# South Kilburn District Heat Network

# Stage 2 Concept Design

# Summary Report

Sustainable
ENERGY

Document Number: S2002-ZZ-XX-RP-Y-0001
Version: D01
Checked by: GG
Date of issue: 24/05/2022

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Sustainable ENERGY

## Contents

# List of Figures

# List of Tables

# List of Abbreviations

| | |
|---|---|
| ADE | The Association for Decentralised Energy |
| ASHP | Air source heat pump |
| BAU | Business as usual |
| CAPEX | Capital Expenditure |
| CHP | Combined Heat and Power |
| CIBSE | Chartered Institution of Building Services Engineers |
| COP | Coefficient of performance |
| $CO_2e$ | Equivalent carbon dioxide |
| DHN | District heat network |
| DHW | Domestic hot water |
| DPCV | Differential pressure control valve |
| EC | Energy Centre |
| EfW | Energy from waste |
| ESCo | Energy Services Company |
| FOG | Fat, Oils, and Grease |
| GIS | Geographic Information System |
| GPR | Ground Penetrating Radar |
| GSHP | Ground source heat pump |
| GWP | Global warming potential |
| HIU | Heat Interface Unit |
| HNCoP | Heat Networks Code of Practice |
| HS2 | High Speed 2 Railway |
| LBB | London Borough of Brent |
| LTHW | Low temperature hot water |
| PFD | Process Flow Diagram |
| PHE | Plate Heat Exchanger |
| PICV | Pressure independent control valve |
| PV | Photovoltaic |
| RHI | Renewable Heat Incentive |
| RMU | Ring main unit |
| SPF | Seasonal performance factor |
| SSHP | Sewer source heat pump |
| UKPN | UK Power Network |

# 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 |
| Counterfactual | 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 |
| 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) |
| GWP | GWP is a measure of how much heat a greenhouse gas traps in the atmosphere up to a specific time horizon (commonly 20 or 100 years), relative to $CO_2$ |
| 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 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 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) |
| 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) |
| SPF | A measure of the operating performance of a heat pump heating system and is the ratio of the heat output to the electricity input (within the system boundary) over the year<br>$SPF_{H1}$ includes the electricity input for the heat pump unit only<br>$SPF_{H2}$ includes the electricity input for the heat pump unit and the abstraction of the heat source e.g. water from the ground<br>$SPF_{H4}$ as $SPF_{H2}$ and including the distribution system components such as circulation pumps, motorised valves, etc. |
| Thermal store | Storage of heat, typically in an insulated tank as hot water to provide a buffer against peak demand |

# 1 INTRODUCTION

This report details the preferred technical solution for the South Kilburn District Energy Network following an update to the predicted annual energy demands and profiles for the connecting buildings. Previous work has been reviewed and updated to provide a full rationale to clearly identify the preferred solution and phasing of the network.

The concept design includes consideration of the primary heat sources, peak and reserve boilers, other energy centre equipment, utilities connections, heat network, and network connections.

Futureproofing measures have been considered throughout the concept design process for the network options. The scheme is futureproofed to supply heat to potential later network phases. The most recent development plans have been used when estimating energy demands.

# 2 HEAT DEMANDS

## 2.1 Phasing

The project is from Phase 1 to 4. Phases 1-4 have been selected based on building connection information gathered from client with connection details and dates in Table 1 and Figure 1. Phase 5 demands are very high level and developed for the purposes for heat network futureproof sizing but not brought into the techno-economic models as the connection time frames are uncertain and could be up to 2040. Therefore, there is a high level of uncertainty around Phase 5 and not included in the project technical and economic project plan.

## 2.2 Identification of potential customers

LBB have shared details of planned construction and existing developments within the assessment area boundary.

A summary of the current information is presented below, along with potential future connections not previously considered.

Table 1: Current information for South Kilburn District Energy Network

| Building ID | Building Name | Building Use | Source | Current Status | Heat Network Phase | Heat Network Connection Date |
|---|---|---|---|---|---|---|
| 1 | Unity Place | • 235 dwellings | LBB Estate Regeneration | Built | 1 | 2024 |
| 2 | Peel - Phase 1 (Block E) | • 38 dwellings | LBB Estate Regeneration | Built | 1 | 2024 |
| 3 | Peel - Phase 2 (Block ABC) | • 103 dwellings<br>• 2300m$^2$ commercial space including gym, medical and retail space | LBB Estate Regeneration | Under Construction | 2 | 2026 |
| 4 | Peel - Phase 3 (Block FG) | • 64 dwellings<br>• 550m$^2$ retail space | LBB Estate Regeneration | Under Construction | 1 | 2024 |
| 5 | Peel - Phase 4 (Block D) | • 106 dwellings | LBB Estate Regeneration | Under Construction | 2 | 2026 |
| 6 | Chippenham Gardens | • 52 dwellings | Estimate | Built | 5 | 2040 |
| 7 | NWCC Neville & Winterleys | • 107 dwellings | LBB Estate Regeneration | Pre-development | 2 | 2026 |
| 8 | NWCC Carlton | • 112 dwellings | LBB Estate Regeneration | Pre-development | 2 | 2026 |
| 9 | Carlton & Granville Residential | • 18 dwellings | LBB Estate Regeneration | Pre-development | 1 | 2024 |
| 10 | Carlton & Granville Non-Residential | • 3500m$^2$ commercial space including office, school and event space | LBB Estate Regeneration | Renovating | 1 | 2024 |
| 11 | Hereford & Exeter - Phase 1 (Granville Park) | • 16 dwellings | LBB Estate Regeneration | Planning | 1 | 2024 |
| 12 | Hereford & Exeter - Phase 2 | • 231 dwellings | LBB Estate Regeneration | Planning | 2 | 2026 |
| 13 | Queens Park Cullen - Phase 1 | • 136 dwellings | Estimate | Future development | 4 | 2030 |

| Building ID | Building Name | Building Use | Source | Current Status | Heat Network Phase | Heat Network Connection Date |
|---|---|---|---|---|---|---|
| 14 | Craik Court | • 148 dwellings | LBB Estate Regeneration | Planning | 2 | 2026 |
| 15 | Crone & Zangwell | • 104 dwellings | LBB Estate Regeneration | Planning | 2 | 2026 |
| 16 | Austen & Blake | • 220 dwellings | LBB Estate Regeneration | Design stage | 3 | 2028 |
| 17 | John Ratcliffe House | • 50 dwellings | Estimate | Built | 4 | 2030 |
| 18 | William Dunbar House | • 123 dwellings | LBB Estate Regeneration | Pre-design | 4 | 2030 |
| 19 | William Saville House | • 74 dwellings | LBB Estate Regeneration | Pre-design | 4 | 2030 |
| 20 | Granville New Homes | • 110 dwellings | LBB Estate Regeneration | Undergoing major renovation | 1 | 2024 |
| 21 | Swift House | • 153 dwellings | LBB Estate Regeneration | Built | 2 | 2026 |
| 22 | St Augustine's School | • Secondary School | DEC certificate | Built | 1 | 2024 |
| 23 | St Augustine's Sports Centre | • Sport Centre | DEC certificate | Built | 1 | 2024 |
| 24 | Chase House | • 40 dwellings | Estimate | Built | 1 | 2024 |
| 25 | Hollister House & Franklin House | • 93 dwellings | Estimate | Built | 1 | 2024 |
| 26 | Argo House | • 93 dwellings | Estimate | Built | 4 | 2030 |
| 27 | Kilburn Quarter East Block | • 229 dwellings | Estimate | Built | 4 | 2030 |
| 28 | Merle Court | • 52 dwellings | Estimate | Built | 4 | 2030 |
| 29 | Cathedral Walk | • 51 dwellings | Estimate | Built | 5 | 2040 |
| 30 | Chichester Road | • 51 dwellings | Estimate | Built | 5 | 2040 |
| 31 | Chichester House | • 30 dwellings | Estimate | Built | 5 | 2040 |
| 32 | Pilgrims Corner | • 60 dwellings | Estimate | Built | 5 | 2040 |
| 33 | L&G Building | • 56 dwellings | Estimate | Built | 5 | 2040 |
| 34 | Birchside Apartments | • 56 dwellings | Estimate | Built | 5 | 2040 |
| 35 | Cedarside Apartments | • 38 dwellings | Estimate | Built | 5 | 2040 |
| 36 | George House | • 88 dwellings | Estimate | Built | 5 | 2040 |
| 37 | Carlton House 1 | • 40 dwellings | Estimate | Built | 5 | 2040 |
| 38 | Carlton House 2 | • 100 dwellings | Estimate | Built | 5 | 2040 |
| 39 | Wallbrook & Thames Court | • 60 dwellings | Estimate | Built | 5 | 2040 |
| 40 | Princess Road Houses | • 60 houses | Estimate | Built | 5 | 2040 |
| 41 | Nelson Close | • 52 dwellings | Estimate | Built | 5 | 2040 |

| Building ID | Building Name | Building Use | Source | Current Status | Heat Network Phase | Heat Network Connection Date |
|---|---|---|---|---|---|---|
| 42 | Stuart Road | • 52 dwellings | Estimate | Built | 5 | 2040 |
| 43 | CVS Housing | • 117 dwellings | LBB Estate Regeneration | Design stage | 3 | 2028 |

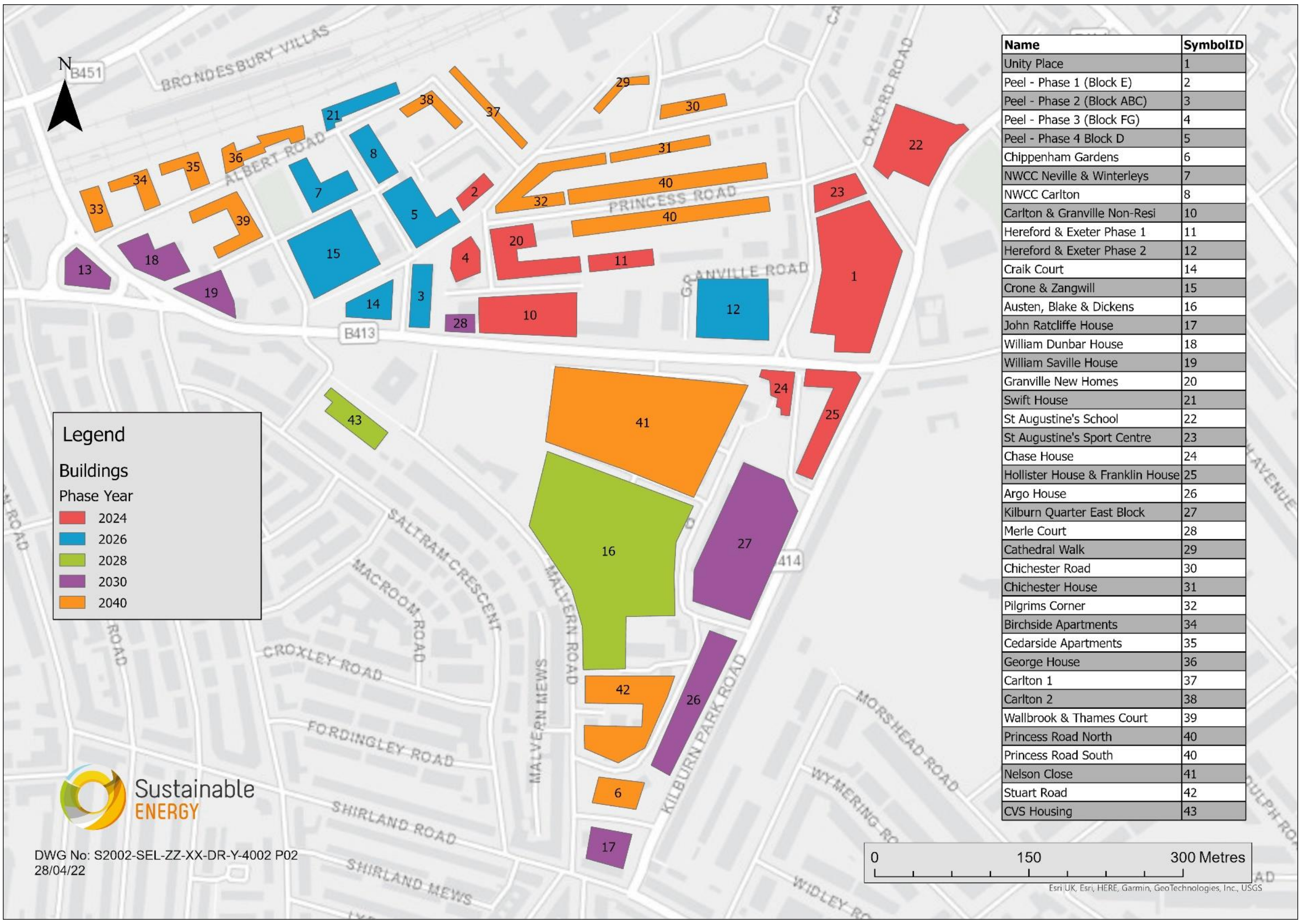


Figure 1: Phased building connection details

## 2.3 Energy Demand Profiles

Energy demands for potential network connections have been assessed (this included the issue of Requests for Information (RFIs) to all stakeholders). The energy demands and profiles for the development buildings were modelled to consider Objective 2.1 of the CIBSE / ADE Heat Networks Code of Practice (to achieve sufficient accuracy of peak heat demands and annual heat consumptions) and comply with Part L of the Building Regulations. In line with best 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 energy loads were then identified, categorised, and mapped.

For planned developments we modelled hourly profiles of heating and domestic hot water demand, normalised against degree day data from the nearest monitoring station (London Heathrow). Profiles were developed using in-house software and

[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.

considered building plans, site measurements, building construction and operating parameters. Peak, base load, seasonal and annual heat demands were identified. Half hourly heat data was available for Unity Place (one of the sites connecting to the heat network) which was used to create a benchmark and profile that has been applied for the other similar building types. It is assumed that the new developments will have a similar occupation and demand profile.

Where no building data was available 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.

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

Figure 2 shows an example heat demand profile for Unity Place (Social Housing), Figure 3 shows an example heat demand profile for private housing and Figure 4 shows an example heat demand profile St Augustine's School (the largest commercial connection).

