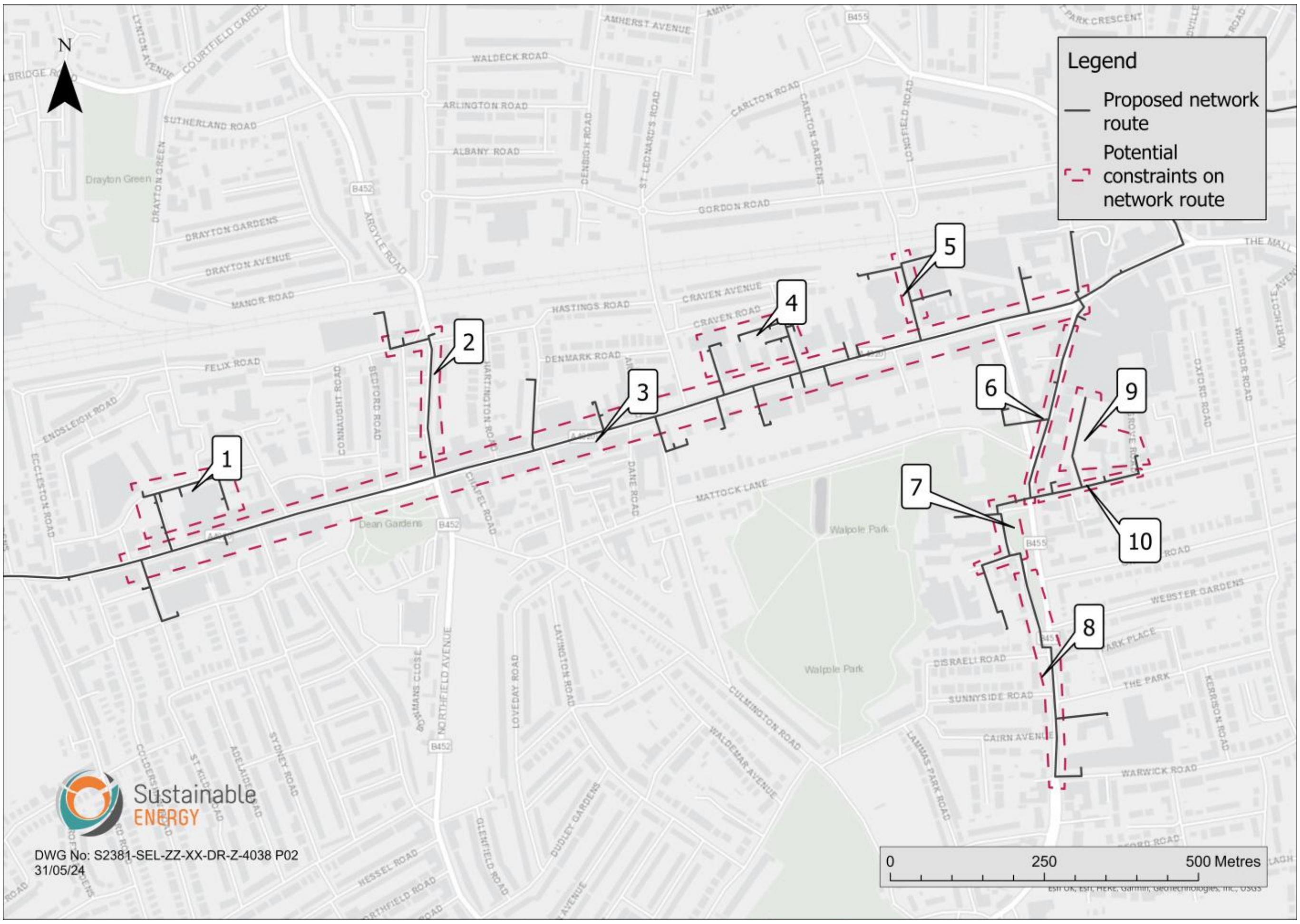

Figure 45: General network route constraints

Table 35: Network constraint details

Map ref	Location name	Potential constraint(s)	Constraint image(s)
1	Green Man Lane	• Thames Water foul sewer along length of Singapore Road • Thames Water distribution main along length of Singapore Road • Cadent LP gas main along length of Singapore Road • SSEN LV mains along length of Singapore Road • SSEN 2-3.3 kV along length of Singapore Road	
2	B452 and Alexandria Road	• Thames Water foul sewer along the length of B452 and Alexandria Road • Cadent MP gas mains along the length of B452 • Cadent LP gas mains along length of B452 and Alexandria Road • SSEN LV mains along the length of B452 • SSEN 2-3.3 kV along the length of Alexandria Road	
3	Uxbridge Road	• Busy 2-lane road, with an eastward bus lane and westward painted cycle lane along a stretch from Ealing Broadway shopping centre to the intersection with St Leonard's Road • 2x Thames Water surface water sewer along length • Thames Water foul sewer along length • 3x Thames Water distribution main along length • Thames Water trunk main along length • 2x Cadent MP gas mains along length • 2x Cadent LP gas mains along length • Proposed Fulcrum MP and LP gas mains, along section of road exact extent unclear • 2x SSEN LV mains along length • 2x SSEN fibre optic cables along stretch from Ealing Broadway to intersection with Craven Road	

Map ref	Location name	Potential constraint(s)	Constraint image(s)
4	Craven Road	• Thames Water foul sewer along Craven Road • Thames Water distribution main along Craven Road • Cadent LP gas mains along Cadent Road • SSEN LV mains along Craven Road • 2x SSEN fibre optic cables along length	
5	Longfield Avenue	• Thames Water surface water sewer along stretch past Perceval House • Thames Water distribution main along length • Thames Water trunk main along stretch past Perceval House • 2x Cadent LP gas mains along stretch past Perceval House dropping to one beyond Perceval House • SSEN LV mains along length • SSEN fibre optic cable along main	
6	B455 past Ealing Broadway	• 3x Thames Water surface water sewer along length • Thames Water foul sewer along the length • 2x Cadent LP gas mains past Broadway Mews, single LP main along rest of length • 2x SSEN LV mains along length	

Map ref	Location name	Potential constraint(s)	Constraint image(s)
7	Ealing Green College and Ealing Studios	• Thames Water foul sewer from Ealing Green College • Thames Water combined sewer from Ealing Studios • Thames Water distribution main along length • Cadent LP gas main connecting sites • SSEN LV mains connecting sites	
8	B455 towards University of West London	• 2x Thames Water combined sewer along length • 2x Thames water foul sewer along length • 3x Thames Water distribution main along length • 2x Thames Water trunk main along length • SSEN LV mains along length	
9	Ealing Broadway entrance	• Ramped entrance to car park, proposed heat network would pass underneath • Thames Water distribution main along length • Thames Water foul sewer along length • Cadent LP gas main along length	

Map ref	Location name	Potential constraint(s)	Constraint image(s)
10	The Grove	• 2x Thames Water distribution mains along length • Thames Water combined sewer • Thames Water foul sewer • Cadent LP gas main along length • 2x SSEN LV mains along length	