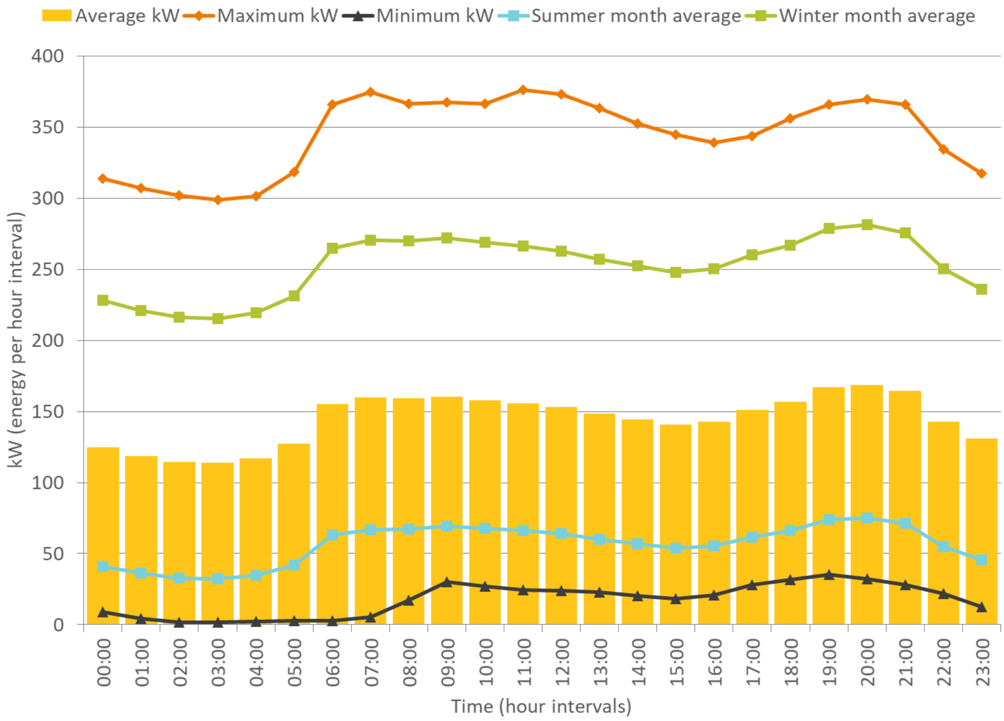


Figure 2: Average, maximum and minimum hourly heat demand for Unity Place (Social Housing)

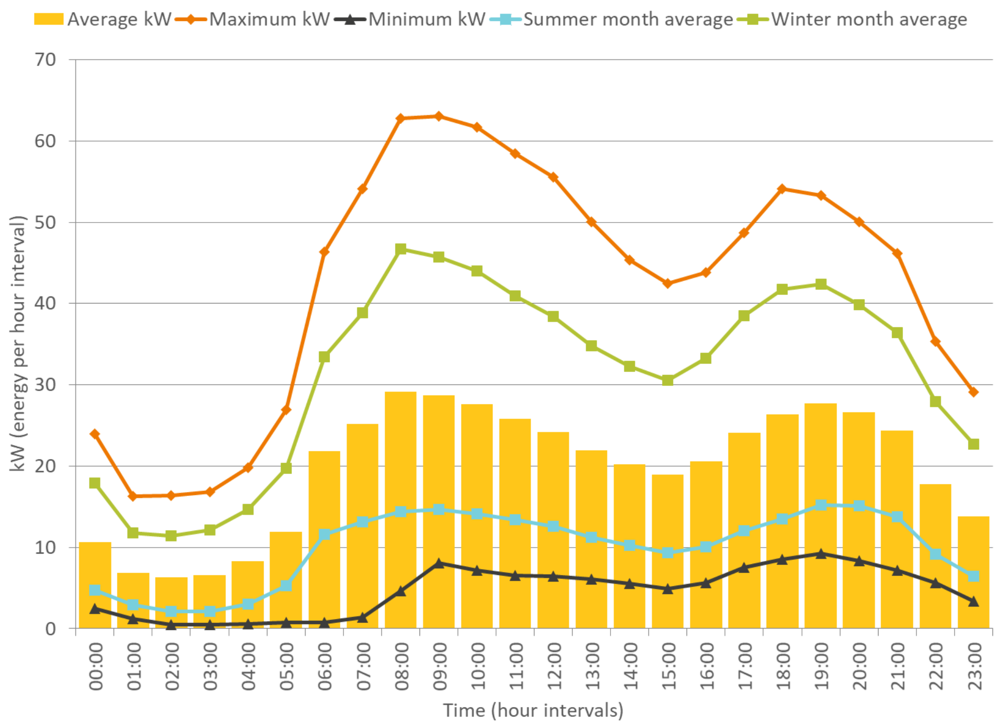


Figure 3: Average, maximum and minimum hourly demand for private housing

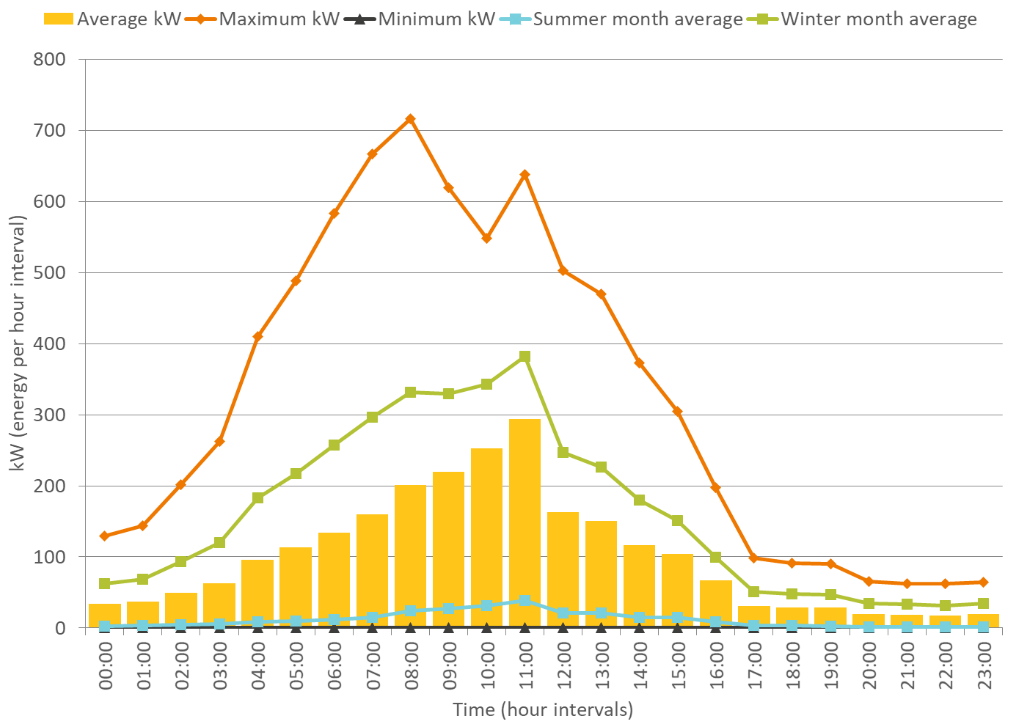


Figure 4: Average, maximum and minimum hourly heat demand for St Augustine's School

## 2.4 Demand Data

The total heat demands for all phases are shown in Figure 5. The total heating demand for all identified key demands withing the assessment area is approximately 24,946 MWh for the fully built out Phase 5 network.

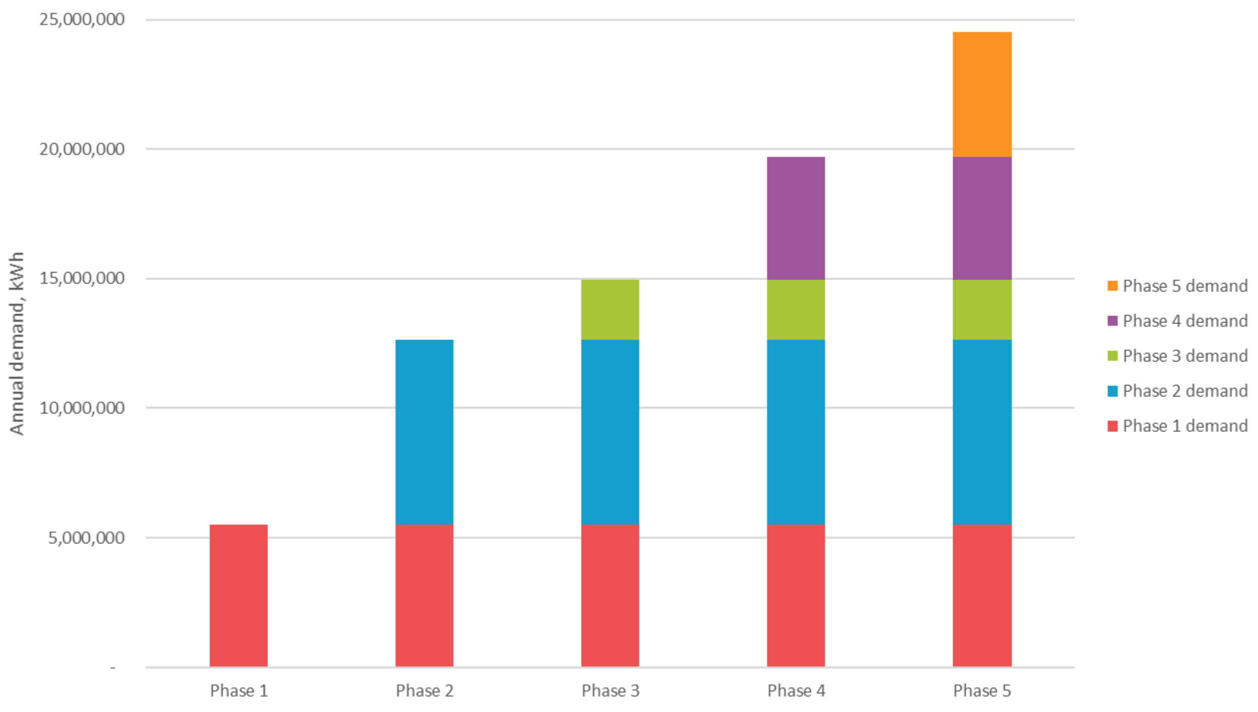


Figure 5: Annual heat demand

At full build out, the energy centre supplying the district energy network is anticipated to provide a diversified peak of roughly 7200 kW.

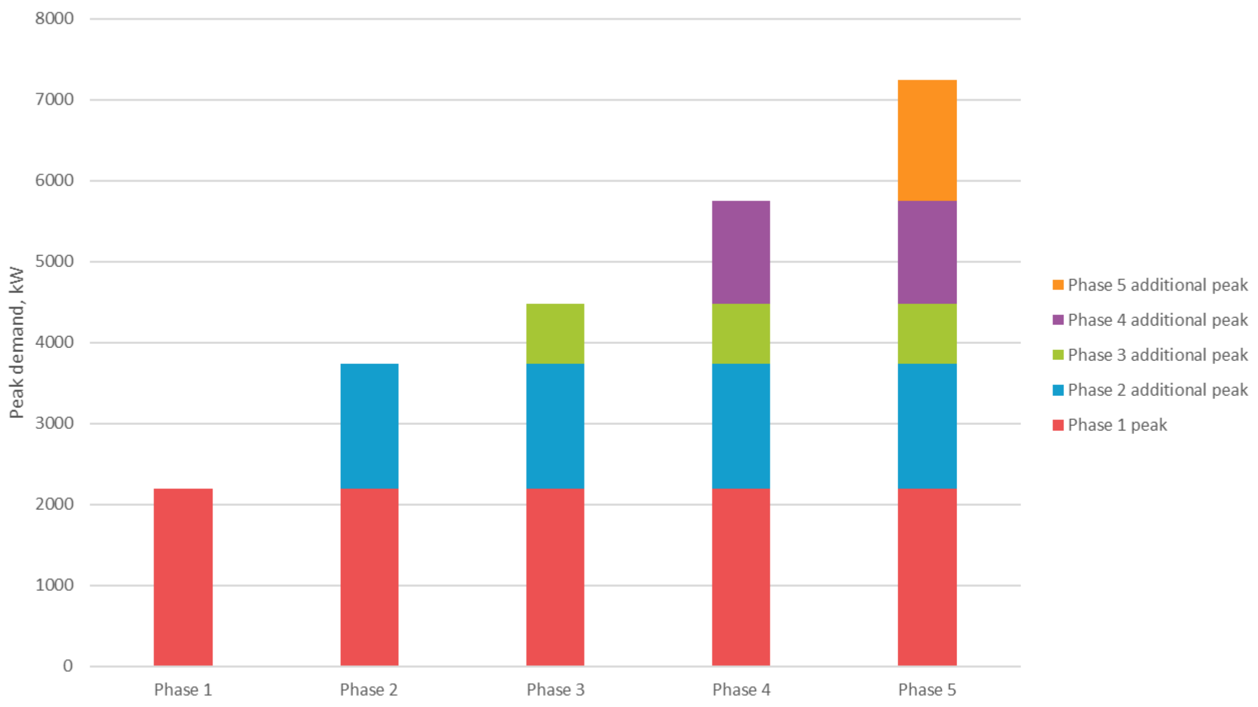


Figure 6: Network peak heat demands

## 2.5 Phase hourly heat demand profiles

The combined annual diversified heating load profile has been developed form the individual load profiles over the course of a typical year. The profiles and load duration curves for each phase are shown below in .These will be used in technology selection and sizing.

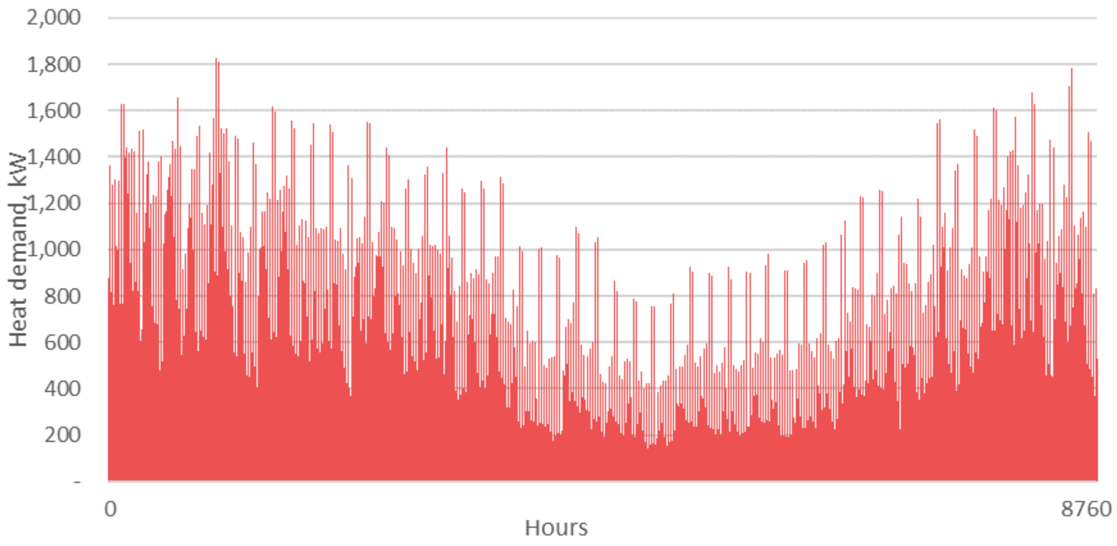


Figure 7: Phase 1 annual demand profile

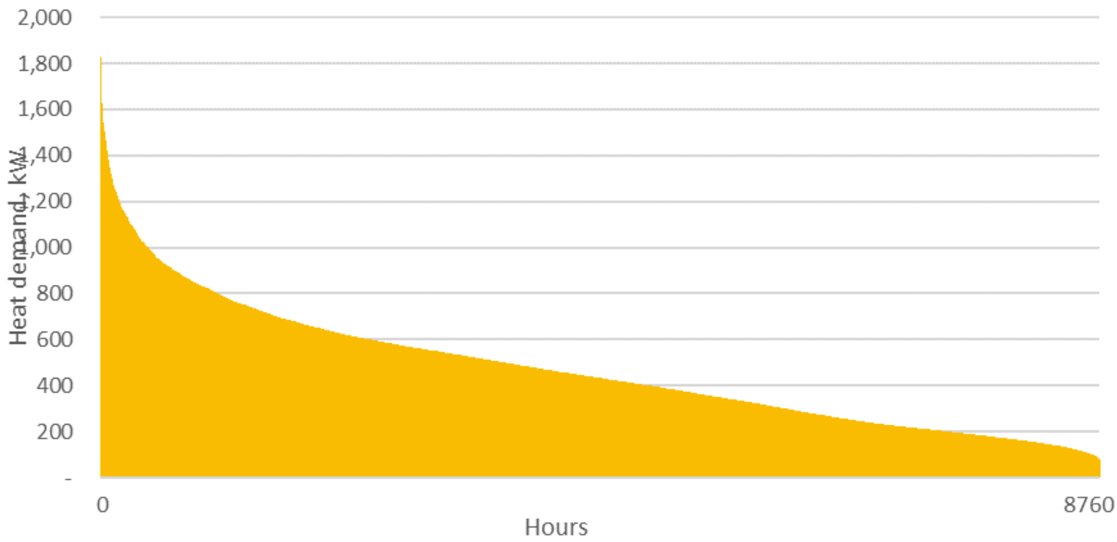


Figure 8: Phase 1 load duration curve

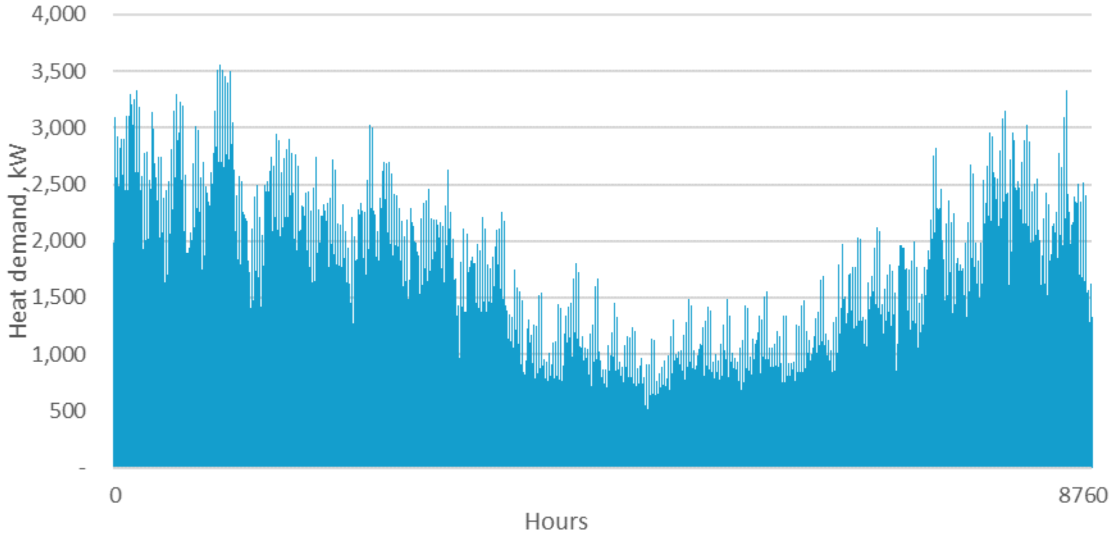


Figure 9: Phase 2 annual demand profile

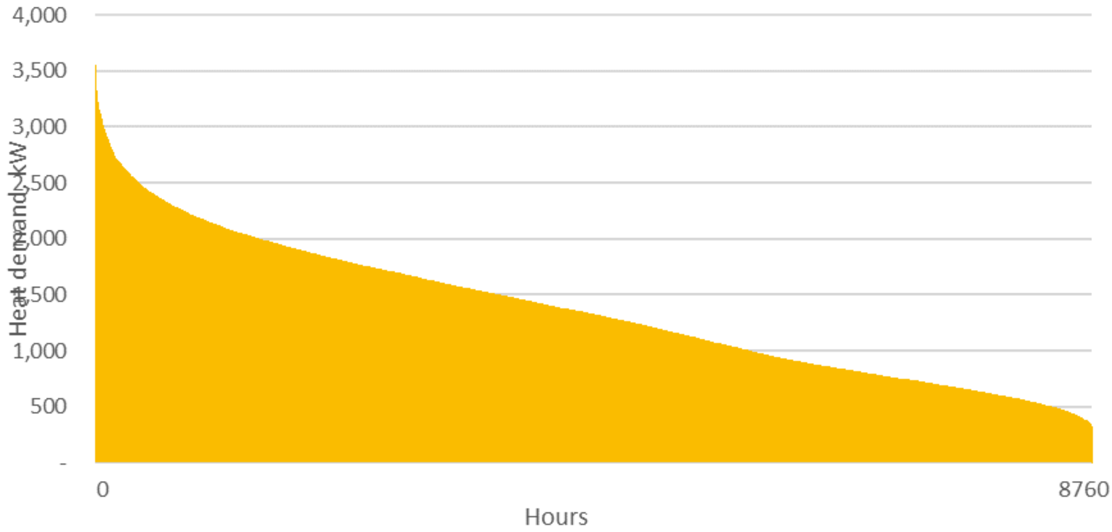


Figure 10: Phase 2 load duration curve

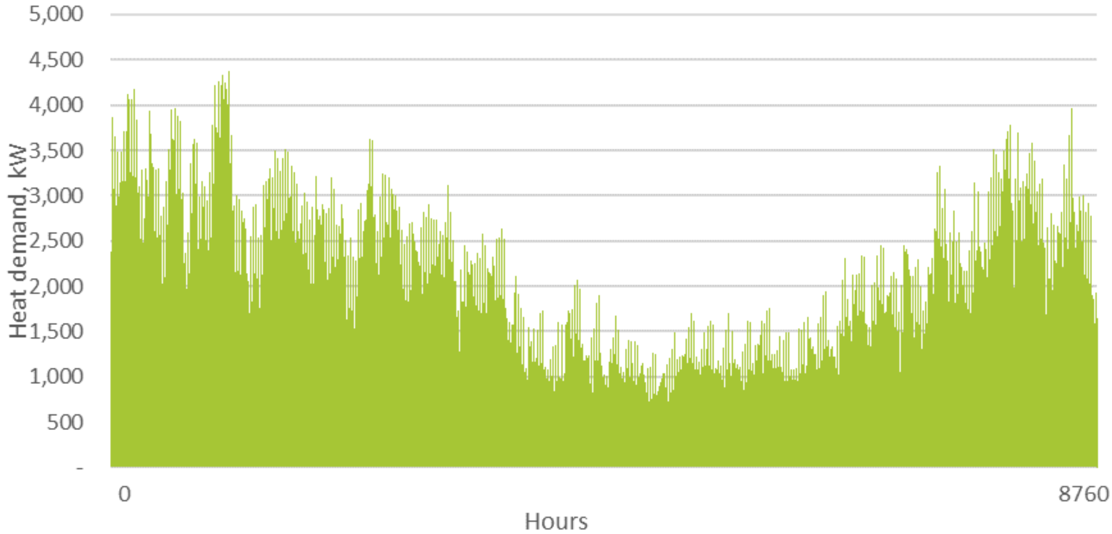


Figure 11: Phase 3 annual demand profile

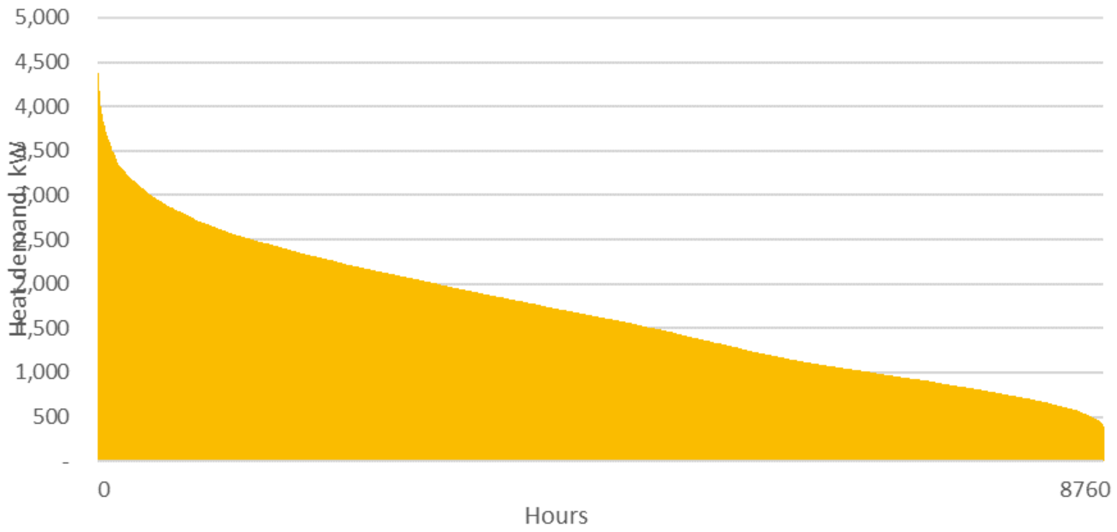


Figure 12: Phase 3 load duration curve

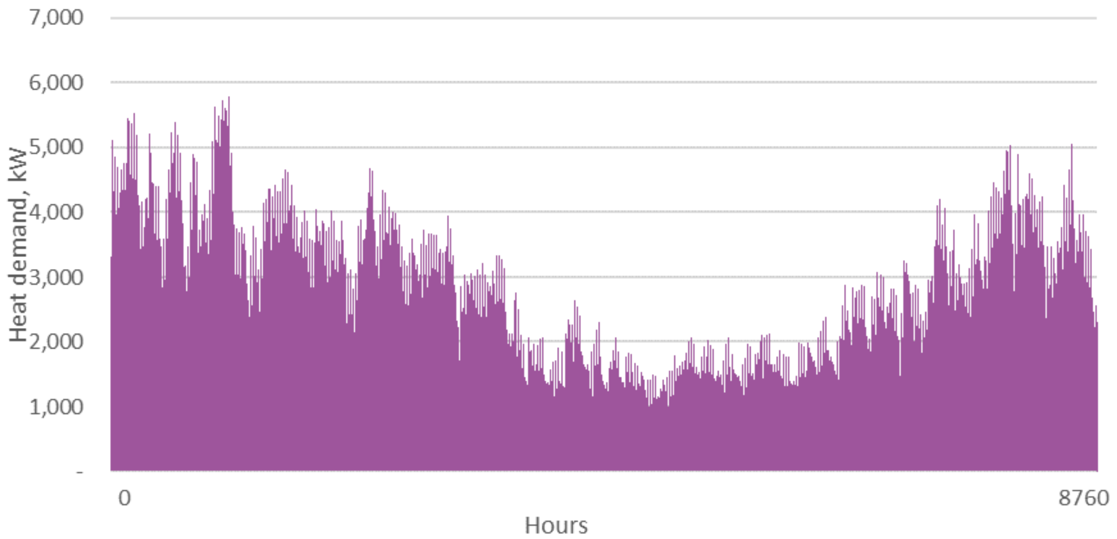


Figure 13: Phase 4 annual demand profile

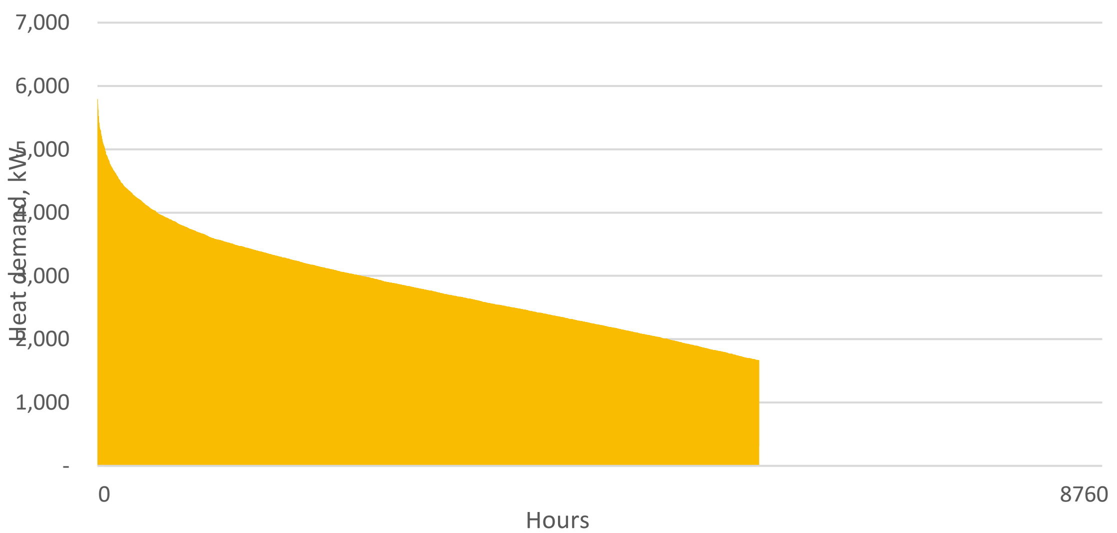

Figure 14: Phase 4 load duration curve

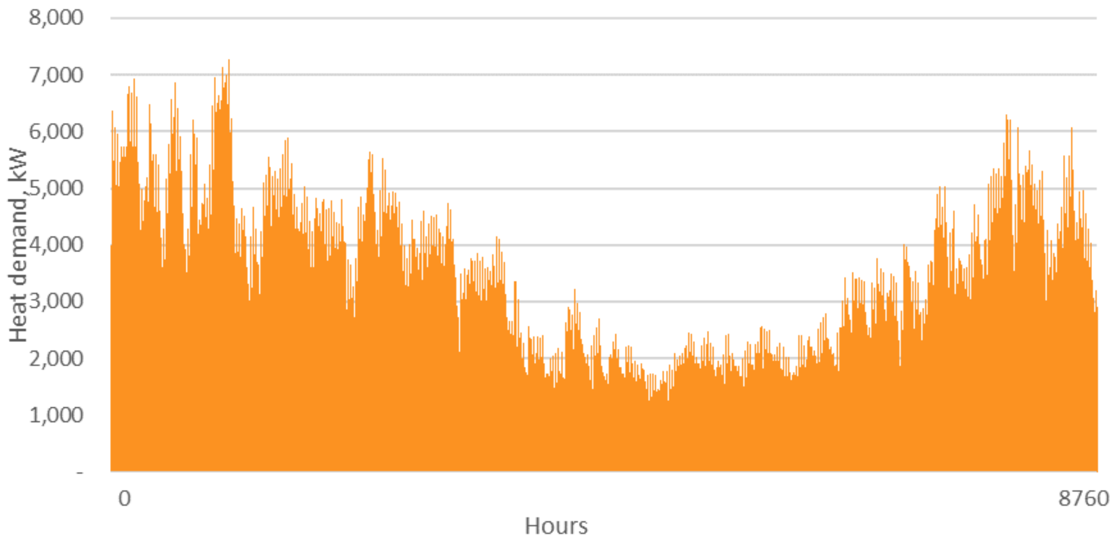


Figure 15: Phase 5 annual demand profile

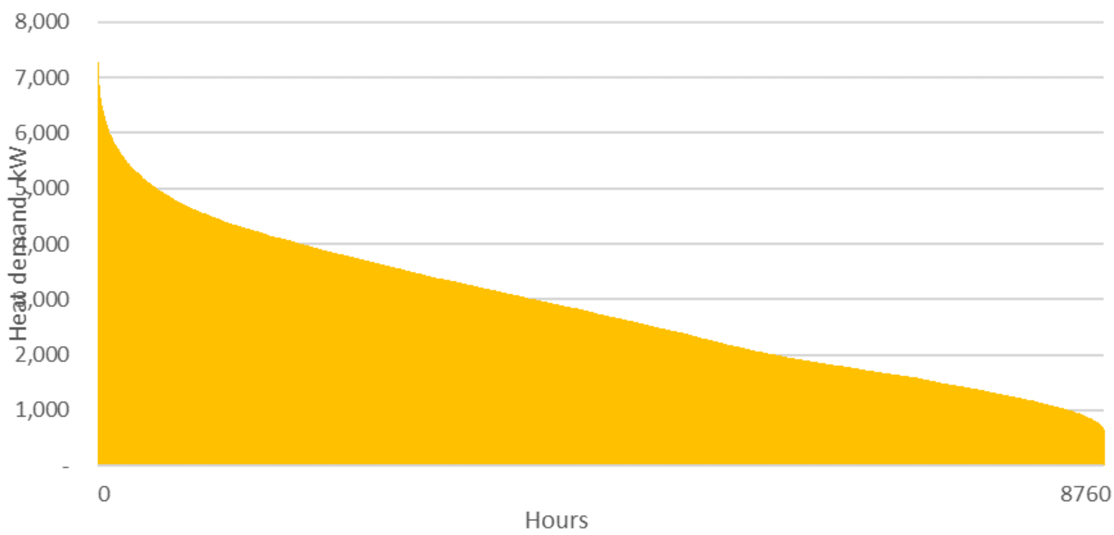


Figure 16: Phase 5 load duration curve

# 3 ENERGY SOURCE OPTIONS

## 3.1 Existing and Planned Energy Sources

Potential low carbon or renewable energy sources that are within or near the network assessment area were assessed to identify any energy sources that may have potential to supply a heat network. Existing energy sources have been considered as well as any planned developments. These are summarised in Table 2.