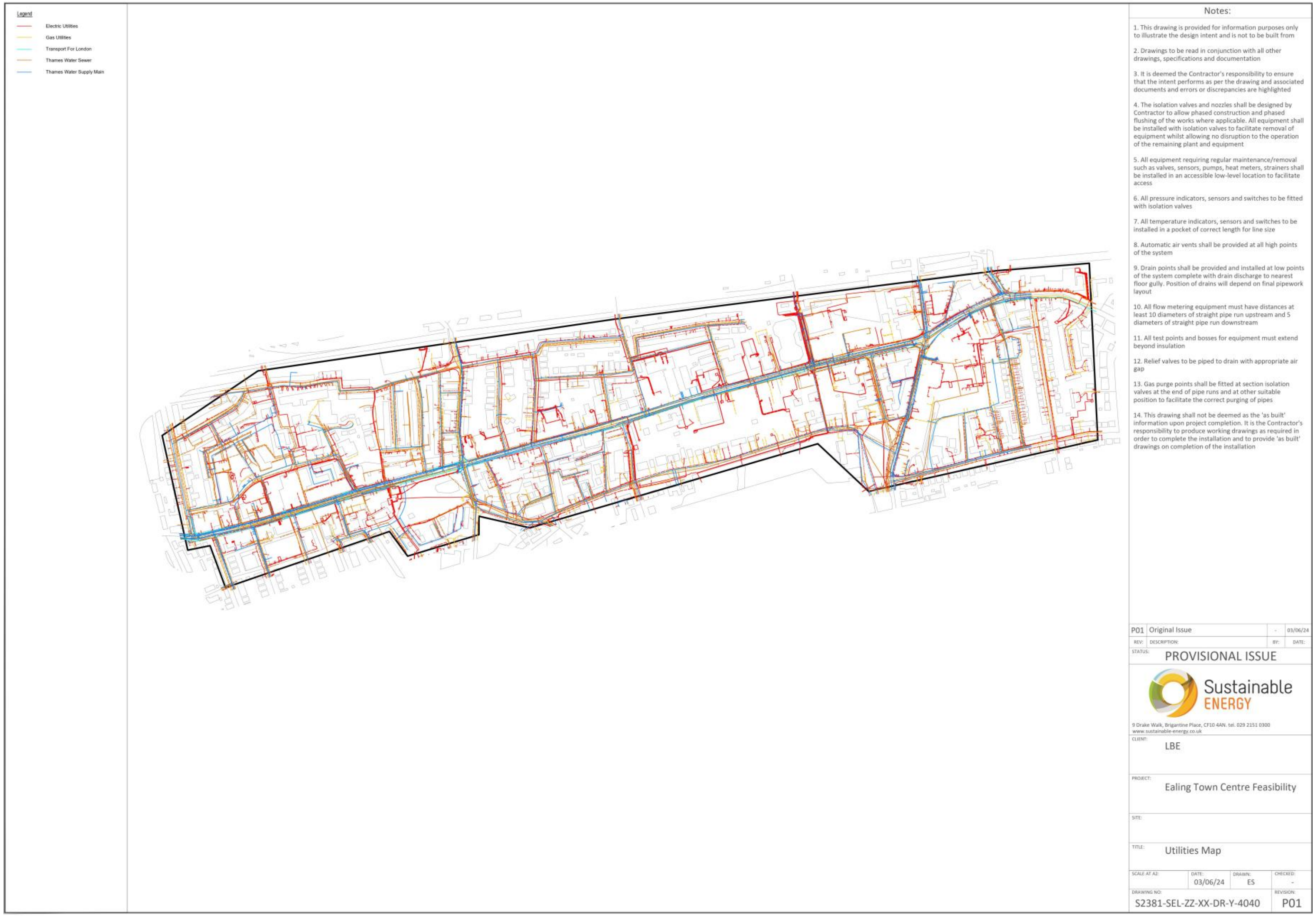

Figure 46: Utilities map for Ealing Town Centre

APPENDIX 5: HEAT PUMP REFRIGERANTS

There are advantages and disadvantages associated with different refrigerants and the choice of refrigerant in heat pumps can depend on a number of criteria including efficiency, required water temperatures and scale.

Most domestic scale heat pumps use synthetic refrigerants (HFCs) that have a high GWP meaning they have a considerable environmental impact when they leak. This impact can be two to three thousand times higher than CO_2. For this reason, the UK has committed to the Kigali amendment of the Montreal Protocol in January 2019 where we commit to cutting the production and consumption of HFCs by more than 80% over the next 30 years and replacing them with less damaging, ideally natural, alternatives.

The European Commission F-gas phase down states that by 2021-2023 the average GWP of refrigerants should be less than 900, and by 2030 the average GWP should be 400. The lifetime of chilling or heating plant is approximately 15-20 years. Therefore, plant installed now will require a GWP of less than 400, as otherwise by 2030, it will exceed the Kilgali Amendment phase down targets. Net zero CO_2e targets will also be affected by plant and equipment installed in buildings that contain powerful greenhouse gases. All new buildings should consider the lifetime impacts of the refrigerant as well as efficiency to reduce overall emissions of greenhouse gases. The main refrigerants used in commercially available heat pumps are summarised in Table 36 below:

Table 36: Refrigerants used in heat pump systems

Refrigerant	GWP	Type	Application	Considerations
R134a	1,430	HFC	Medium and large heat pump systems	• Higher efficiency than R410a but lower than ammonia • Low pressure and high volume requirements which result in higher CAPEX • Mainly used in split heating and cooling units
R410a	2,088	HFC	Domestic heat pumps and heat and cooling installations	• Can be used in low temperature systems • Lower volume requirements and resultant CAPEX than R134a • Lower efficiency than R134a
R32	675	HFC	Domestic heat pumps	• Relatively new refrigerant often used as a substitute for R410a • Mildly flammable and non-toxic • More efficient than R410a
R454c	146	Hydro -fluoro-olefin	Commercial and industrial refrigeration systems and domestic	• Suitable for low and medium temperature refrigeration systems • Mildly flammable
R600a/R600 (iso/butane	3	Natural refrigerant	Large heat pump and refrigerant installations	• Can provide temperatures higher than 80°C • Subject to strict safety requirements due to fire and explosion hazard
R290 (propane)	3	Natural refrigerant	Large heat pump systems and more recently a limited choice of domestic heat pumps	• Due to its low environmental impact and thermodynamic properties has started to be used in domestic heat pumps • Domestic heat pump systems higher cost than those utilising HFCs • Lower efficiency than R32 at higher temperatures in domestic models
R717 (ammonia)	0	Natural refrigerant	Large heat pump and refrigerant installations	• High efficiency

Refrigerant	GWP	Type	Application	Considerations
			in industrial environments	• Can provide temperatures of up to 80°C • Although non-flammable, it is subject to strict safety requirements as it is toxic and carries a strong odour
R744 (CO_2)	1	Natural refrigerant	Large heat pump and refrigerant installations	• Requires a maximum return temperature of 30°C, which limits its suitability in domestic heat pumps

APPENDIX 6: BUILDING CONNECTIONS – EXISTING HEATING SYSTEMS

Table 37 and Table 38 show examples of potential improvement measures for existing heating systems and hot water systems respectively. It has been assumed that all existing buildings currently have gas fired heating systems.

Table 37: Types of heating system

Heating system	Type	Flow temperature, °C	Return temperature, °C	Potential measures for improvements
Radiators	Traditional or cast iron	82	71	• Recommission flowrates • Rebalance radiator circuits • Replace radiators • Radiator connections to use 'top entry and opposite bottom exit' • Variable speed pumps • Pressure independent TRVs designed for low flow rates to be used • TRVs to be locked with maximum temperature setting of 22 °C • Remove any high bypass flows
	Typical flat panel	80	60/55	
	Retrofit - best practice	70	40	• Radiator connections to use 'top entry and opposite bottom exit' • Variable speed pumps • Pressure independent TRVs designed for low flow rates to be used
	New build – best practice	60	30	
Air handling unit (AHU)	Low surface area	82	71	• Upgrade fan coils to allow function on lower average temperatures • Ensure variable flow
	Best practice	80	60/55	
Underfloor heating	Standard	40	30	• The lower operating temperatures of under floor heating systems are advantageous for heat networks
Electric heating	All	See figures for best practice of chosen technology - typically 70 / 40 °C		• A wet system will need to be installed to connect to the district heating network • Install should be to best practice

Table 38: Types of hot water system

Hot water system	Type	Flow temperature, °C	Return temperature, °C	Potential measures for improvements
Calorifier	Internal coil	82	71	• Recommission flowrates • Use of constant temperature-controlled pumps • Replace heating coil with external plate heat exchanger - Heat exchanger over external plate provides greater performance and lower return temperatures
	External PHX	70	25	

Hot water system	Type	Flow temperature, °C	Return temperature, °C	Potential measures for improvements
				• Consider pre-heat heat exchanger of cold feed
Instantaneous hot water PHX		70	25	• The lower operating temperatures of instantaneous hot water systems are advantageous for heat networks
Direct fired hot water		N/A	N/A	• Replace with Instantaneous or semi-instantaneous

APPENDIX 7: KEY PARAMETERS AND ASSUMPTIONS

Energy Centre Tariffs

The energy tariff used in the Ealing Town Centre Network Techno-Economic Modelling assessment are shown in Table 39.

Table 39: Energy centre import tariff

Scenario	Gas unit rate, p/kWh	Gas standing charge, £/day	Energy centre electricity tariff, p/kWh
Ealing Town Centre Network	4.69	49.42	18.05

Key Technology Parameters

Key technology parameters for the network are shown in Table 40.

Table 40: Technical inputs

Parameter	Value	Source of data / assumption
SPF_{H1} for heat pump	Various	Varies for each network phase derived from manufacturers' performance curves based on the selected heat pump, assumed water conditions for the site and required network temperatures.
Peak and reserve boiler efficiency	90% gas 100% electric	Expected efficiency of new gas boilers based on the experience of the operating plant.

Technology replacement costs have been calculated on an annualised basis and take into account the expected lifetime of the technology, fractional repairs and the length of the business term. Plant/equipment lifetimes are shown in Table 41.

Table 41: Plant and equipment lifetime

Plant / equipment	Lifetime	Fractional repairs
Heat pumps	20 years	50%
Peak and reserve boilers	30 years	100%
Heat network customer-building connections	20 years	100%

Table 42: Energy centre building costs

Energy Centre, m^2	Cost, £/m^2
450	4000

DESNZ Energy Price Projections

The DESNZ fossil fuel price projections (central scenario) are shown in Table 43.

Table 43: DESNZ fossil fuel price projections

	Sector	Units	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
Electricity	Industrial	p/kWh	19.3	17.9	18.0	17.1	16.0	14.6	12.9	12.5	12.2	12.3	12.0	11.7	11.4	11.5	11.5	11.1
	Residential	p/kWh	32.6	35.5	32.9	30.2	28.9	26.8	25.6	24.6	24.1	23.2	22.7	22.2	21.7	22.0	21.5	21.2
	Services	p/kWh	20.3	19.3	19.6	18.8	17.6	16.2	14.5	14.2	13.9	13.9	13.5	13.1	12.6	12.8	12.8	12.3
Natural gas	Industrial	p/kWh	5.3	4.3	4.7	4.0	4.2	3.8	3.5	3.2	2.8	2.8	2.8	2.8	2.8	2.8	2.9	2.9
	Residential	p/kWh	8.6	9.5	7.6	7.9	7.0	7.1	6.7	6.3	6.0	5.6	5.6	5.6	5.6	5.6	5.5	5.5

	Sector	Units	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
	Services	p/kWh	5.1	5.1	5.5	4.8	5.0	4.7	4.4	4.1	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7

CO_2e Emissions Factors

The electricity grid CO_2e emissions figures used in assessments are shown in Table 44.