## 3.2 Renewable/ Low Carbon Heat Source

Table 2: Long list options for potential heat sources

| System architecture | Technology | High level technical viability considerations | Considered further? |
|---|---|---|---|
| Centralised Air Source Heat Pump (ASHP) serving district heat network | | • Lower initial CAPEX than GSHP or WSHP, however higher operating costs due to lower CoP<br>• Potential noise restrictions close to residential developments<br>• ASHP at large scale may have cooling effect on local environment<br>• Potential to utilise local renewable electricity generation to further reduce carbon emissions<br>• Visual and acoustic impact | Yes |
| Open loop heat pump | GSHP utilising aquifer | • South Kilburn lies within a favourable geological area for open loop[2] GSHP<br>• Only local borehole yield in immediate area was 1 l/s, although very low drawdown noted which indicates more resource could be available (see Appendix 1 – Borehole Records**Error! Reference source not found.** for more details)<br>• Deepest borehole in the immediate area does not produce water until 200 ft (chalk found)<br>• Additional CAPEX associated with abstraction infrastructure<br>• Test well would be required<br>• Aquifer boreholes and interconnecting pipework require a large area adjacent to the energy centre which is difficult to achieve considering new constructions and network pipes<br>• Interconnecting pipework between boreholes and heat pump will be large diameter and will be difficult to coordinate with existing infrastructure and new DH infrastructure | No |
| | Deep geothermal | • South Kilburn has a relatively low geothermal[3] potential of rock (approximately 50-60 mW/m$^2$)<br>• Significant space requirements<br>• Complex drilling requirements | No |
| | Wastewater source heat pump | • Thames Water trunk sewer runs parallel to Unity Place along Kilburn Park Road<br>• Sewer monitoring has confirmed lowest flow of 50-150 l/s<br>• Heat pump output could be up to 1300 kW thermal<br>• Commercial terms need to be agreed with Thames Water<br>• Increased CAPEX will have an impact on economics<br>• Potentially lowest CO2e option due to increased heat pump COP | Yes (in conjunction with other options as source is not large enough to provide heat to full development) |

[2] British Geological Survey GSHP viability screening tool https://mapapps2.bgs.ac.uk/gshpnational2/app/index.html

[3] http://www.bgs.ac.uk/research/energy/geothermal/

| System architecture | Technology | High level technical viability considerations | Considered further? |
|---|---|---|---|
| Closed loop heat pump | GSHP using boreholes (closed loop) | • Significant land space requirement for boreholes<br>• Kilburn Park, south of Carlton Vale Road has potential for ~40 boreholes<br>• High level estimate of ~300 kW available<br>• Borefield CAPEX will have significant impact on economics<br>• Borefield thermal response unknown and cooling network is not being considered to recharge borefield | No |
| Heat recovery | Heat pump with recovery from HS2 ventilation | • HS2 shaft located to north of development area<br>• Located far from energy centre<br>• HS2 team confirmed that fans only operate between midnight and 6am, they do not run when trains are running<br>• Commercial terms need to be agreed with HS2 | No |
| Gas CHP | | • Higher carbon emissions compared to other technologies<br>• Air quality issues | No |
| Electric Boilers | | • Expensive if used during peak electricity usage times<br>• Grid capacity constraints<br>• Grid carbon intensity likely to be high at times of peak heat demand<br>• Possible price reduction /kWh in future | Yes, only as peak and reserve |
| Gas Boilers | | • High $CO_2e$<br>• Potentially lower OPEX than electric boilers | Yes, only peak and reserve |
| Biomass | | • Air quality considerations for biomass<br>• High cost of fuel compared to natural gas, however reduced carbon emissions<br>• Unlikely to be sufficient space due to larger space requirements compared to other heat sources because of solid fuel delivery and storage<br>• May cause congestion / environmental impact due to frequency of fuel deliveries<br>• Sustainability of biomass dependent on availability of a local, reliable source of fuel<br>• Not economic against alternative scenarios (particularly without RHI)<br>• Not suitable for either main source of heat or peak/reserve due to scale required | No |
| Hydrogen Fuel Cell CHP | | • Economics of hydrogen-based CHP very uncertain<br>• Security of fuel supply issues<br>• Requires significant space for fuel cell<br>• No local hydrogen generation<br>• Fuel will need to be transported by road<br>• Economic and regulatory issues relating to private wire<br>• Fuel cell market not developed | No |
| EfW | | • No EfW facilities in local area | No |
| Industrial waste heat | | • No industrial waste heat sources identified near or within the assessment area | No |
| Solar thermal on dwellings | | • Would work as a complement to other technologies<br>• Displaces PV panels | No |
| Solar thermal | | • Significant initial capital costs<br>• Significant land required for collector arrays | No |

### 3.2.1 Short list assessment

Table 3 provides details of the short list options taken forward. Diagrams of each option are shown in Appendix 2 – Short List Option DiagramsTable 3.

Table 3: Specific issues, risks, benefits and disbenefits for short listed options

| Short list option | Viability consideration | | Risks | Benefits | Disbenefits |
|---|---|---|---|---|---|
| ASHP DHN | Technology selection | • Potentially low CAPEX option<br>• ASHPs efficiency will vary with external air temperature, an ASHP will be less efficient in winter and have a lower output | COP at low air temperatures will impact project economics, $CO_2e$ savings and renewable heat availability during cold periods | | |
| | Heat resource | • Heat output is limited to availability of roof space | | No third-party cost for accessing heat resource. Potential to accommodate additional heat sources in future e.g., Sewer source heat pump | |
| | Plant operation | • Heat generated from the ASHP will be prioritised with gas/electric boilers only supplying peak demands and in times of ASHP maintenance / failure | Acoustic attenuation of roof top ASHPs may be required | ~90% of network heat demand will be from renewable technology | |
| | Energy centre design | • Additional space required for air heat exchangers on roof of energy centre | | Monoblock ASHP remove requirement for refrigerant in basement plantroom | Will require space on building roofs to accommodate evaporators |
| | Impact on the surrounding development | • Potential opposition to ASHP within development | Perceived visual, noise and cold plume impact | | May reduce space for PV on building roofs |
| Sewer Source Heat Pump DHN | Technology selection | • Higher CAPEX option<br>• Sewer source temperature is stable year-round leading to higher COP; operating temperatures will be important to increase efficiency | Increased potential for flooding risk depending on if wet well or in-sewer system is selected | | |
| | Heat resource | • Resource will be dependent on sewer flow rates and temperatures<br>• Access and heat off-take agreement required with Thames Water<br>• Sewer monitoring has shown that daily night-time flows will only be able to provide ~1.2 – 1.3 MW | Availability of resource is not guaranteed | Higher CoP than ASHP will improve $CO_2e$ savings and renewable heat availability year-round and will have lower operating costs | Heat resource will not cover fully built out demand. Additional low carbon heat generation will be required |

| Short list option | Viability consideration | | Risks | Benefits | Disbenefits |
|---|---|---|---|---|---|
| | Plant operation | • Heat generated from the Sewer Heat Pump will be prioritised with additional low carbon heat prioritised before gas/electric boilers only supplying peak demands and in times of heat pump maintenance / failure | | ~90% of network heat demand will be from renewable technology | |
| | Energy centre design | • Additional space required for foul water heat exchangers and heat pump<br>• Additional ventilation requirements for heat pump depending on refrigerant used<br>• | | | Will likely take up parking spaces in the energy centre basement<br>Additional ventilation will be required for basement energy centre |
| | Impact on the development | • Large space required for heat exchangers will likely take up parking spaces in the energy centre basement<br>• Large wet well or in-sewer system required to access sewer heat | | | Heat exchangers will likely take up parking spaces in the energy centre basement |

# 4 ENERGY CENTRE

## 4.1 Location

A potential location for an energy centre has already been constructed as part of the Unity Place development. Other options have been assessed to determine if this is the optimum location for the Energy Centre. The heat network is in an area that is undergoing significant redevelopment with no identified space to accommodate a standalone energy centre. Given the shortlist assessment for the heat resource the energy centre needs to have access to a large area for the ASHPs and needs to be near Kilburn Park Road to access the main sewer. The Unity Place energy centre is therefore the preferred choice especially given the significant land value within the local area and large CAPEX requirement if a separate energy centre was to be constructed.

## 4.2 Energy Centre Summary

The energy centre includes heat pumps (air source or sewer source heat pumps), peak and reserve gas boilers, thermal storage tanks and provision for auxiliary equipment. The heat pump sizing and installation phasing has been developed to maintain a low carbon intensity (kg/$CO_2$e) and thus provide ~90% of network demand. Gas or electric boilers are used as an auxiliary source for peak supply, or as a reserve heat source for periods of heat pump or abstraction maintenance or failure. Controls will prioritise heat from the heat pump.

A summary of plant capacities is shown in Table 4.

Table 4: South Kilburn energy centre summary

| | Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 | Total |
|---|---|---|---|---|---|---|
| ASHP capacity | 1200 kW | 400 kW | 400 kW | 400 kW | - | 3600 kW |
| Sewer heat pump capacity | - | - | - | - | 1200 kW | 1200 kW |
| Peak and reserve boiler capacity | 6500 kW | - | - | - | 1000 kW | 7500 kW |
| Thermal store capacity | 50,000 litres | - | - | - | - | 50,000 litres |
| Energy centre footprint | 460 m² | - | - | - | - | 460 m² |
| % Low Carbon Heat | 98% | 90% | 91% | 89% | 92% | 92% |
| Year 1 Carbon Intensity $kgCO_2e/kWh$ | 0.101 | - | - | - | - | - |

The carbon intensity of the network falls steadily as the proportion of heat supplied via heat pumps is kept high and therefore follows the predicted BEIS grid decarbonisation. The BAU assumes that all existing buildings will continue to use gas and any new developments will install individual ASHPs at the building level. Figure 17 shows how the network intensity changes as the grid decarbonises.

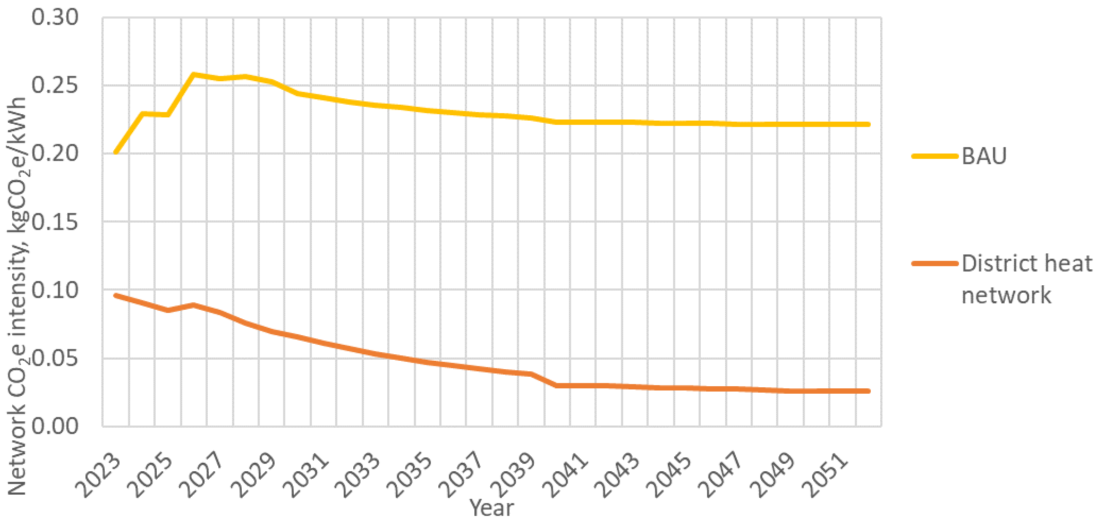


Figure 17: Yearly network carbon intensity

### 4.2.1 ASHPs

The heat pumps will be packaged units located on the roof of the energy centre. They will be connected to two main circuits: the air cooler circuit and the primary heating circuit. The air cooler circuit operates by running a low-temperature, low pressure refrigerant fluid through a heat exchanger to extract heat from the air.

The refrigerant fluid 'absorbs' the heat 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 Low Global Warming Potential refrigerant.

The heat pump capacity will be limited based on the phased network demand and the space available on the energy centre roof. Consideration has also been given to the optimum balance between heat generation capacity, capital cost, maintenance costs and physical size.

A detailed 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, air 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 peak and off peak electricity tariffs. Following this exercise, a 1,200 kW capacity heat pump system, comprising 3no. 400 kW heat pumps has been selected for phase 1 with an additional 400 kW installed in each future phase up to Phase 4 to ensure ~90% of heat demand is provided by low carbon technologies.

The heat pump sizing strategy includes smaller, modular heat pumps rather than fewer, larger heat pumps to ensure capacity increases in line with the development build out rate as well as fitting the physical constraints of the energy centre building. This sizing strategy reduces the risk in relation to delays in development build out rate and allows the additional flexibility in operation of the scheme in periods of scheduled maintenance and resilience in the event of heat pump failure.

***ASHP Location***

The required air source heat pumps will need to be located on the roof of the proposed energy centre building. As this is already constructed, it is necessary to confirm if the selected heat pumps will fit. Figure 18 shows the dimensions of Unity Place roof along with the dimensions of the selected heat pump models. This confirms that there is sufficient space for the ASHPs. A structural survey of the roof structure has been carried out. The report confirms that the roof structure can support the expected loads from the ASHPs. This report is available in Appendix 1 – Borehole Records

Appendix 2 – Short List Option Diagrams

Appendix 3 – Unity Place Structural Report

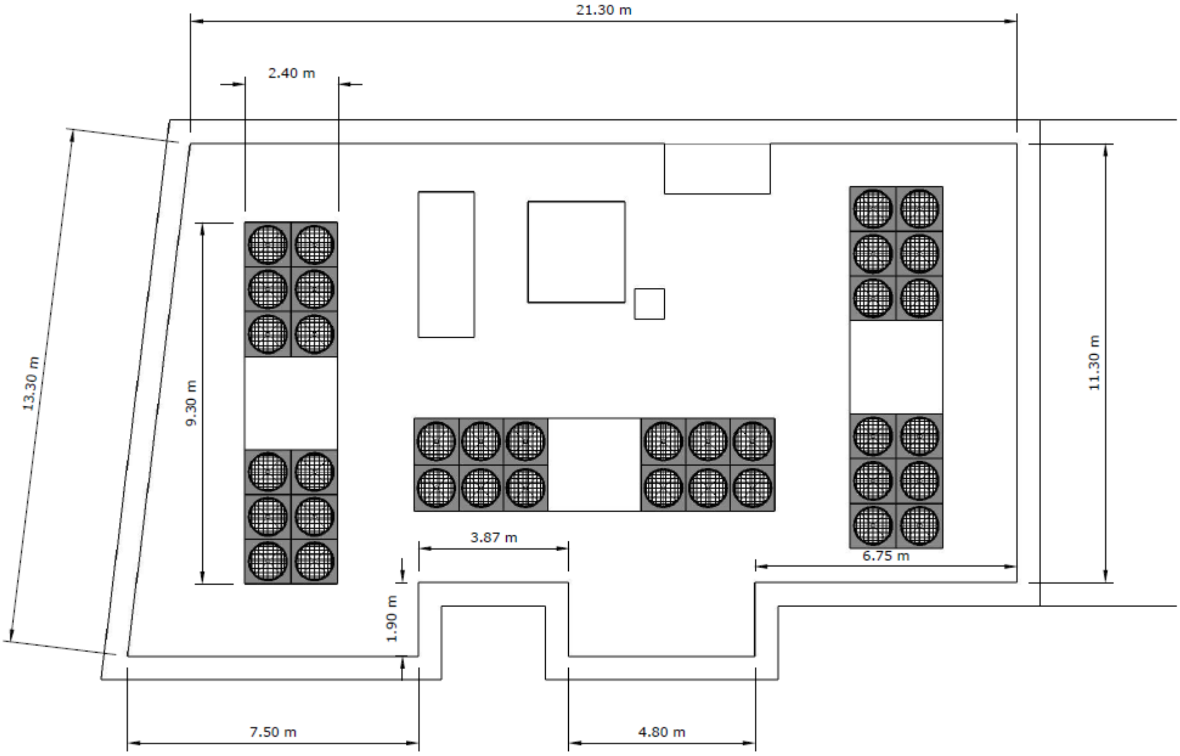


Figure 18: Unit Place Energy Centre Roof

### *Noise*

Following a meeting with the local planning officers, a planning application will be required for this modification. As a minimum, the heat pumps will require visual screening and possible acoustic attenuation. An acoustic survey is underway and awaiting results. The visual screening will be provided as per Figure 19. Examples of available screens are shown in Figure 20 and the final colour will match the existing Unity Place finish.

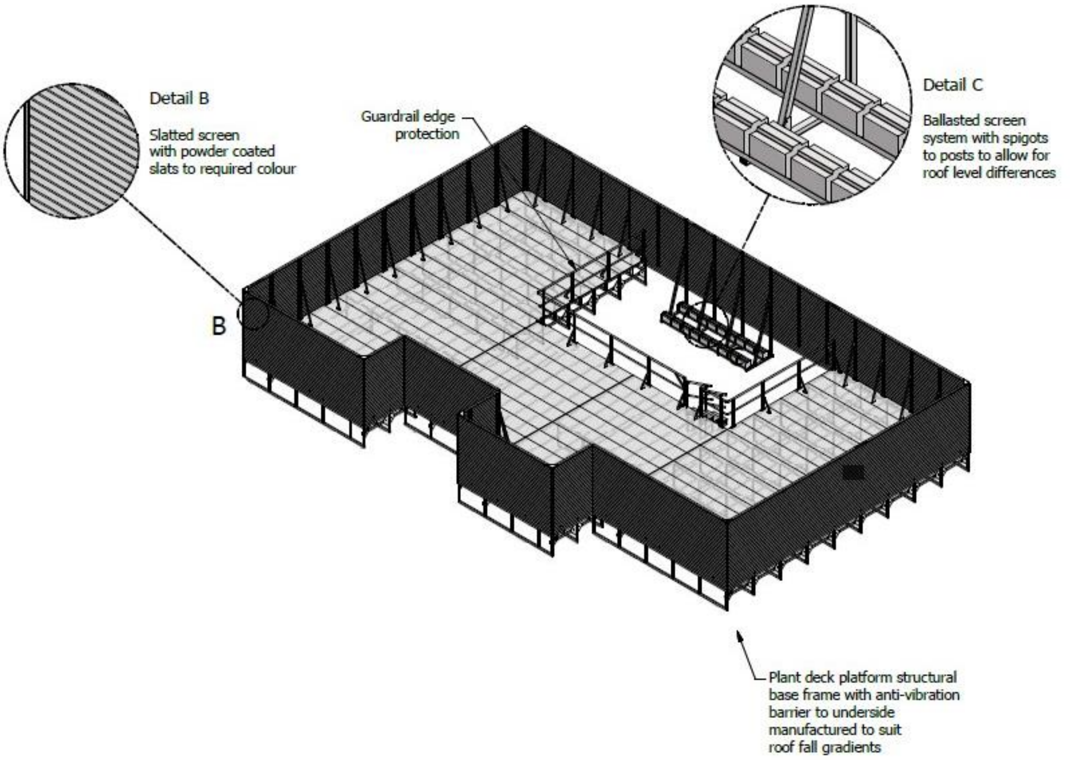


Figure 19: Platform and screen option for Unity Place roof

Figure 20: Examples of screens from Configured Platforms, slat colours available in RAL and BS colour ranges with polyester powder coat

### *Future phases*

Future phases of the network will require further heat pumps to maintain the desired ~90% low carbon heat. There is not enough space on the Unity Place energy centre roof for more ASHPs therefore another location will be required. This could be from a separate energy centre or on the roof of a nearby building feeding directly into the main energy centre.

If a separate energy centre is to be built, then the network size will need to be increased to allow energy flow from the two separate energy centres. Hereford and Exeter development is currently in the design and planning phase and is adjacent to the current energy centre. Therefore, it is preferable to locate the additional ASHPs on Hereford and Exeter to feed directly to Unity Place Energy Centre. Block C1 has potential space for up to 4 x 400 kW ASHPs if required as shown in Figure 21.

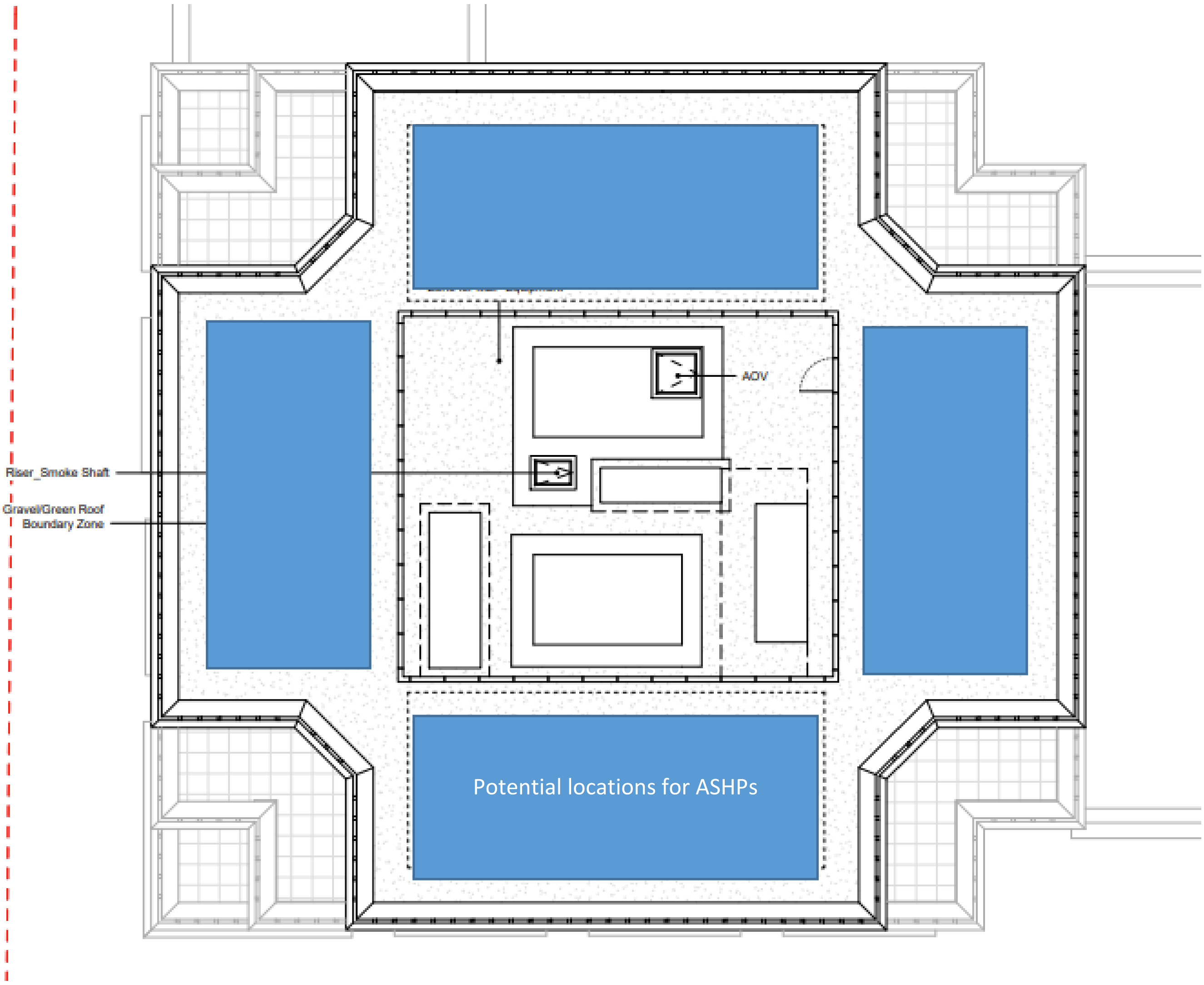


Figure 21: Hereford & Exeter roof plan

### 4.2.2 Sewer heat recovery

ASHPs on Unity Place and Hereford and Exeter roofs will be capable of serving up to Phase 4 of the current plan. However, if the network is to expand to incorporate all the potential developments within the network boundary, more additional heat sources will be required. One of the options to provide heat for the future expansion of the network is for sewer heat recovery.

There are multiple large sewers around the area of the proposed energy centre location, see Figure 22. The largest of these is the Ranelagh Trunk sewer running along Kilburn Park Road. This sewer is a combined foul and storm water drain that serves a large part of the upper catchment area and has consistent flows.

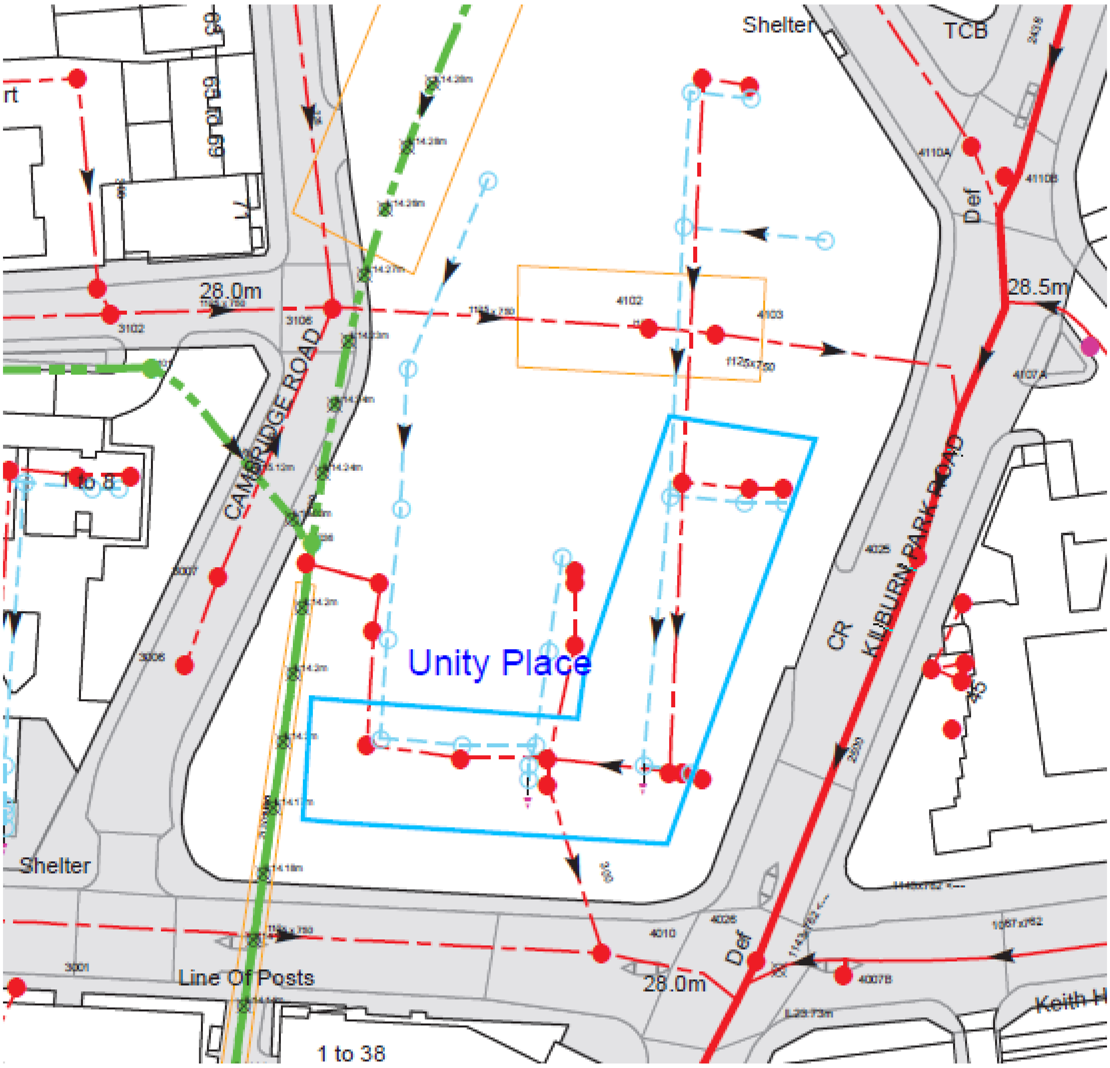


Figure 22: Map of sewer locations around Unity Place

### *Available resource*

As part of the sewer feasibility investigation, monitoring of the flow rates and temperature in the sewer was carried out. The flow monitoring took place in May 2021 and again in January 2022, each for 6 weeks. A sample of the results is shown below in Figure 23

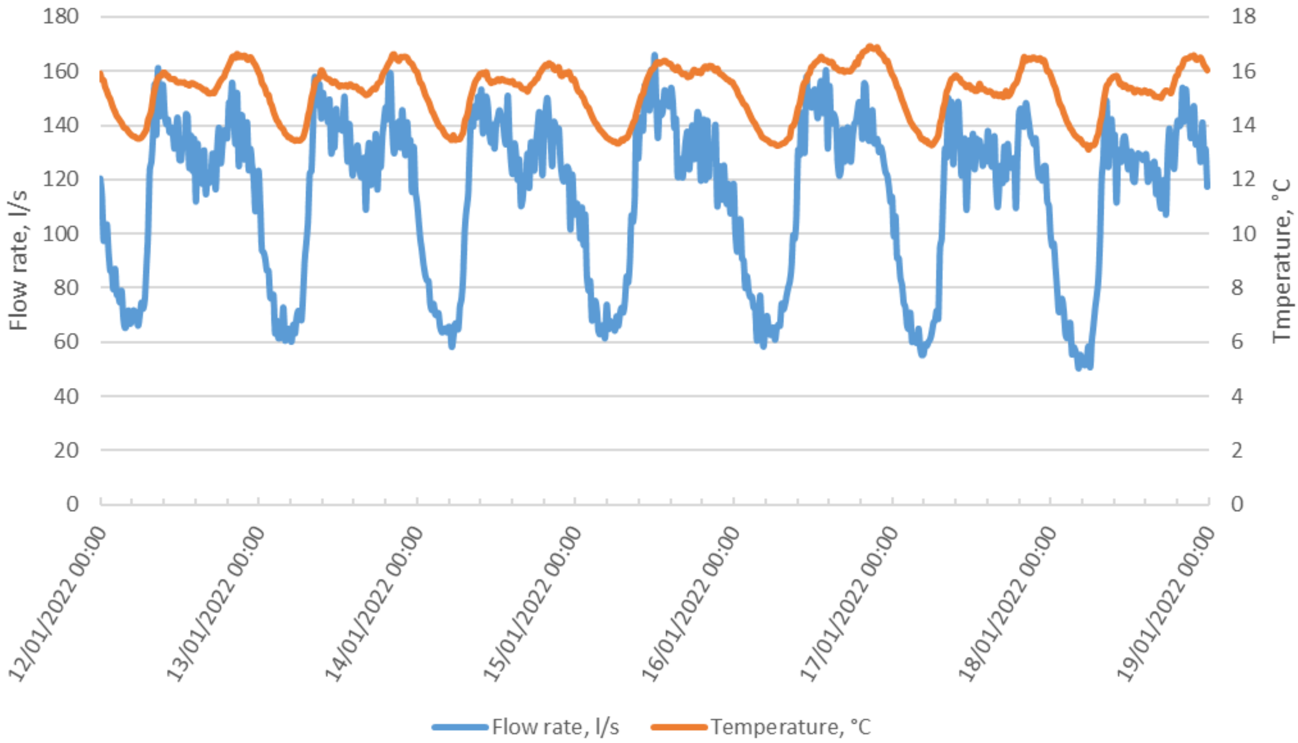


Figure 23: Kilburn Park Road sewer monitoring results

From this monitoring the minimum flow rates were around 50 l/s and the minimum temperature was 13 °C. The average flow rate throughout the day was 120 l/s. After consultation with Thames Water, it was recommended that the minimum return temperature to avoid solidification of Fats, Oils and Grease (FOG) would be 10 °C, however, this could change following a more detailed survey of the sewer.

To determine the largest size of heat pump that could be used it is assumed that 2/3rds of the average sewer flow could be taken. To always maintain the temperature above 10 °C, a maximum ΔT off 3 °C is assumed. Therefore, a sewer source heat pump with a maximum of 1300 kW output is the largest realistic heat pump that could be installed.