Table 44: Electricity grid CO_2e emissions

Year	Electricity grid CO_2e emissions, gCO_2e/kWh				Year	Electricity grid CO_2e emissions, gCO_2e/kWh		
	LCP marginal	IAG marginal (commercial)	DEFRA average			LCP marginal	IAG marginal (commercial)	DEFRA average
2021	395.4	274.0	282.8		2036	263.8	19.0	36.4
2022	401.9	259.0	269.3		2037	250.0	14.0	29.4
2023	382.8	243.0	255.0		2038	248.9	11.0	23.8
2024	381.1	226.0	240.0		2039	249.5	8.0	19.3
2025	381.2	207.0	224.0		2040	243.4	6.0	15.6
2026	382.0	187.0	207.2		2041	239.3	6.0	12.9
2027	367.9	166.0	189.4		2042	249.0	4.0	12.3
2028	359.2	143.0	170.6		2043	246.9	3.0	12.0
2029	333.8	118.0	150.7		2044	228.7	2.0	11.3
2030	311.9	91.0	129.7		2045	228.7	1.0	9.6
2031	316.1	70.0	104.9		2046	228.7	1.0	8.7
2032	293.0	54.0	84.9		2047	228.7	1.0	8.0
2033	279.5	41.0	68.7		2048	228.7	1.0	7.6
2034	260.0	32.0	55.6		2049	228.7	2.0	7.1
2035	248.3	24.0	45.0		2050	228.7	1.0	7.0

Table 45: Natural gas CO_2e emissions

Parameter	Value
Natural gas CO_2e emissions factor, gCO_2e/kWh	183.9
Average efficiency for BAU gas boilers	90%

Heat Sales Tariffs Calculation

The heat sales tariffs applied to individual connections are calculated based on the counterfactual cost of heat from individual ASHPs. An example of the cost of heat calculation of an ASHP system is shown in Table 46.

Table 46: Example of ASHP heat tariff

Average heat tariff – ASHP		
Assumed average CoP	2.4	
Expected lifetime of ASHP, years	20	
Electricity unit rate, p/kWh	22.95	Average of supplier unit rates
Maintenance, £/MWh	15	Calculated using average heat demand and input costs as above
Replacement costs, £/kW	300 - 4,000	Depends on the capacity of the heat pump; smaller HP capacity results in a greater replacement cost
Fixed current heat tariff, £/day	£10.60 – £1,091	Calculated based on maintenance cost and replacement cost
Average cost of heat, p/kWh	9.56	Calculated based on electricity unit rate

Energy Heat Sales Tariff and Heat Network Standing Charge

Table 47: Heat sales tariff and heat network standing charge

Site	Variable heat sales tariff, p/kWh	Fixed heat sales tariff, £/day/connection
CP House	9.56	£291.30
Perceval House Car Park	9.56	£200.20
Perceval House	9.56	£188.30
Ealing Town Hall	9.56	£142.60
Ealing Green College	9.56	£49.90
Christ the Saviour CoE School	9.56	£19.30
Sandringham Mews	9.56	£365.40
Christ the Saviour Church	9.56	£33.80
The Arcadia Centre	9.56	£98.70
Marks and Spencer	9.56	£80.00
Christ the Saviour CoE School - Grove Site	9.56	£26.00
Ealing Broadway	9.56	£495.80
Broadway Connection	9.56	£41.60
Bakers House + Wells House	9.56	£87.00
A2 Dominion	9.56	£47.30
Hilton	9.56	£91.00
Dawley House	9.56	£138.50
Ibis Styles	9.56	£55.00
Ealing Cross	9.56	£204.60
Travelodge	9.56	£44.60
Ealing Gateway	9.56	£158.10
Ealing Aurora	9.56	£134.00
Premier Inn	9.56	£86.60
Longfield House	9.56	£97.00
Ealing Studios	9.56	£101.40
Met Film School	9.56	£147.40
Hotel Xanadu	9.56	£10.90

Capital Costs

Capital costs for the scheme are based on a combination of previous project experience, quotations for recent similar works and soft market testing. Soft market testing has been conducted with potential suppliers of plant and equipment.

A summary of network capital costs for the Ealing Town Centre Network is shown in Table 48

.

Table 48: Capital costs – Ealing Town Centre Network (Kilburn, Cardiff and Solihull)

	Contingency	CAPEX including contingency		Source of value
		Phase 1	Phase 2	
Further project development (e.g. professional fees, legal, design, surveys, etc.)	10%	£925,572	£538,637	Previous project experience (Royal Borough of Greenwich, Bristol City Council and Bradford Metropolitan District Council)
Contractor costs for preliminaries, project management and design	10%	£1,295,800	£754,092	
Construction insurance	10%	£61,088	£35,550	
Cost of land purchase/lost land value	10%	-	-	
Energy centre building	15%	£2,070,000	£1,656,000	Previous project experience (Newport City Homes, Bristol City Council and Bradford Metropolitan District Council)
Heat pump	10%	2,310,000	£1,815,000	Previous project experience (Royal Borough of Greenwich district heating) and soft market testing with Star Renewables, and Durr
Structural and civil - Rooftop heat exchangers & screening	10%	£1,100,000	£660,000	Previous project experience
Heat pump M&E	20%	£1,260,000	£990,000	
Peak and reserve gas boilers	10%	£198,000	£121,000	Previous project experience / soft market testing with numerous companies including Hoval, Danstoker and Hamworthy
Pressurisation & Water treatment	10%	£60,500	£14,300	Previous project experience and soft market testing (Newport City Homes, Bristol City Council and Bradford Metropolitan District Council)
Peak and reserve boiler flues	20%	£296,400	£240,000	
Main district heat network pumps	10%	£146,300	£118,800	
Controls	20%	£378,000	£307,200	
Other energy centre M&E	20%	£558,000	£412,200	
Thermal store(s)	10%	£165,000	£99,000	
Gas grid connection	10%	£253,000	£253,000	Cadent budget quote
Electricity grid connection	10%	£95,700	£95,700	SSE budget quote
Heat network spine (pipe and trench costs)	15%	£7,037,025	£2,082,538	

	Contingency	CAPEX including contingency		Source of value
		Phase 1	Phase 2	
Additional network costs (including traffic management, avoiding utilities, etc.)	30%	£301,600	£125,450	Previous project experience and soft market testing (with rates from 3DTD, Eneteq, Pinnacle, Vital and CPV)
Heat network feeds (including pipe, trench, traffic management, etc.)	15%	£1,731,971	£1,154,237	
Cost of heat substations at building connections	20%	£1,391,235	£1,115,779	Previous project experience (Bristol City Council and Bradford Metropolitan District Council) and soft market testing (Danfoss Amarc and SAV systems)
Cost of secondary side improvements	10%	-	-	Previous project experience
Total		**£21,635,190**	**£12,588,484**	

Network Costs

Network costs for the Ealing Town Centre Network are shown below in Table 49 and Table 50.

Table 49: Network spine costs not cumulative (not including contingency)

Pipe size	Trench length, m		Pipe supply, installation, trenching and civils cost, £/m		Network costs (spine and feeds)	
	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2
DN25	-	4.05	-	2,244	-	9,084
DN32	-	-	-	-	-	-
DN40	24.2	20.0	2,570	3,351	62,193	67,082
DN50	79.4	52.7	2,106	2,562	167,107	135,062
DN65	341.0	193.5	2,389	2,223	814,655	430,021
DN80	79.7	239.3	2,026	2,304	161,522	551,179
DN100	57.9	206.7	3,188	2,546	184,427	526,284
DN125	305.4	178.7	2,572	3,416	785,373	610,372
DN150	13.1	-	5,163	-	67,479	-
DN200	1,165.2	36.7	4,447	2,902	5,181,659	106,507
DN250	82.0	85.5	5,436	5,409	445,644	462,651
Total	2,148	1,017			7,870,060	2,898,241

Table 50: Network connection costs

Site ref.	Site name	Phase	Network connection costs – heat, £	Additional network length to connect to main network spine, m	Cost of additional network length, £
1	CP House	1	£158,646	57.9	£184,427
2	Perceval House Car Park	1	£39,765	3.7	£10,662
3	Perceval House	1	£113,999	6.8	£16,849
4	Ealing Town Hall	1	£52,882	73.0	£144,674
5	Ealing Green College	1	£52,605	70.5	£124,594
6	Christ the Saviour CoE School	1	£71,092	19.0	£53,728
7	Sandringham Mews	1	£39,765	5.2	£31,851
8	Christ the Saviour Church	1	£41,837	15.7	£30,242
9	The Arcadia Centre	1	£68,291	118.6	£304,181
10	Marks and Spencer	1	£64,600	14.5	£45,823
11	Christ the Saviour CoE School - Grove Site	1	£40,364	150.2	£326,334
12	Ealing Broadway	1	£312,477	8.6	£31,951
13	Broadway Connection	1	£46,352	3.9	£183,906
14	Bakers House + Wells House	1	£56,687	88.8	£16,838
15	A2 Dominion	2	£52,211	7.8	£60,717
16	Hilton	2	£65,255	30.0	£118,720
17	Dawley House	2	£52,882	61.8	£52,355
18	Ibis Styles	2	£51,338	26.3	£9,084