Table 5: Sewer heat pump sizing

| Sewer flow rate | Sewer flow rate, kg/s | ΔT, °C | Available heat from sewer, kW | Heat pump generation @COP 3.5, kW |
|---|---|---|---|---|
| Minimum | 50 | 3 | 630 | 810 |
| 2/3 Average | 80 | 3 | 1015 | 1305 |
| Average | 120 | 3 | 1512 | 1944 |

### *Sewer connection design*

A heat exchanger system must be used to extract the useable heat from the sewer. There are two main technical solutions for this: an in-sewer system or a wet well system. The benefits and disbenefits of each solution are discussed below in Table 6: Sewer system design benefits and disbenefits

Table 6: Sewer system design benefits and disbenefits

| Heat exchanger design | Benefits | Disbenefits |
|---|---|---|
| In-sewer | • Does not require extra space for external heat exchangers<br>• Simpler construction | • Complex installation into existing sewer<br>• Complicated maintenance requirements within sewer |

| Heat exchanger design | Benefits | Disbenefits |
|---|---|---|
| | | • Increased risk of flooding from sewer blockages |
| Wet well | • Most of the construction can be done without impacting sewer<br>• Lower risk of flooding as no equipment installed in sewer<br>• Maintenance is external to sewer in self-contained wet well | • Increased CAPEX<br>• Large wet well construction ~3m diameter close to sewer<br>• Space required for external heat exchangers in Unity Place carpark |

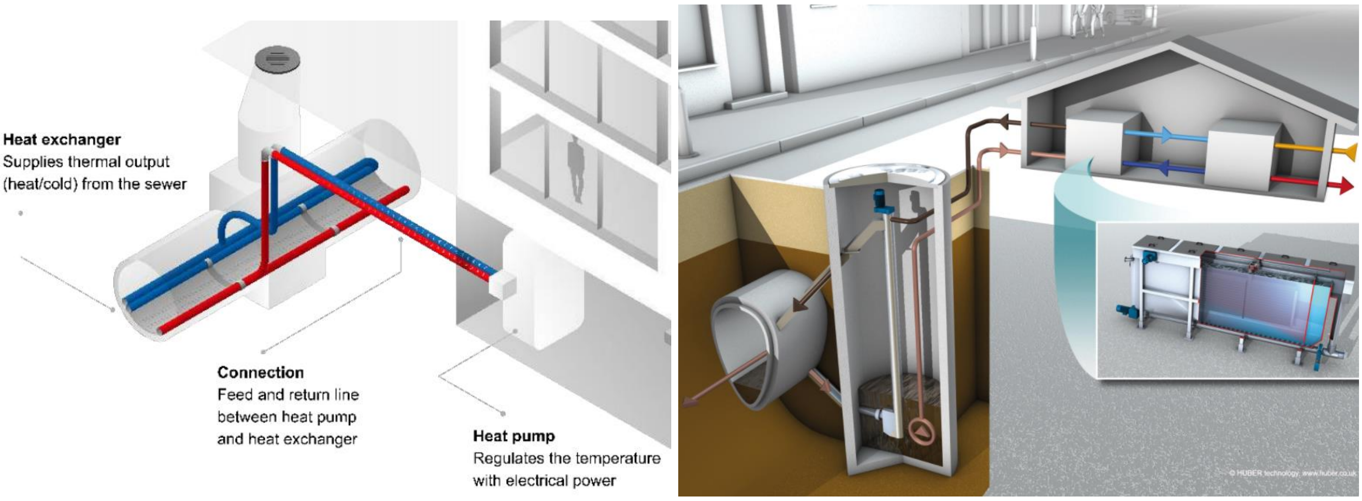


Figure 24: In-sewer system (left) and wet well (right)

### *Energy Centre considerations*

Given the constraints of installing the in-sewer system in an existing sewer and the complex maintenance requirements, the preferred technology for sewer heat recovery is the wet well design. The best location for the wet well is the large footpath area to the Northeast corner of the basement of Unity Place as shown in Figure 25.

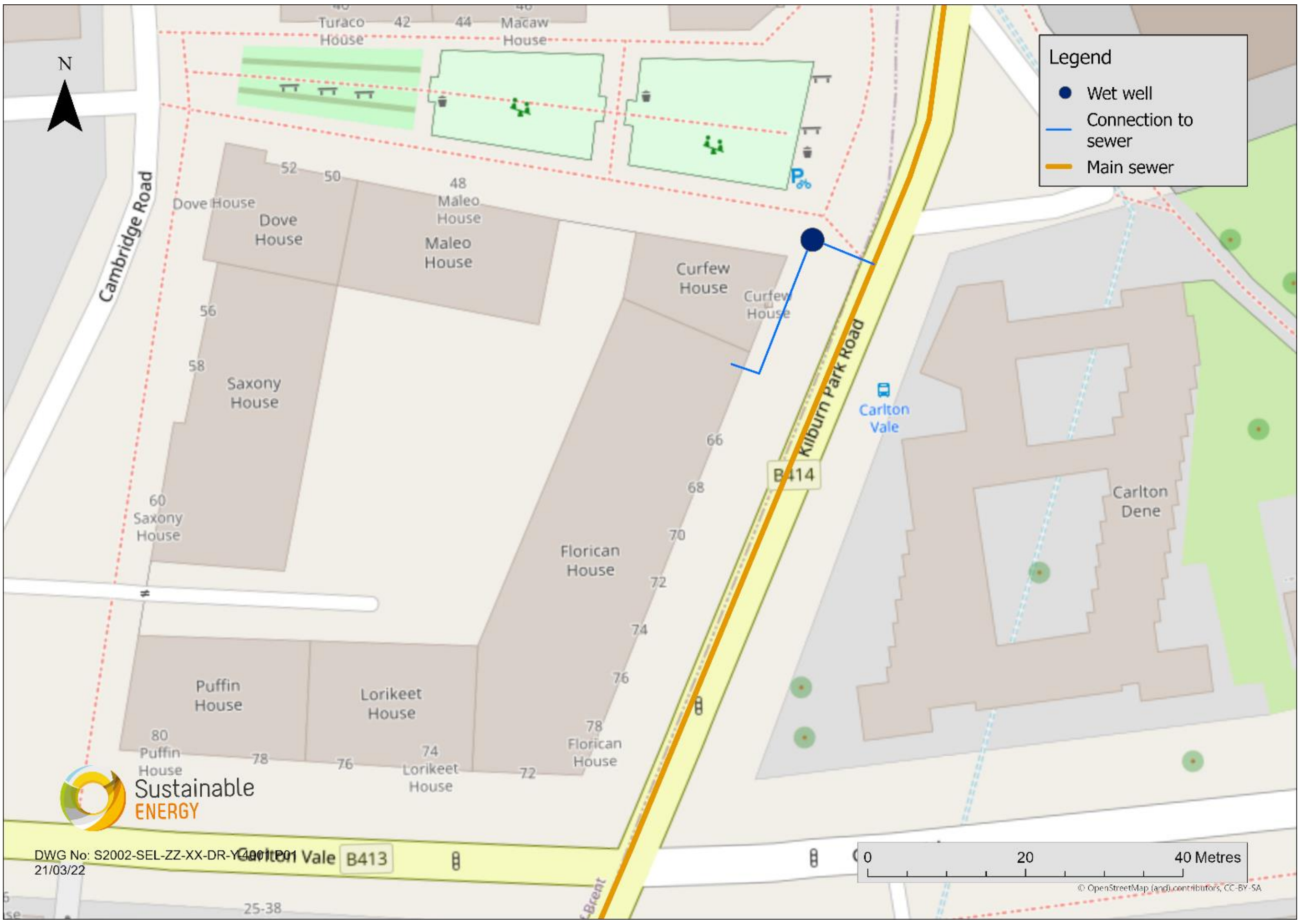


Figure 25: Wet well position

The key equipment items are shown in Figure 26 which details the connections from the sewer to the heat pumps which will be located in the basement energy centre.

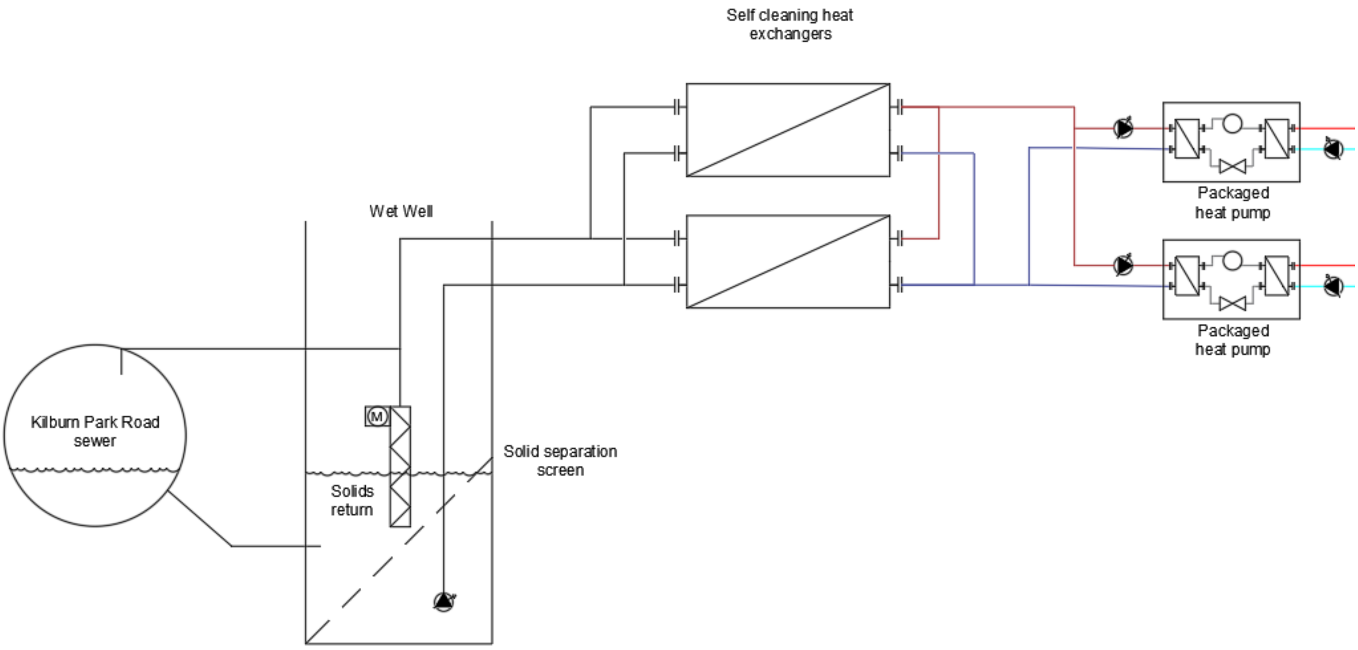


Figure 26: Sewer connection PFD

The heat exchangers will require space in the basement carpark. This location has been chosen due to the proximity to the external wet well to minimise foul water pipe runs within the basement. The current parking space layout would require 4 disabled parking spaces.

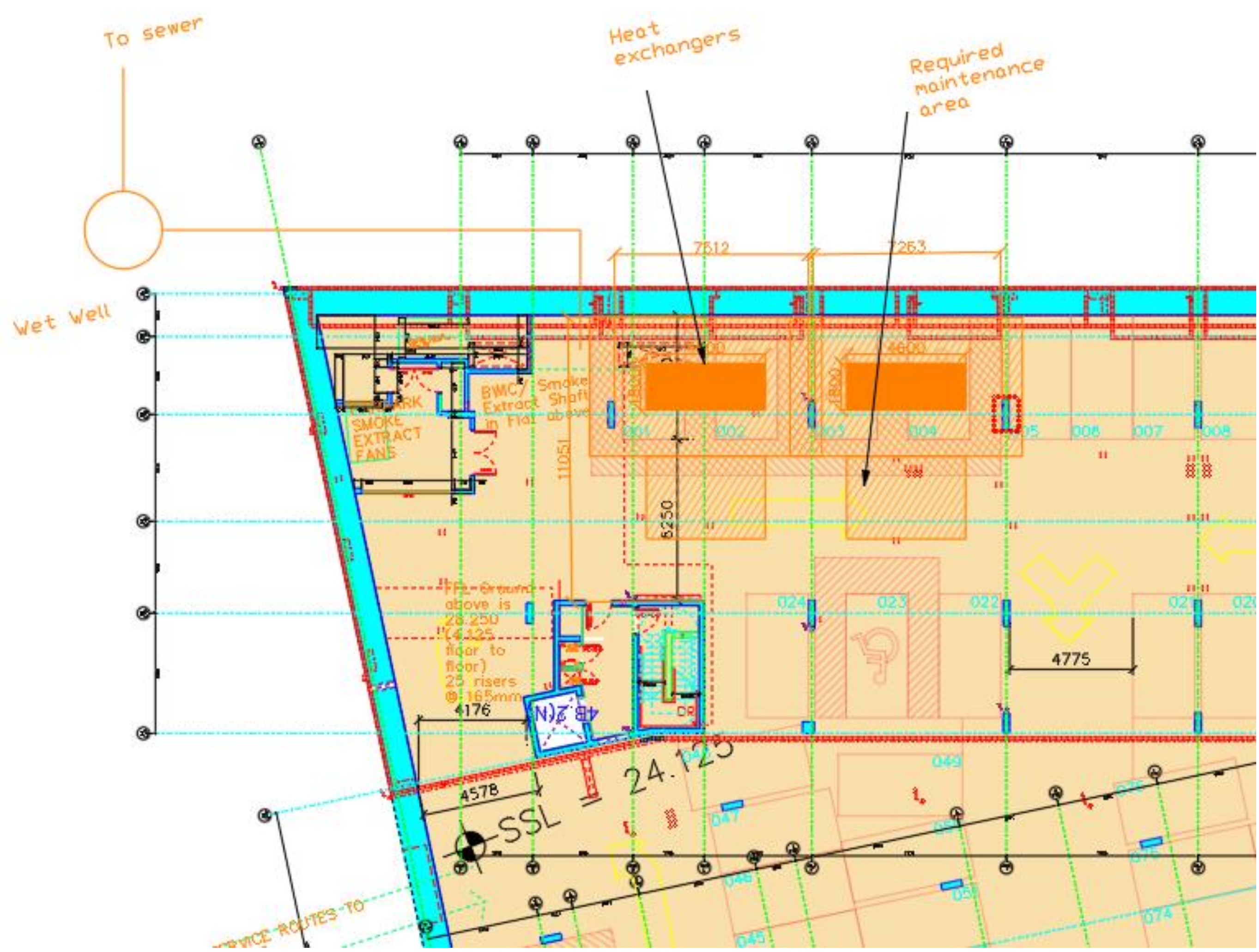


Figure 27: Basement car park with sewer heat exchanger location

### 4.2.3 Peak and Reserve Boilers

Peak and reserve boilers have been sized to provide full charging capacity for the thermal storage tanks and to meet peak supply conditions directly. The boilers have been sized to allow multiple boilers to modulate in unison to meet heat demands, this will provide redundancy and allow boilers to operate at their highest efficiency throughout the range. The boilers have been sized to ensure that failure of any one item of equipment will not prevent the peak heat demand from being met.

***Gas boilers***

Gas boilers will provide a low OPEX solution based on existing gas prices. The gas connection is available and low cost.

***Electric boilers***

CAPEX will be low for the electric boilers, however, the electrical connection to the energy centre will require significant grid reinforcement to provide full peak and reserve capacity and will come at significant extra CAPEX.

When grid infrastructure is stronger in the area, electric boilers can be installed alongside gas boilers to balance economics and carbon emissions as required.

## 4.3 Energy Centre Footprint

The energy centre space allocated in Unity Place is approximately 460m$^2$ with a varying height between 4 – 5m. The plant selected fits into the current energy centre. A general arrangement for the energy centre is shown in **Error! Reference source not found.**. The arrangement includes consideration of the installation, operation, maintenance, and decommissioning of key plant items.

Process flow diagrams (PFDs) outlining the key functionality of the heating system for the initial and fully built-out networks and are shown in

Figure 28 to

Figure 30

Figure 29.