Site ref.	Site name	Phase	Network connection costs – heat, £	Additional network length to connect to main network spine, m	Cost of additional network length, £
19	Ealing Cross	2	£137,937	4.1	£79,188
20	Travelodge	2	£49,525	35.8	£67,082
21	Ealing Gateway	2	£109,060	20.0	£86,733
22	Ealing Aurora	2	£86,007	24.1	£65,696
23	Premier Inn	2	£63,570	20.9	£91,408
24	Longfield House	2	£53,421	28.1	£65,868
25	Ealing Studios	2	£69,203	18.6	£45,572
26	Met Film School	2	£99,900	23.8	£231,575
27	Hotel Xanadu	2	£39,506	119.3	£29,684
28	131 Broadway	3	£28,145	4.8	£26,426
29	99-113 Broadway	3	£33,110	26.9	£66,265
30	West London Islamic Centre	3	£56,093	14.0	£45,603
31	Chignell Place	3	£10,676	4.3	£13,572
32	Green Man Lane	3	£111,406	3.2	£12,375
33	Freedom House	3	£40,788	14.3	£42,703
34	Sainsburys	3	£52,882	93.0	£182,565
35	96-102 Broadway	3	£39,765	14.6	£43,208
36	Hyde House	3	£50,633	4.8	£12,336
37	59-65 Broadway	3	£33,110	15.1	£43,660
39	66-86 Broadway	3	£28,145	19.4	£35,669
40	Waitrose	3	£60,941	98.6	£225,784
41	Luminosity Court	3	£42,126	11.4	£36,207
42	42 Hastings Road	3	£39,765	14.9	£50,181
43	Broughton Court	3	£82,042	129.8	£259,923
44	Jobplus Centre	3	£55,695	31.4	£77,017
45	84 Uxbridge Road	3	£79,065	5.3	£13,824
46	Exchange Plaza	3	£80,247	4.2	£14,355
47	Cavalier House	3	£53,432	29.2	£56,764
48	Craven House	3	£68,901	1.8	£9,571
49	Bruce Court	3	£14,746	5.1	£12,796
50	Arc Tower	3	£55,149	31.3	£109,919
51	49-69 Broadway	3	£72,438	112.1	£234,335
52	Dickens Yard	3	£234,844	44.6	£105,888
53	Filmworks	3	£140,879	10.7	£20,588
54	South Ealing YMCA	3	£49,899	86.7	£163,881
55	University of West London	3	£237,938	13.9	£34,316

APPENDIX 9: SOUTHALL DATA CENTRE PLANNING NOTE

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Sustainable ENERGY

Southall Data Centre Planning Note

London Borough of Ealing

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

This document summarises the heat mapping work conducted for Southall and the wider region. The aim of this document is to provide the planning team at the London Borough of Ealing (LBE) with an evidence base to justify the requirement for heat offtake from the planned data centres in Southall.

1.1 Project Background and Previous Work

This study builds from several pieces of previous work assessing heat networks in Ealing. These studies build a clear picture of the significant heat demand across the Borough of Ealing and the potential of a heat network scheme. These reports were reviewed and considered during this study. Previous work includes:

- London Heat Map Study for London Borough of Ealing (Ramboll 2010)
- Decentralised Energy for London, LBE: Southall Masterplanning (Arup 2013)
- Southall Decentralised Energy Network Feasibility (Arup 2015)
- Route Feasibility Study (Arup 2017)
- Ealing Council Heat & Power Network Opportunities (Buro Happold 2023)
- West London Local Area Energy Plan (WLLAEP) (Arup 2023)
- Ealing Town Centre Heat Network Feasibility Study (SEL 2024)
- Local Energy Accelerator Waste Heat Strategic Areas Summary (Buro Happold 2024)

The WLLAEP (2023) set out a key evidence base for the future energy strategy in the borough across heat, power and transportation. The study identifies the increasing pressure on electricity distribution and transmission grid in West London, especially due to the higher than typical density of data centres and redevelopment. This report highlights the importance of planning a future energy system with low carbon heating, and notes that finding effective heat network solutions is especially critical with the increasing demand for electricity.

The Waste Heat Strategic Areas Summary (2024) identifies strategic areas, displayed in Figure 1[1], with potential waste heat that could serve the local area. Sections of Ealing are shown covered within Strategic areas E and G. However, the plans for the data centres in Southall had not come forward at the time of this study and were therefore not included.

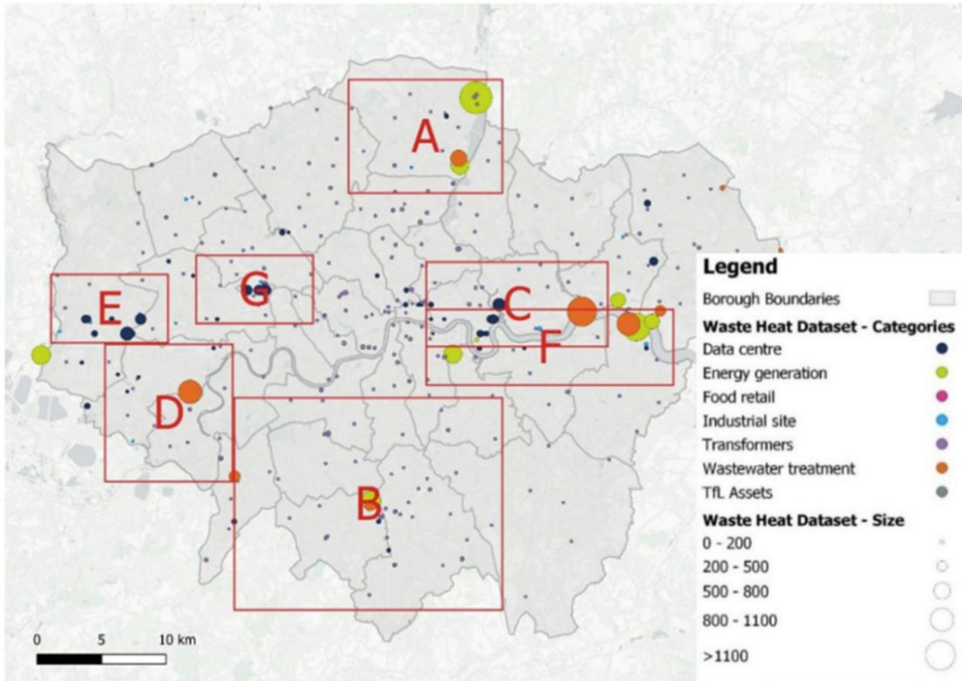

Figure 1: Waste heat sources strategic areas

The previous Southall feasibility study (2015) identified the potential for a small heat network connecting the Green Quarter development, other residential developments and the Ealing, Hammersmith & West London College site. The

[1] : Waste Heat Strategic Areas Summary report by Buro Happold

network was to be supplied by gas CHP and gas boilers. Although the Southall area has changed over the last 10 years, the key outputs including the network route assessment and crossing points identified in the study have been included during this work.

1.2 Data Centres

Two large data centres are planned for the Southall area and are shown in Figure 2. A full planning application has recently been submitted for the GTR data centre at the International Trading Estate; CyrusOne data centre, located at the former Honeymonster factory site is currently at the pre-application stage, but the submission of a full application is imminent.

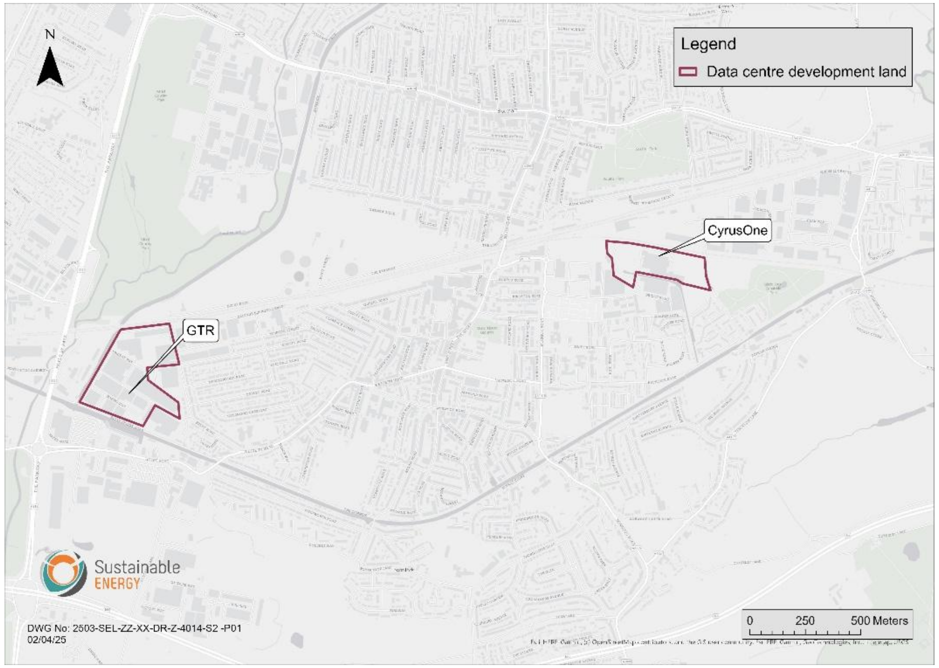

Figure 2: Southall data centre locations

Details of the electrical and potential heat offtake capacity for both sites are presented in Table 1. It is established that up to 70% of data centre electrical capacity could be utilised for waste heat offtake. However, sensitivity has been applied to also consider cases for lower heat offtake (20% and 50% of electrical capacity).

Table 1: Data centre capacity details

Data centre	Electrical capacity	Potential heat offtake capacity		
		Low: 20%	Medium: 50%	High: 70%
GTR	260 MW	52 MW	130 MW	182 MW
CyrusOne	108 MW	22 MW	54 MW	76 MW
Total	368 MW	74 MW	184 MW	258 MW

Table 2 presents the potential heat available after a heat pump for the low, medium, and high capacity of heat offtake from the data centres. This is the heat that could be utilised to serve a heat network, after the temperature of the waste heat has been increased using a heat pump. This is based on a high level assumption for the heat pump CoP of 5.3. The table shows the potential heat that could be utilised, should higher temperature heat offtake be secured from the data centres. Further details of the impact of heat offtake temperature on the overall efficiency of heat networks are provided in section 3.5.

Table 2: Heat available from data centres after heat pump

	Potential heat after heat pump		
Data centre	20% heat offtake	50% heat offtake	70% heat offtake
GTR	77 MW	154 MW	215 MW
CyrusOne	32 MW	64 MW	90 MW
Total	109 MW	218 MW	305 MW

2 HEAT DEMAND MAPPING

A high level assessment of the heat demands in Southall, Ealing and the wider region was undertaken. Large planned developments were identified and heat demands estimated based on data from similar sites. This identifies a clear heat demand in the area that has the potential to be supplied by waste heat from the data centres.

2.1 Southall

Heat demands identified within the Southall area are shown in Figure 3 with a summary of annual and peak demands provided in Table 3.

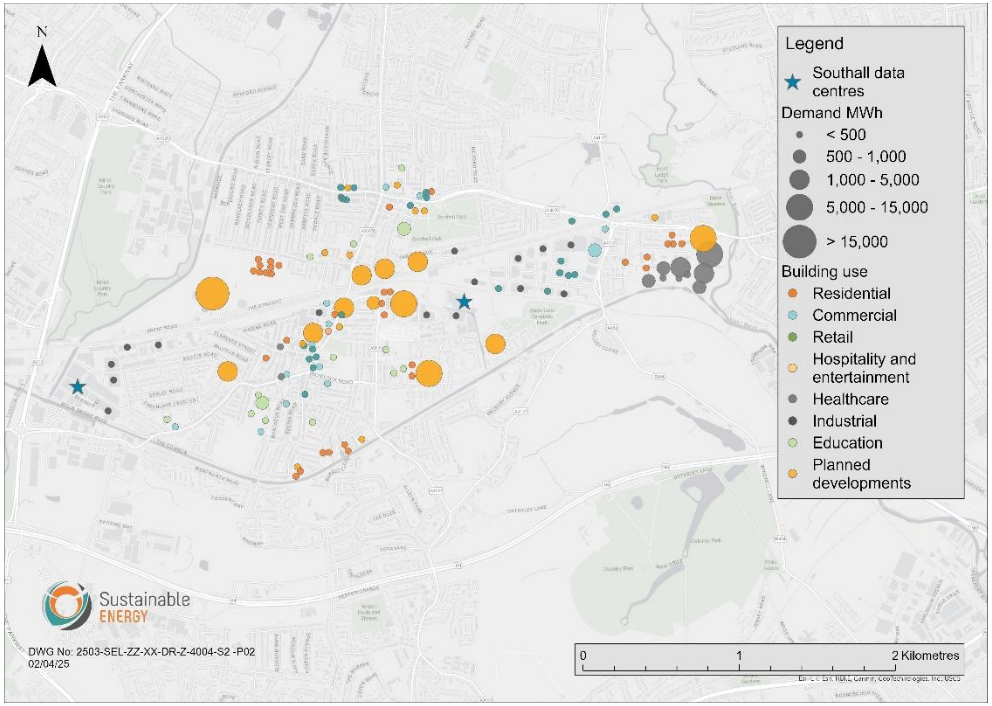

Figure 3: Southall heat demands

Table 3: Southall heat demand summary

Southall summary	
Peak demand	28 MW
Annual demand	116 GWh
No. connections	140
Heat demand from planned developments	70%

Potential key network connections within the area were identified and the 10 largest heat demands are shown in Figure 4, with further details of these sites presented in Table 4.

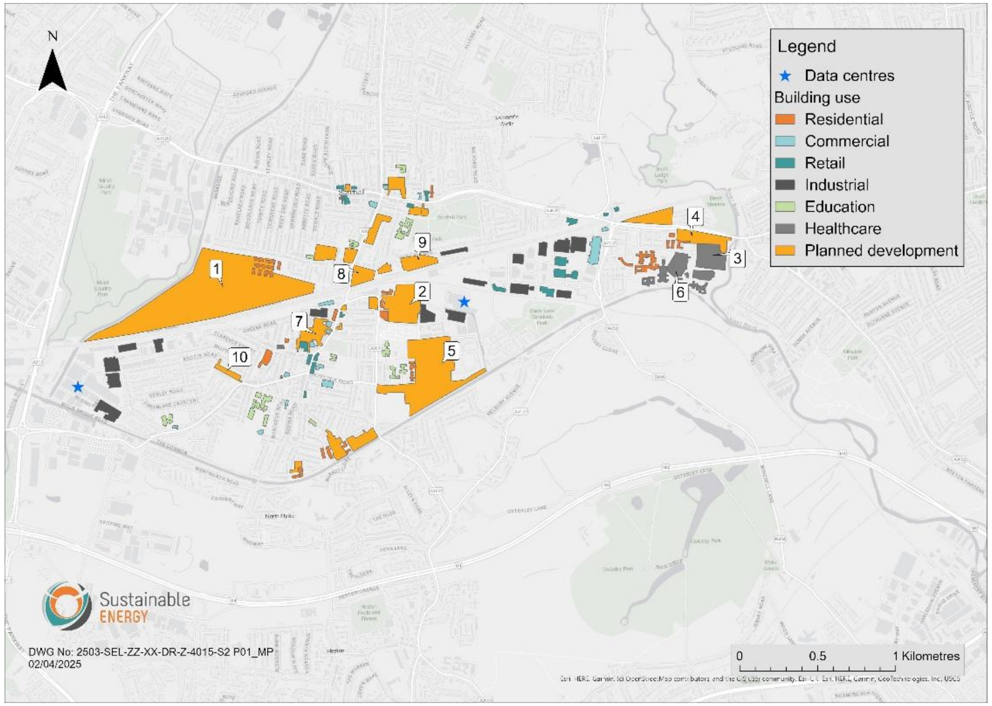

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Figure 4: Southall potential connections, displaying 10 largest demands

Table 4: 10 largest potential connections

Ref	Name	Status	Annual heat demand, MWh	Peak demand, kW
1	The Green Quarter	Planned development (in construction)	40,586	7,336
2	Middlesex Business Centre	Planned development	14,353	3,187
3	Ealing Hospital Main Building	Existing	11,553	4,323
4	Land to the front of Ealing Hospital	Planned development	6,107	2,528
5	Havelock Estate	Planned development	5,064	1,166
6	St Bernard's Wing (Ealing Hospital)	Existing	4,138	1,126
7	The Green	Planned development	2,793	755
8	Southall Crossrail Station & Gurdwara	Planned development	2,083	691
9	Southall Sidings	Planned development	1,902	644
10	Scotts Road Trading Estate	Planned development	1,634	502

2.2 Borough of Ealing

The heat demands identified within the borough of Ealing are shown in Figure 5 with a summary of annual and peak demands provided in Table 5.

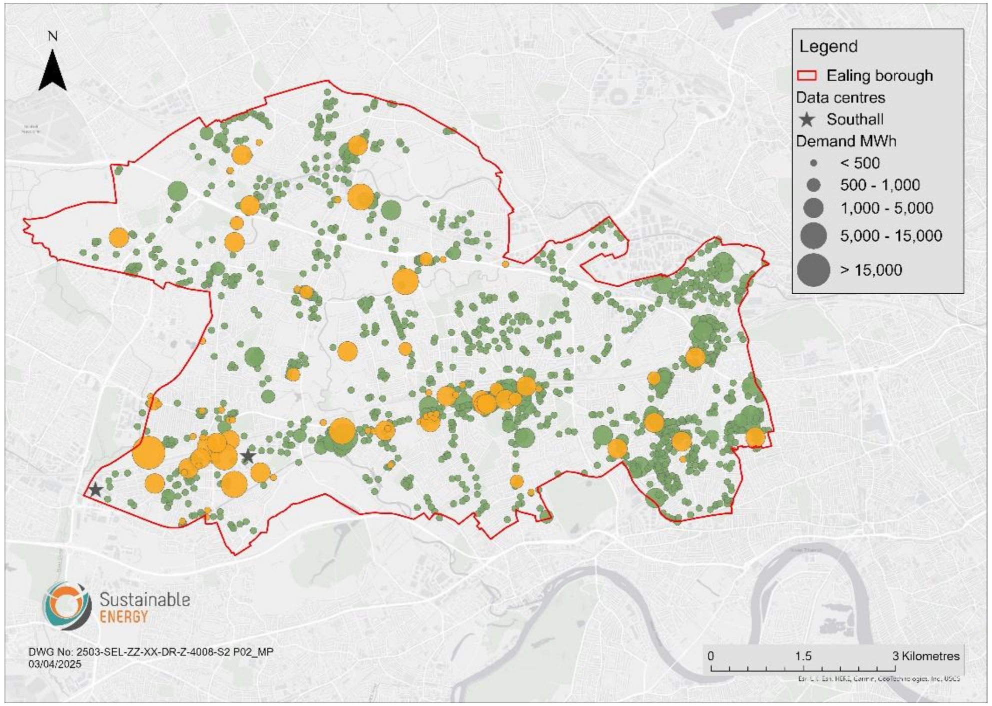

Figure 5: Ealing borough heat demands

Table 5: Ealing borough heat demand summary

Ealing summary	
Peak demand, MW	150
Annual demand, GWh	384
No. connections	1,435
% heat demand from planned developments	38

2.3 Wider Area

A heat demand assessment was also undertaken for the wider area, in addition to the Ealing borough, this assessment included sites in the neighbouring borough of Hillingdon and the region of Hounslow above the M4. The results of this assessment are shown in Figure 6 with a summary of annual and peak demands provided in Table 6 (this is the total demand including Southall, Ealing and the wider area).