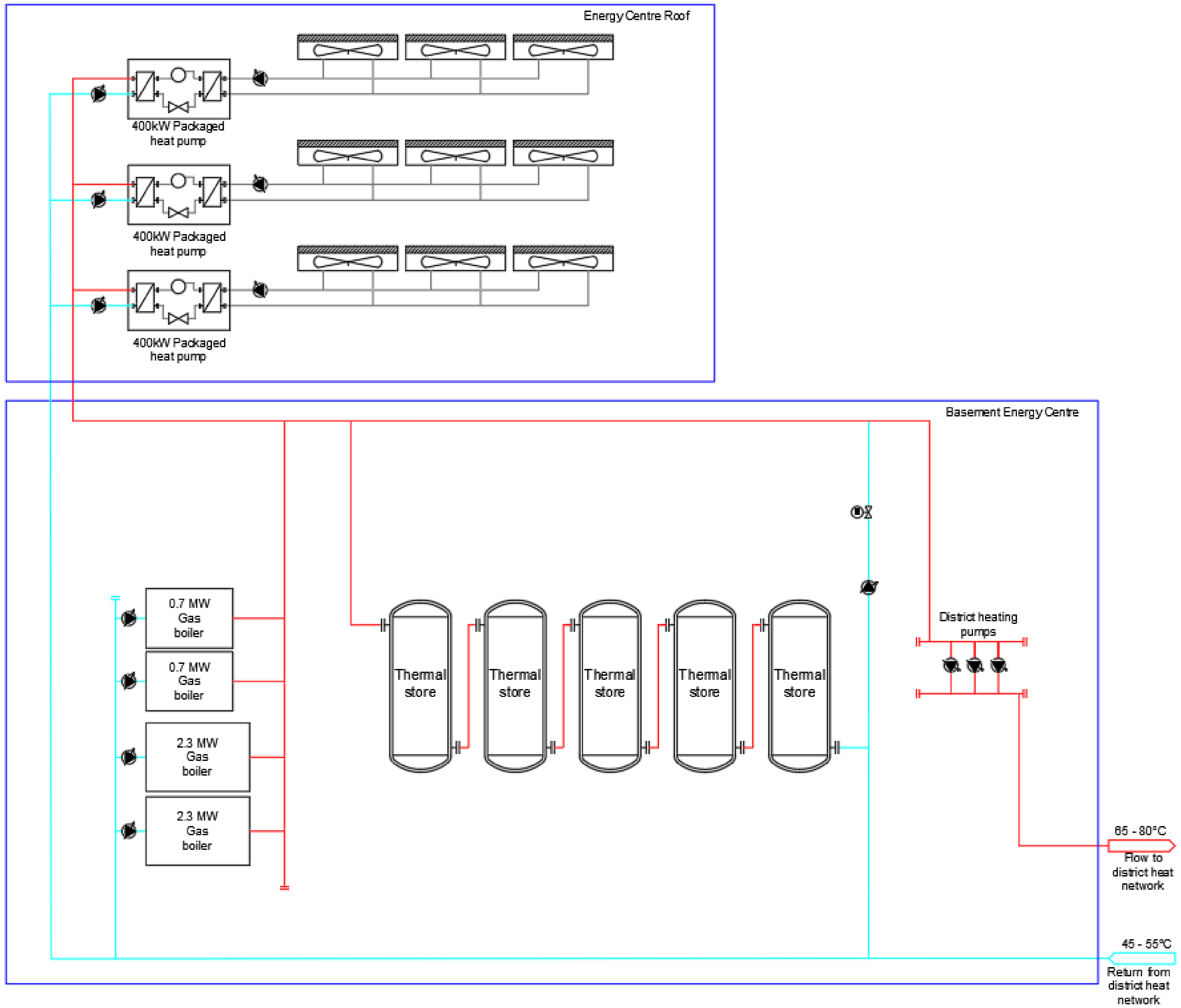


Figure 28: Energy centre PFD – phase 1

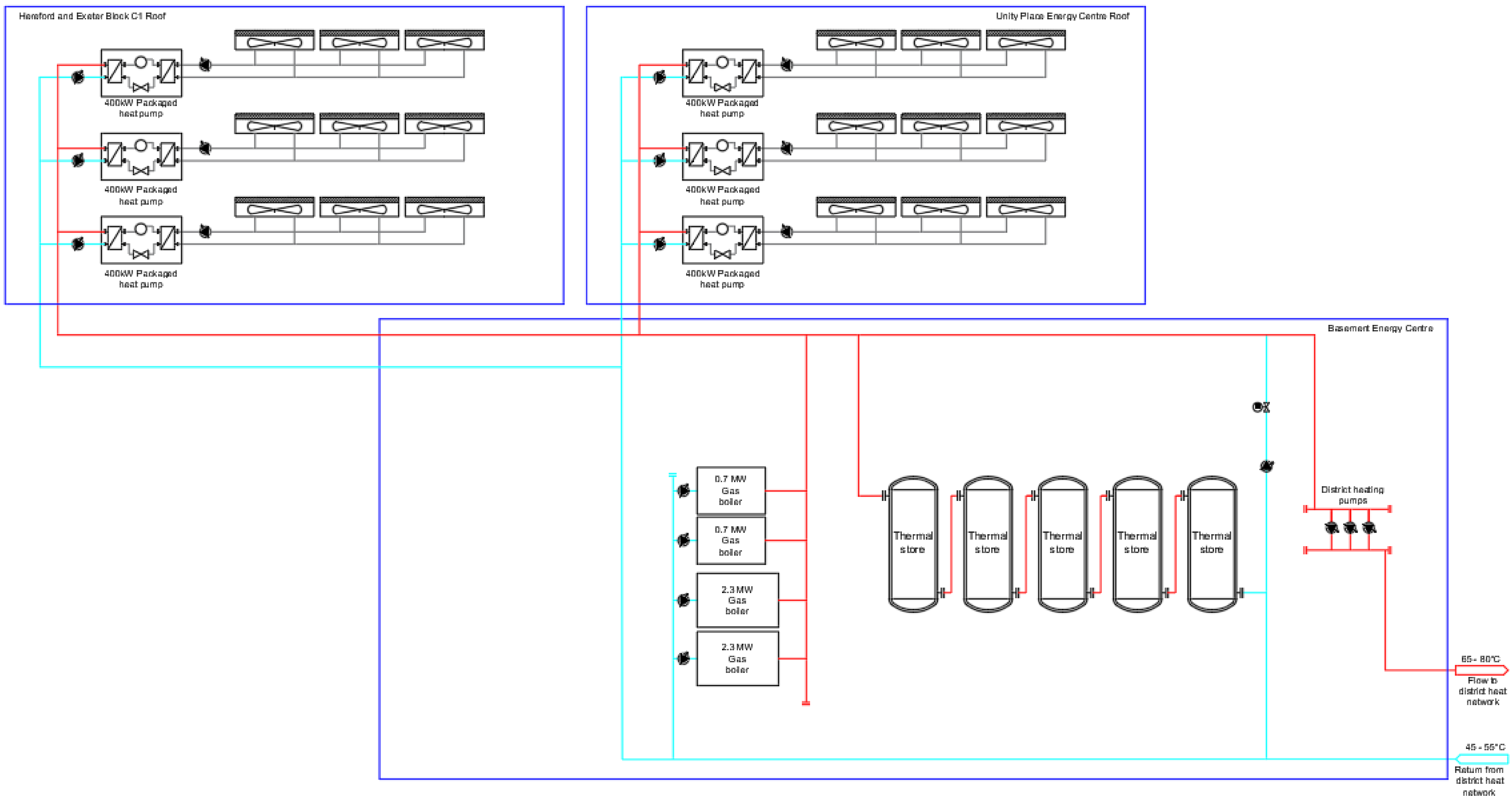


Figure 29: Energy centre PFD – phase 2 - 4 ASHP only

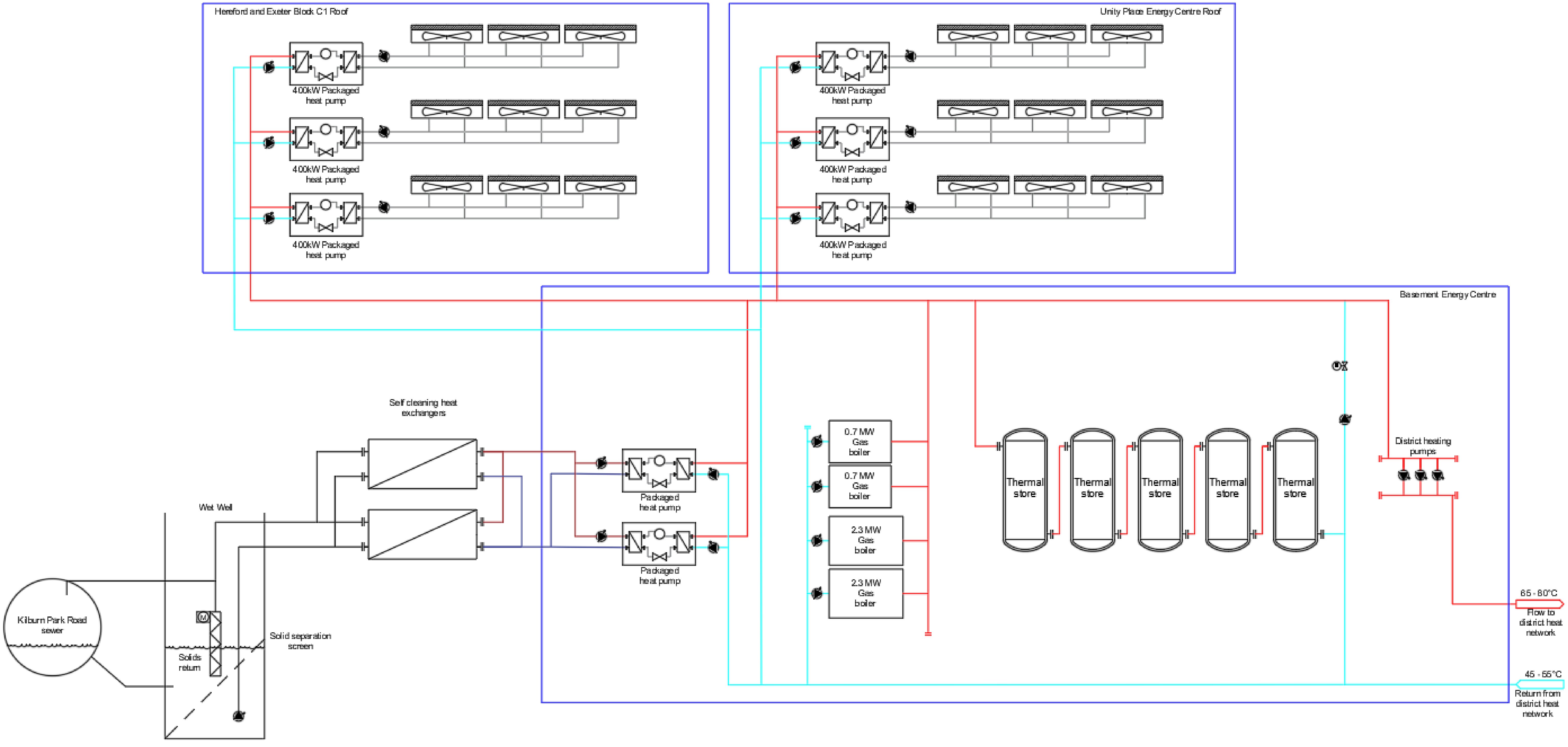


Figure 30: Energy centre PFD - future sewer heat pump integration

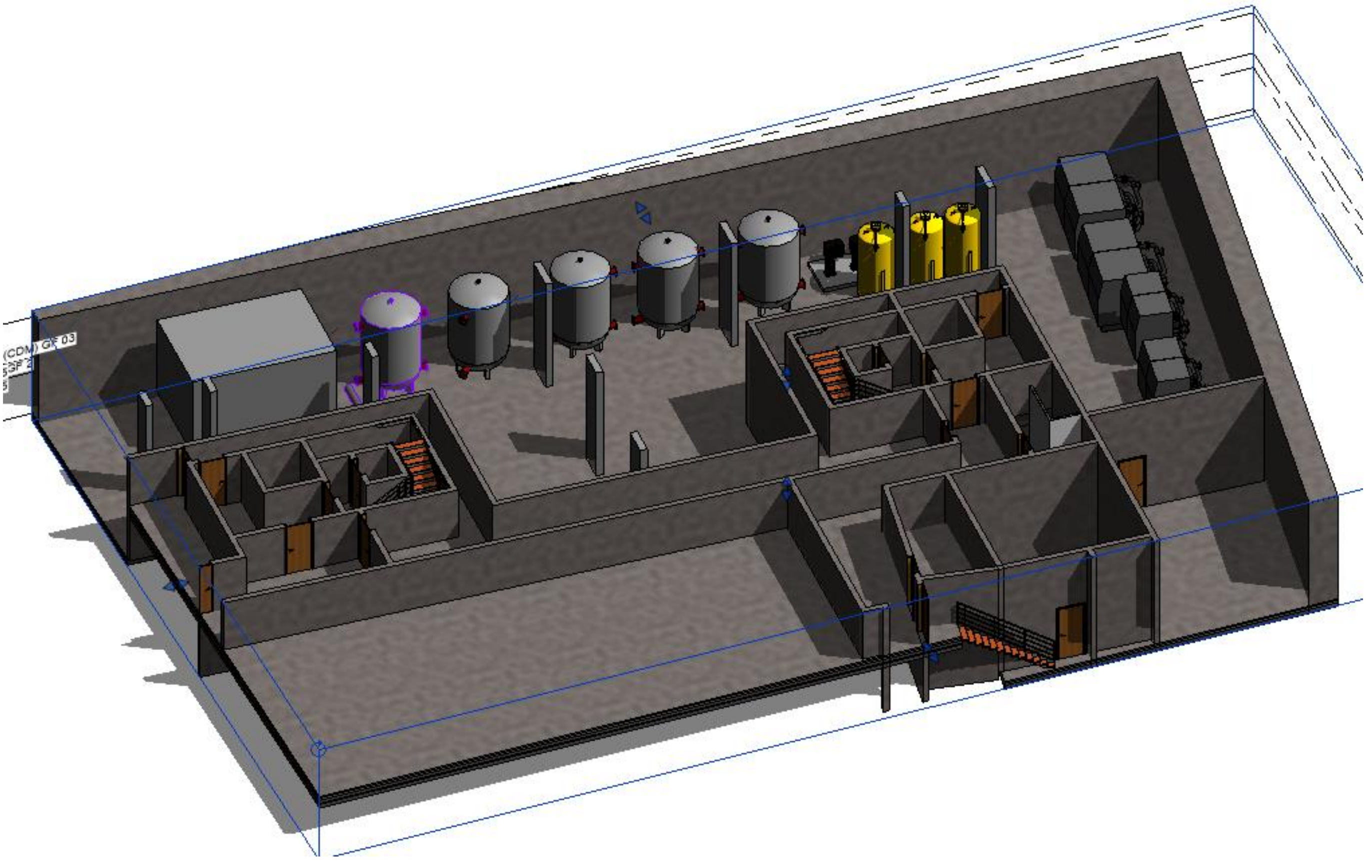


Figure 31: Energy centre – internal view

## 4.4 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 network will utilise 5 x ~10,000 $m^3$ thermal stores of circa 2 m diameter and 4 m height.

The thermal storage capacity could be increased to increase the percentage of low carbon heat. However, this would require additional space in the basement carpark or in another building. The effect of thermal storage volume on the percentage of low carbon heat delivered is shown in Figure 32

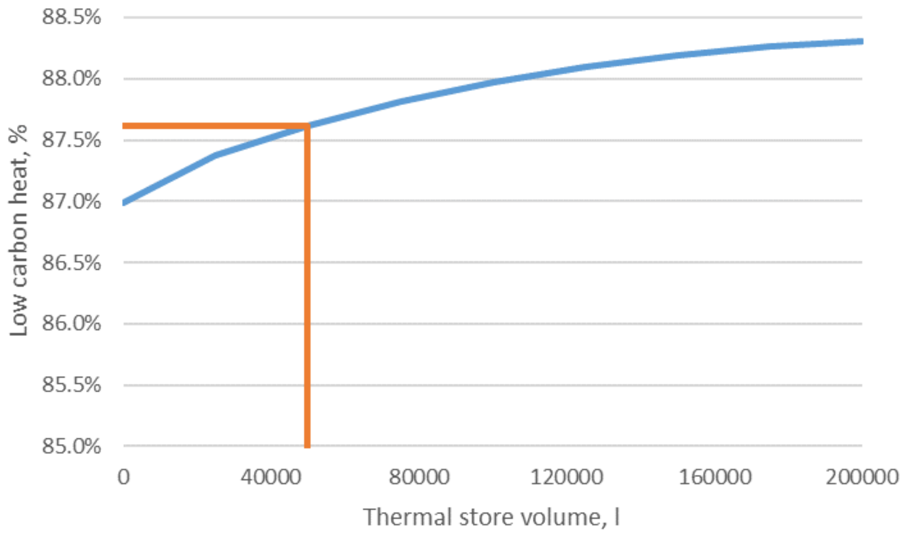


Figure 32: Low carbon heat % with changing thermal store volume

## 4.5 Flues

The design of the gas boiler flues needs to achieve sufficient velocity of exhaust gas to achieve adequate dispersion, avoiding concentrations of harmful gasses such as nitrogen oxides (NOx). The effects of wind loading and structural requirements of the flues must also be assessed and incorporated into the structural design of the energy centre.