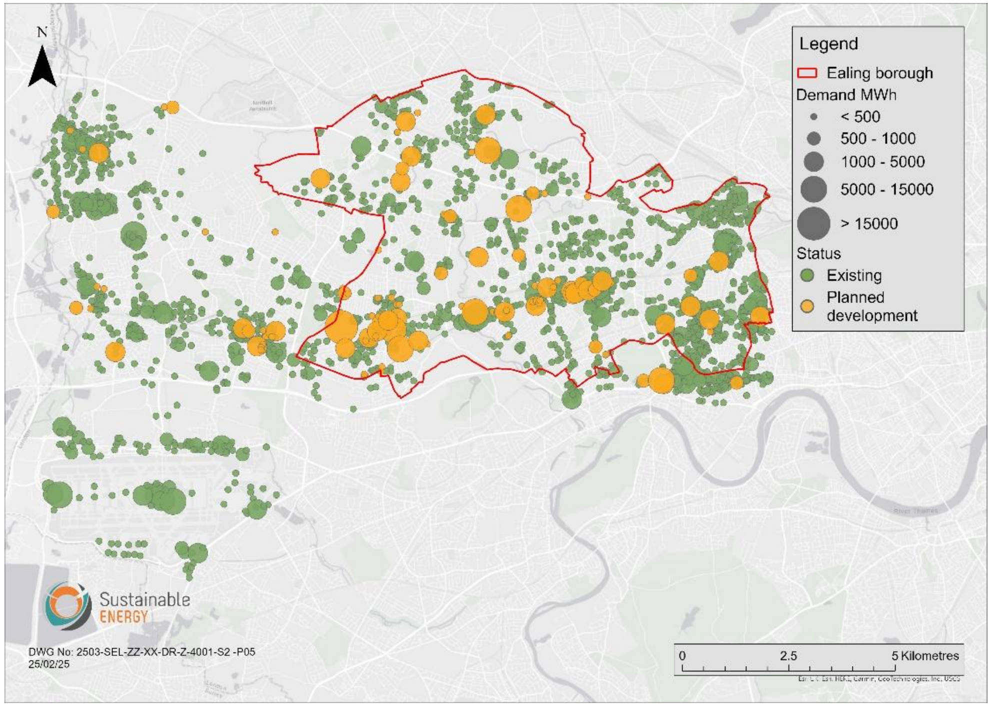

Figure 6: Wider area heat demand

Table 6: Wider area heat demand summary

Wider area summary	
Peak demand, MW	280
Annual demand, GWh	640
No. connections	2,460
% heat demand from planned developments	27

3 HEAT SUPPLY OPPORTUNITY

3.1 Heat Demand and Supply

Figure 7 shows the potential heat available to supply heat networks utilising waste heat offtake and heat pumps. The peak heat demand in the wider area is approximately 280 MW and the total heat that could be supplied is approximately 305 MW. Therefore, there should be sufficient supply to heat the whole borough and wider area. A phased increase in the offtake of heat over time will be required to match the increase in demands in the borough as well as the data centre phasing.

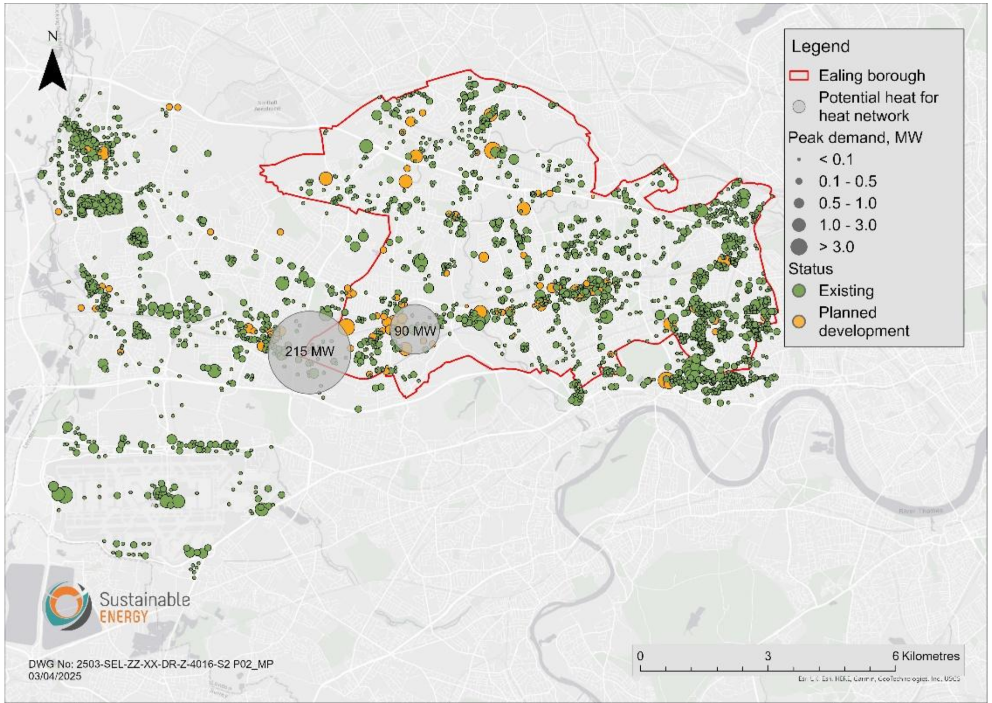

Figure 7: Ealing heat demand and heat supply

3.2 Heat Network Phasing

High level phasing has been considered for a network in Southall, indicative phasing is presented as follows:

- Phase 1: short term planned developments and lower risk connections, such as public sector owned buildings
- Phase 2: existing buildings further from the data centres and medium term planned developments
- Phase 3: longer term planned developments

It is likely that the build out of large scale residential developments will occur over a number of years, such as Green Quarter that will build at a rate of 200 dwellings a year. The indicative phasing is shown in Figure 8 and details are provided in Table 7.

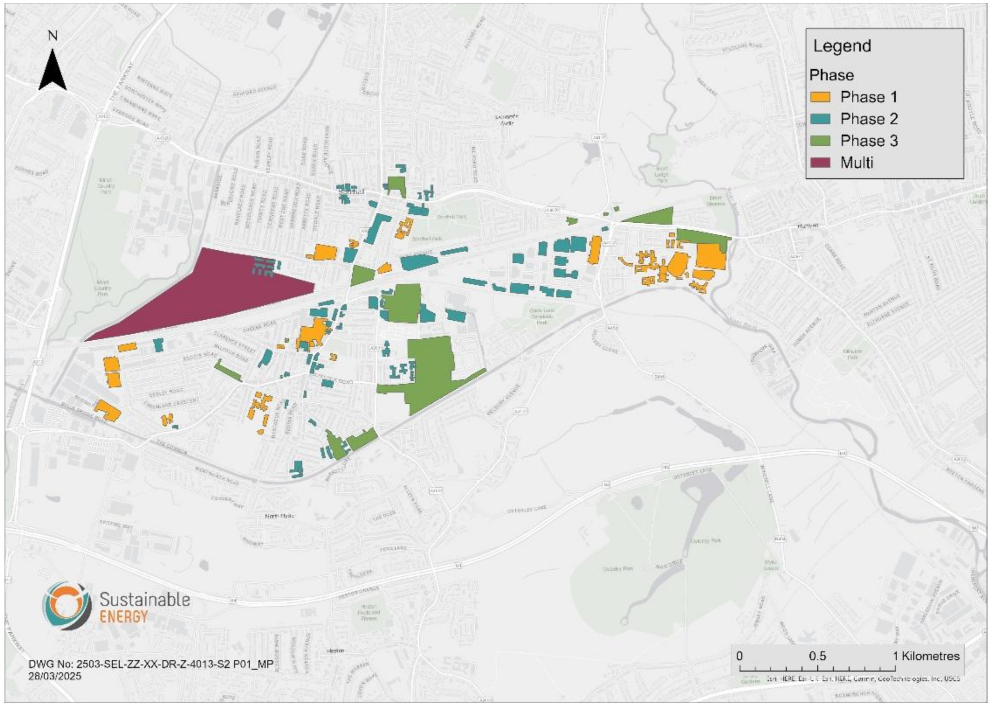

Figure 8: Southall high level phasing

Table 7: High level phasing details

Network build out	Phase 1: 2029	Phase 2: 2032	Phase 3: 2035	Phase 4 (Ealing Borough): 2045+
Peak demand, MW	16.4	28.2	38.6	150
Heat demand, MWh	36,130	50,734	82,856	384,000

For this study, a low temperature hot water network with a centralised energy centre(s) supplied by waste heat offtake from the data centres has been considered only. Going forward, further assessment should be undertaken to assess the preferred heat offtake and heat network design including consideration of an ambient network with satellite energy centres and/or heat pumps located at each key heat demand.

3.3 Energy Centre Requirements

The area required for the energy centre(s) will be dependent on the offtake capacity from the data centre and scale of the network. Estimated energy centre footprints are displayed in Table 8. Key factors when considering potential energy centre locations include:

- Proximity to heat supply and heat demands
- Land ownership (including planned development sites)
- Adjacent network constraints
- Visual impact
- Availability of land
- Other utilities, such as electricity transmission
- Adjacent building use e.g. proximity to residential

The energy centre(s) would ideally be located as close as possible to the planned data centres and heat offtake locations. This is to minimise the length of pipework and associated capital costs and friction losses. Although there is no rule of thumb for the maximum distance between the sites, the capital costs and system inefficiencies increase (reduced CoP), the further the energy centre is developed.

These factors should be considered further going forward when selecting energy centre locations.

Table 8: Energy centre requirements over different scales

Network phase	Peak demand, MW	Low carbon peak capacity, MW	Energy centre footprint benchmark, m^2/MW	Approximate energy centre footprint, m^2
Phase 1	16.4	11.5	100	500 (West) 650 (East)
Phase 2	28.2	19	100	1,900
Phase 3	38.6	27	75	2,000
Phase 4 (Ealing Borough)	150	105	75	7,900
Wider area	280	196	75	14,700

The area required per MW of installed capacity reduces slightly as the scale of the network increases, as the space available for ancillary equipment becomes more efficient.

3.3.1 Phase 1 Energy Centre

The development of the heat networks and energy centres could be phased and smaller energy centre(s) could built to serve the initial Southall network. An expansion or additional larger energy centre could then be developed to serve the full network area. Further details on the benefits and disbenefits of multiple energy centres is provided in section 3.3.3.

Two energy centres could be developed in phase 1 to connect to the heat offtake in both data centres. Although current provisions for services on the data centre sites do not allow for an energy centre within the development footprints, it may be beneficial to establish requirements for the data centres to accommodate energy centres that could serve the Southall area. This could help initiate the development of the heat network while providing the council and any prospective heat network developer with additional time to secure a permanent, larger site for the energy centre for future network expansion. Examples of the scale of phase 1 energy centres located within GTR and CyrusOne development boundaries are shown in Figure 9[2] and Figure 10[3] respectively.

Figure 9: GTR data centre with example phase 1 energy centre footprint

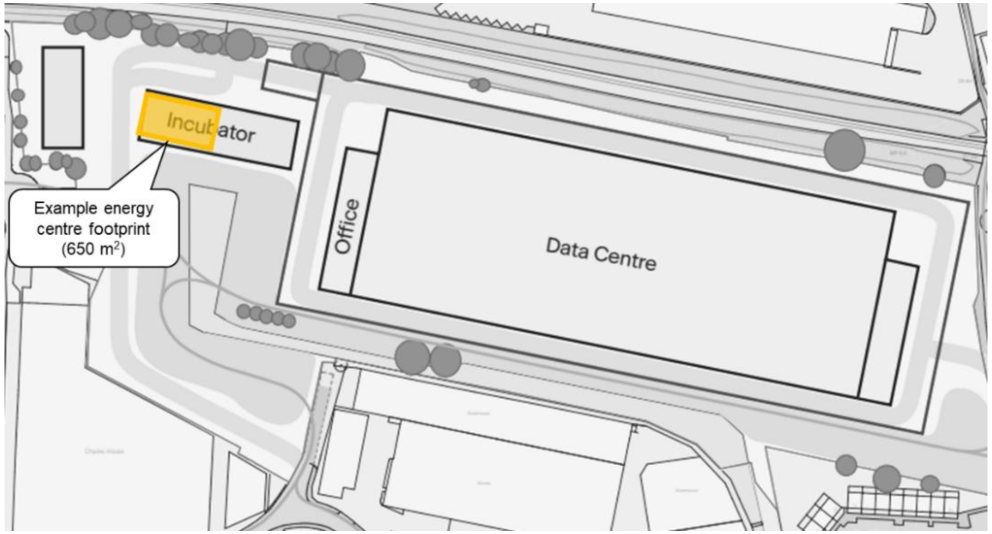

Figure 10: CyrusOne data centre with example phase 1 energy centre footprint

3.3.2 Energy Centre for the Full Network

The preferred location of an energy centre to serve the full network would be close to the data centre - this may require acquisition of an adjacent industrial unit. Examples of industrial land near the GTR and CyrusOne planned data centres that could have sufficient space for a large energy centre to supply the Borough of Ealing are shown in Figure 11 and Figure 12 respectively. These sites are provided as indicative examples of the scale of the required energy centres and proximity to the data centres only. Further assessment (by LBE and/or heat network developer) is required to assess the feasibility of acquiring privately owned industrial land for potential energy centre locations.

[2] GTR pre-application DHN Connection, accessed 1st May 2025

[3] CyrusOne pre-application Pre-App 03 – Design – Architecture & Landscape (26th September 2024), accessed 1st May 2025

LBE should consider the safeguarding of sites near the planned data centres for larger scale energy centres to allow for the future expansion of the heat network.

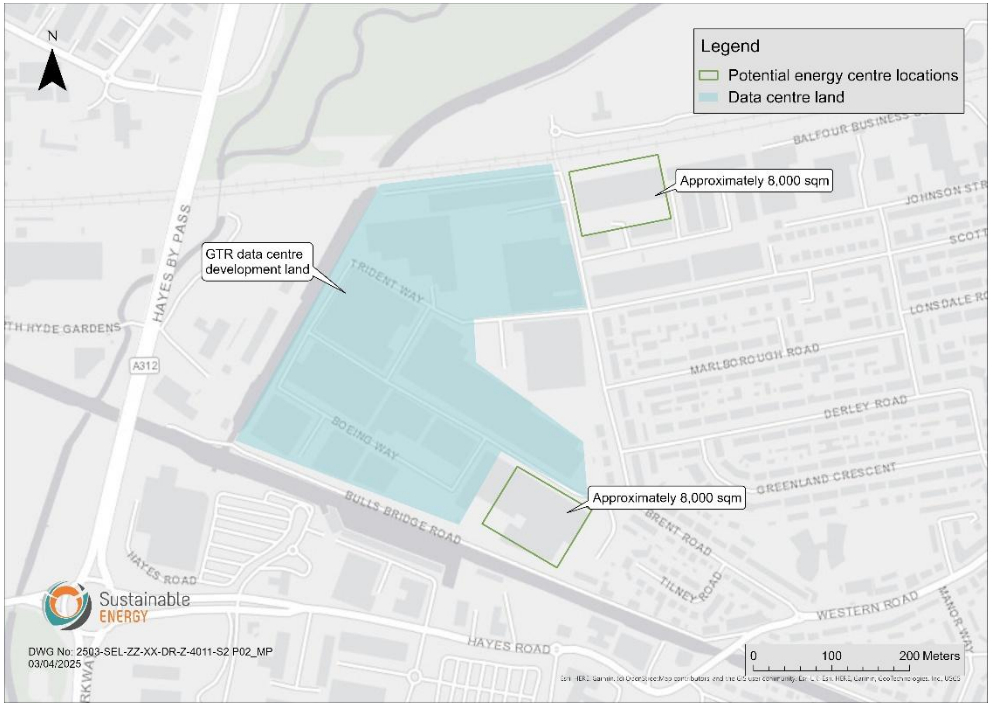

Figure 11: Potential energy centre locations for GRT data centre

Figure 12: Potential energy centre locations for CyrusOne data centre

3.3.3 Energy Centre Strategy

A detailed technical assessment is required to appropriately assess the optimal energy centre strategy for the Southall and Ealing heat network and determine whether multiple, smaller energy centres or larger, futureproofed energy centres would result in a more economically viable and lower risk proposition. However, high level benefits and disbenefits of multiple, smaller energy centres are presented in Table 9.

Table 9: Benefits and disbenefits of multiple, smaller energy centres

Benefits	Disbenefits
• Lower upfront investment for an initial smaller energy centre, costs will be staggered as the network grows • Potential for smaller network pipes as heat is distributed from multiple places, therefore easier to install, lower pumping requirements • Avoids the risk of a large energy centre being oversized and the network never extending beyond initial scheme	• Significantly greater overall capital costs to build multiple smaller energy centres and additional connecting pipework • Smaller capacity heat pumps could miss out on efficiency improvements and economies of scale compared to larger equipment • Risk that network pipes are undersized in key locations and may need replacing before end of life • Large grid connection required across multiple sites • Additional risk to secure multiple energy centre sites e.g. commercial negotiations, engagement, cost • Ambition to extend network and decarbonise Ealing at scale could be missed

3.4 Heat Network Route

A Thermos software modelling exercise was undertaken to identify the shortest network length route for the Southall area; the high level indicative network route is shown in Figure 13. More detailed assessment is required to determine a technically feasible and cost effective network route. The high level network route results in an average linear heat density of 6 MWh/m, which indicates the potential for an economically viable network. However, the heat demands and network route will require further assessment and refinement to confirm.

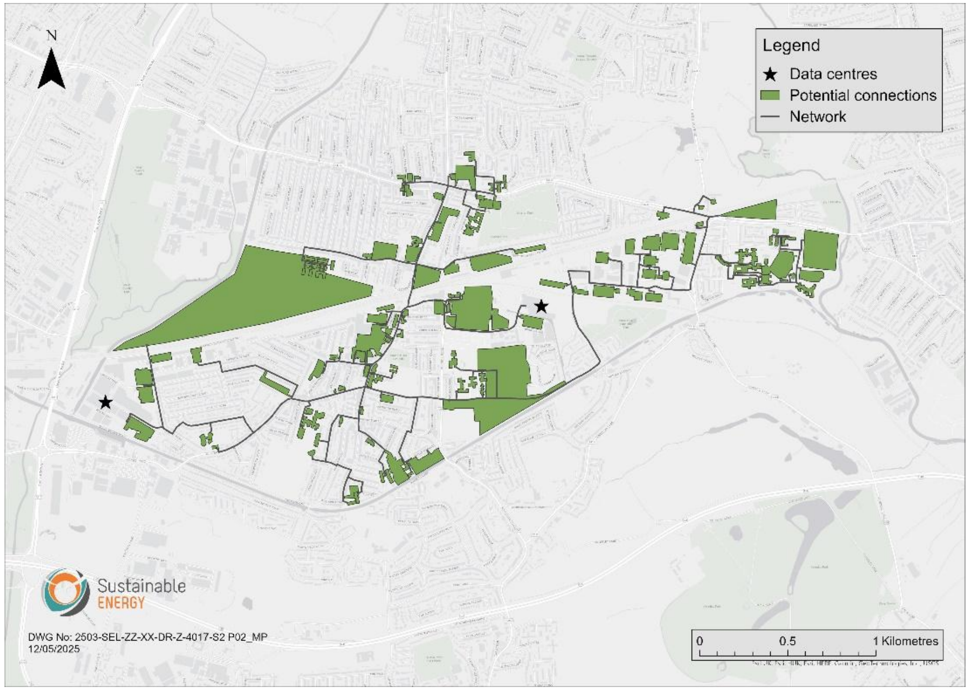

Figure 13: High level indicative network route in Southall

Indicative routes that could connect Southall to other network areas are also shown in Figure 14.

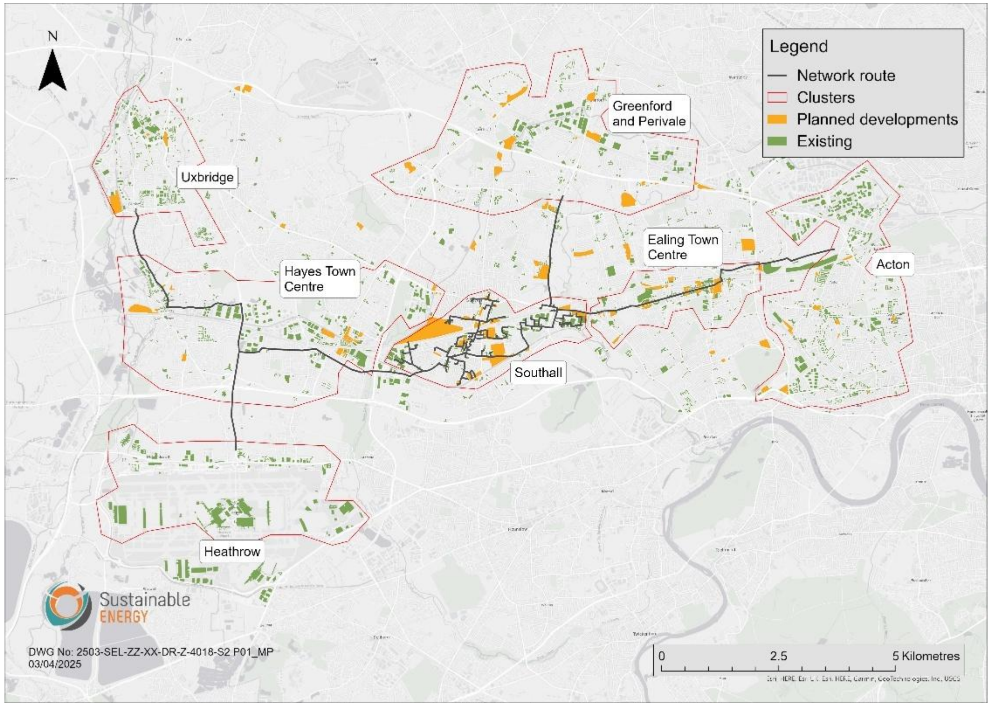

Figure 14: High level indicative network route connecting wider network areas

3.5 Waste Heat Offtake Grade

Heat can be taken off at different points of the data centre cooling systems, which will result in different temperatures of heat offtake. The range of temperatures that can be achieved through heat offtake from data centre cooling systems are presented in Figure 15, alongside the associated heat pump coefficient of performance (CoP), which provides a metric of system efficiency at each temperature. At the lowest heat offtake temperatures, the resulting system efficiency is very similar to an equivalent air source heat pump (ASHP) that uses the ambient air as a heat source. The ability to utilise higher temperatures (up to 35°C) allows for higher efficiency systems and will lead to lower electricity consumption within the heat network energy centre.

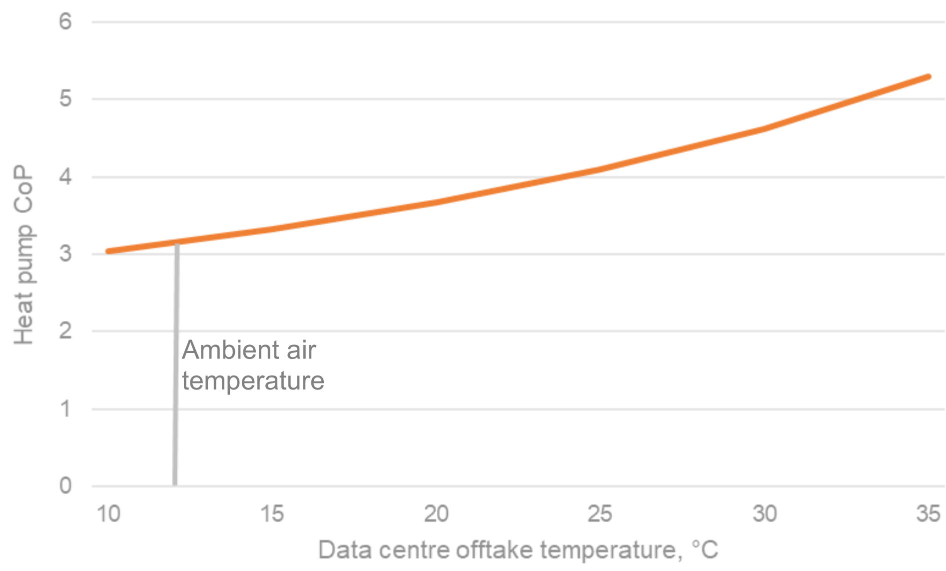

Figure 15: Effect of heat offtake temperature on heat pump efficiency

It is essential that the higher band of temperatures is explored alongside any requirement for heat availability from data centres. Seeking offtake agreements with higher grade heat would significantly increase the efficiency and viability of a heat network.

3.6 Availability of Heat

It will be between the data centre and the heat network developer to negotiate and determine the commercial arrangements regarding the availability of waste heat, the amount supplied, and heat supply guarantees. However, the preferred commercial model is typically that the data centre provides heat when available and the heat networks take the heat when available, which avoids the requirement for minimum guarantees on either stakeholder. As there will likely be no guarantee from the data centre for a minimum supply of waste heat, future changes and technology advances could result in a significant reduction in waste heat availability. However, this is a risk that the heat network developer would need to assess over the project lifetime considering the likelihood, benefits and disbenefits of utilising securing waste heat from the data centre to supply the heat network.

3.7 Cost of Heat

Heat offtake from data centres utilises the rejected heat from the building cooling systems, reducing the electrical consumption required. Therefore, any heat offtake will provide an economic advantage to the data centre by reducing electrical consumption. Generally, this benefit of reduced cooling demand compensates the data centre for the cost of the physical connection and provision of heat to a heat network.

If the data centre is constructed at the outset with the capability of higher temperature waste heat offtake, then the later stage connection to a heat network would have stronger viability and lower capital costs at the time of connection. If heat offtake is not considered within the initial design and construction of the data centre, retrofitting waste heat recovery will be more capital intensive and potentially reduce viability of heat network connection in the future. The likelihood of heat reuse from the data centre will be low if space is not safeguarded in advance as retrofitting an operational data centre becomes extremely difficult due to resiliency requirements of the data centre.

The waste heat offtake arrangement will be negotiated between the data centre and the heat network developer and will determine how the data centre will be remunerated e.g. through a fixed cost of heat or variable p/kWh as well as the frequency of payments.

3.8 Data Centre Requirements

At minimum, the data centre should be developed to be heat network ready. This will include the provision of space for heat offtake equipment including plate heat exchangers, pumps, and a safeguarded route for insulated pipework allowing for heat network connection. This may also include requirements for an initial energy centre. These types of requirements may be laid out in an S106 agreement, as used previously for the OPDC data centres.

To allow for heat offtake connection, the data centres should safeguard a trench of approximately 3.6 m wide and 2.4 m deep. This would provide sufficient space for 2no. DN1200 pipes to be installed, connecting the heat offtake equipment to the energy centre (where the heat pumps are located). In the initial phasing of the heat network development, the heat offtake capacity and equipment will be smaller and use a smaller extent of the safeguarded route (e.g. 10 MW offtake would use half of this trench size). However, as the network expands and additional offtake capacity is connected, additional pipe capacity would be installed within the safeguarded trench, with longer term opportunities to replace the installed pipework with a greater capacity.

Data centres should also provide transparency and share information with LBE as required. Examples of information that could be requested include:

- Assessment of waste heat recovery potential including capacity (MW), annual (MWh), export and temperature ranges
- Grid capacity requested and details on peak IT load, data centre type (Enterprise, Colo, Hyperscale etc.), cooling system type(s), expected power usage effectiveness (PUE)
- Approximate peak and annual cooling requirements on site
- Estimated development timescales including phasing of data hall build out and expected utilisation rate over time
- Evidence that the developer has tried to find opportunities to reuse their waste heat and how this has been considered into the initial planning application design.

4 RECOMMENDATIONS

Based on the assessment of Southall and the wider area, there is sufficient heat demand and environmental benefits to justify the requirement that the data centres must be designed for waste heat offtake. The key recommendations for the two planned data centres in Southall are as follows:

- The data centres should be developed to be heat network ready
- Data centres should be transparent in sharing information and data to the council and heat network developer
- The design should allow for the highest grade of heat offtake possible
- A phased approach to heat offtake connection and heat network development will be required in line with phasing of data centre development
- LBE planners should note that energy centre locations are best suited close to the data centre and consider safeguarding land for energy centre(s) within development plans