Gas boilers will be low NOx versions and will run only when the network demand exceeds the capacity of the heat from the heat pumps and thermal stores, therefore impact on the air quality of the area will be reduced. An air quality assessment for a previous iteration of the energy centre which included the same gas boilers and additional CHP engines has been done showing that the energy centre will have an insignificant to slight effect to the local area. See Appendix 7 – Air Quality Assessment for proposed energy centre

## 4.6 Ventilation

Futureproofed options for sewer will require additional work to determine if existing ventilation riser is of sufficient dimensions to install ducts for phase 5 heat pump ventilation to EN 378.

## 4.7 Variable Speed Pumps

The design utilises variable speed pumps in a multi-pump arrangement (3 pumps – 1no. duty, 1no. assist 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 at the index of the heat network. The pressure independent control valves at the substations will modulate to control heat delivered to the buildings and ensure 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.

## 4.8 Ancillary equipment

All balance of plant such as pressurisation, expansion and water treatment are designed with redundancy so that failure of any one item will not prevent the plant from generating and distributing heat to the network.

## 4.9 Utilities Connections

### 4.9.1 Electricity

An electricity connection able to supply up to 500 kVA will be required for Phase 1 energy centre. A budget quote of £125,000 (excluding VAT) was received from UKPN, which includes electricity for the energy centre only and does not consider the additional electricity demand for the wider development.

A further 500 – 1000 kVA will be required in the Hereford and Exeter energy centre and should be applied for as part of the Hereford and Exeter building.

An alternative worst-case option of a 7000 kVa connection was received which would enable the use of electric boilers for peak and reserve. This quote was £1,979,800 which would cover the installation of extra RMUs and associated 11kV cabling.

### 4.9.2 Gas

The cost of the gas connection has been estimated as £100,000 (excluding VAT). The high connection cost is due to the requirement for a medium pressure gas main and the significant distance from a possible connection point. The medium pressure gas kiosk will be located a minimum of 8m from Unity Place building. The plans for the gas kiosk building are in Appendix 6 – Medium Pressure Gas Kiosk.

### 4.9.3 Water and drainage

A mains water supply and drainage is available as part of the Unity Place development.

## 4.10 Metering

All metering will 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.

### 4.10.1 Heat

The energy centre will have three heat meters installed: one combined heat pump heat meter, a combined gas boiler heat meter 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 measure of flow and energy. Data from all meters will be imported into the control system and used for control and monitoring of system performance.

### 4.10.2 Gas

There will be a gas boilers consumption meter. The meter will output cumulative values and be monitored to provide performance measurement and control of the energy centre.

### 4.10.3 Water

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 the energy centre. All data will be collected by the control system.

### 4.10.4 Electricity

Electricity meters will be fitted to the supply to the heat pumps, the supply to energy parasitic load and the import electricity from the grid.

# 5 HEAT NETWORK

## 5.1 Operating Conditions

A detailed assessment of the proposed network has been undertaken and the proposed operating conditions reflect the optimal network efficiency. To effectively serve the new build and existing developments the heat network will operate with variable temperature conditions.

### 5.1.1 Primary Network Temperatures

Heat pumps have a performance which is significantly impacted by the temperature conditions of the network and, to maintain efficient performance, network flow and return temperatures should be as low as possible. The primary heat network will provide heat via plate heat exchangers which means the flow temperature on the primary network into each building at up to 80°C at peak conditions and 65°C flow temperatures for off peak and summer conditions.

### 5.1.2 Secondary Systems / Building Heating System Temperatures

Buildings should be designed to reduce building heating system temperatures in accordance with CIBSE / ADE CP1 and will result in lower average return temperatures and therefore increase the efficiency of the network and the heat generating technologies.

***Existing buildings***

Existing buildings target peak secondary side flow temperatures should be 75 °C and secondary circuits should be upgraded to reduce return temperatures as far as practically possible with a target between 50-55 °C.

***New developments***

For new developments, target secondary side temperatures should be 55°C flow and 35°C return, in line with the Future Homes directive for systems to be compatible with low temperature heat sources. Key considerations for the heating design are to allow for low temperatures while maintaining flowrates that can be effectively controlled. This means a ΔT across the emitters of 20°C maximum would be optimal.

### 5.1.3 Operating Pressure

The highest point of the primary system will be the roof top plant at Unity Place or Hereford and Exeter. To maintain a pressure of 0.7-1.0 barG at this point gives a static pressure requirement of circa ~5 barG in the basement energy centre.

The pumping pressure defines the maximum operating pressure to generate 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 throughout the seasons and the concept design considers maintaining maximum pressure in the system at less than 9 barG.

## 5.2 Network Route

The pipe routes have been designed to consider pipe length and barriers such as highways and construction limitations. The network has been designed with futureproofing to allow expansion of the scheme.

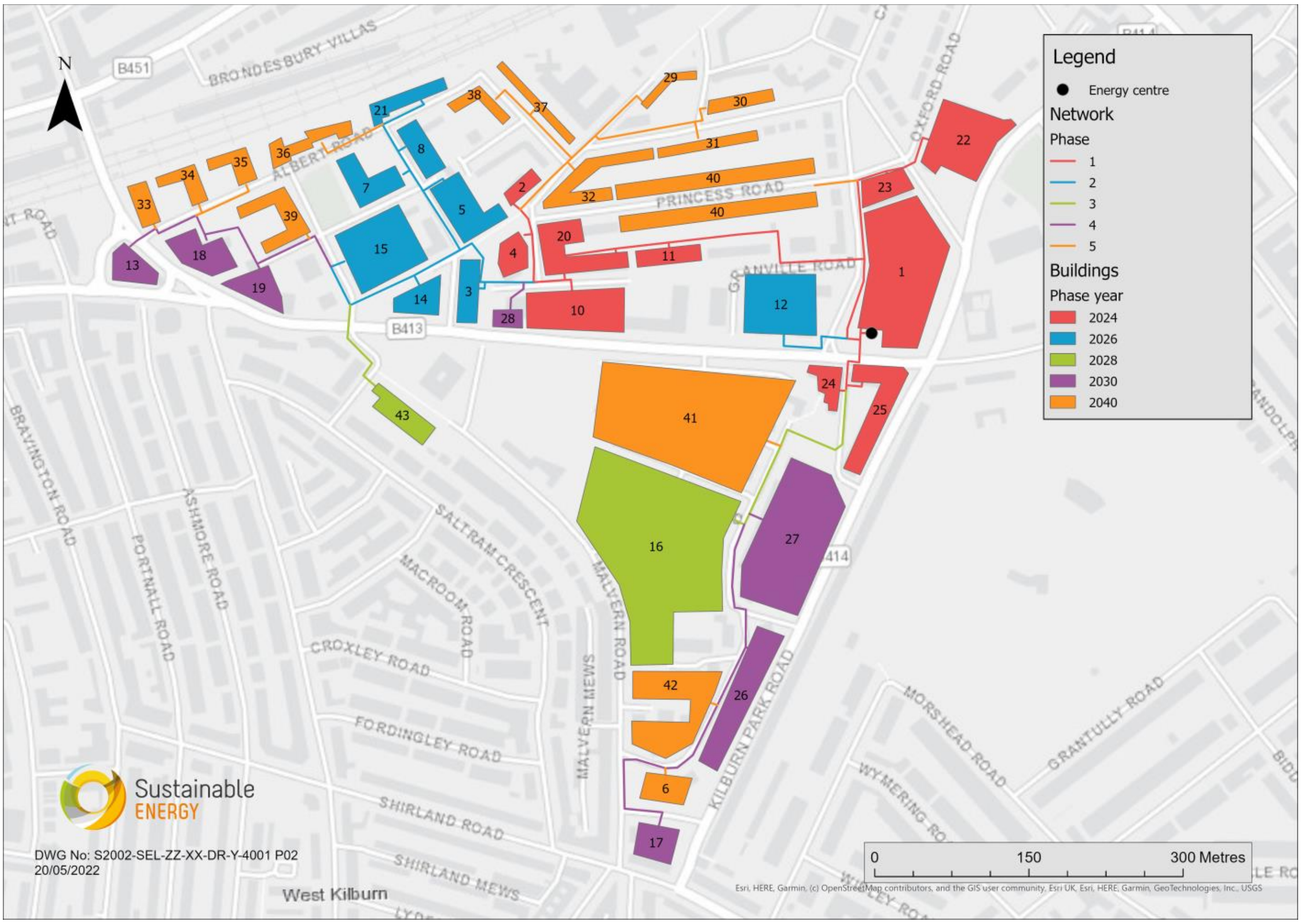


Figure 33: Network route

## 5.3 Pipe Sizing and Insulation

Netsim modelling software was used to determine the characteristics and sizing for each part of the network with the aim of minimising pumping energy costs and heat losses. The software allows for scenarios to be modelled to determine pipe characteristics, velocity and flow temperatures. Energy centre pumping requirements are also considered to ensure the optimum pipe size is selected. Figure 34 shows an example output from the software displaying pipe velocity under diversified load conditions.

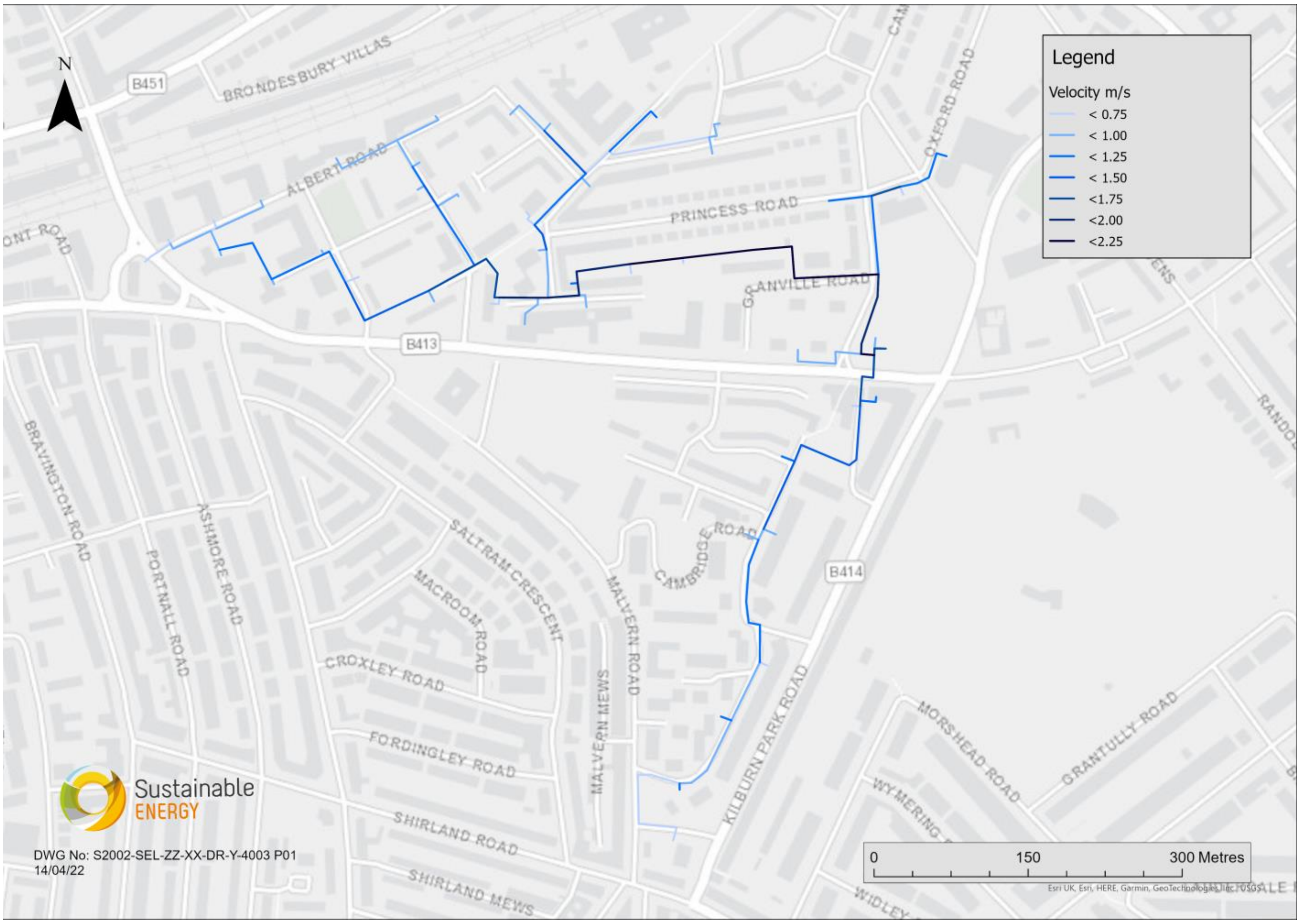

Figure 34: Example of pipe velocity under diversified load conditions

As stated, the network has been designed with futureproofing to allow expansion of the scheme.

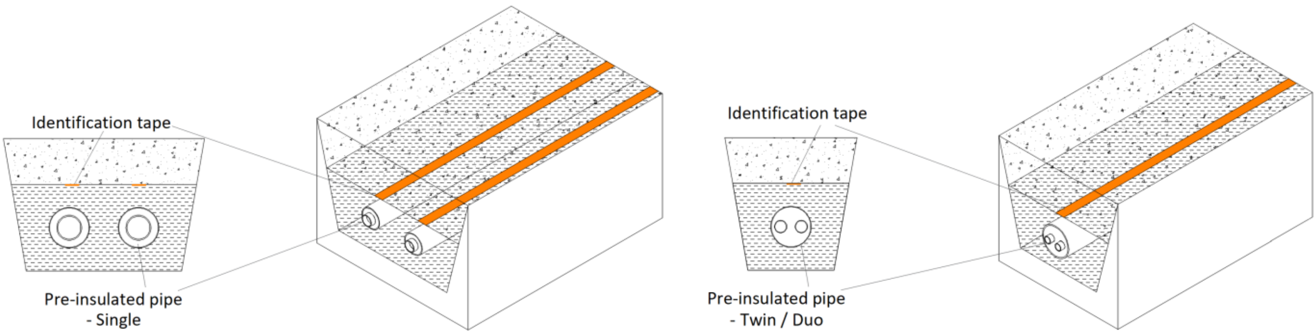


Figure 35: Pipes in trench

The heat network has been designed as a pre-insulated ridged steel pipe system for larger pipe diameters and where possible flexible pre-insulated polymer pipe for smaller diameters. The pre-insulated pipe will either be installed as single pipe (with a separate pipe for the flow and the return) or twin pipe where both the flow and return pipe are housed within the same casing, see Figure 35.

The network includes the spine (connecting the energy centre to the development parcels) and the branches and feeds within the parcels network (connecting the spine to the heat users). The spine network dimensions are shown in Table 7 below. There is xx km of spine network.

Table 7: Spine pipe sizes and lengths

| Pipe size | Trench length, m | | | | | |
|---|---|---|---|---|---|---|
| | Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 | Total |
| DN65 | | | | | | |
| DN80 | | | | | | |
| DN100 | | | | | | |
| DN125 | | | | | | |
| DN150 | | | | | | |
| 40+40/142 | | | | | | |
| 50+50/182 | | | | | | |
| 63+63/202 | | | | | | |
| **Total** | | | | | | |

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 polyethylene (HDPE) pipe casing and all fittings and joints will be manufactured in compliance with EN 253 standards. The heat losses and size of trenches for the spine network have been based on a series three insulation thickness of polyurethane foam with diffusion barrier.

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

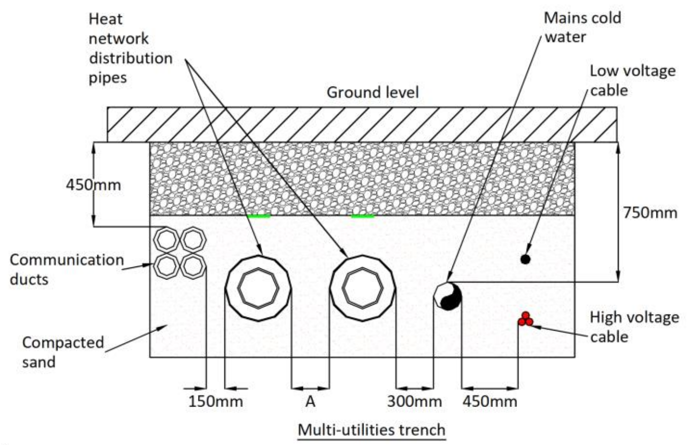


Figure 36: Multi-utilities trench

In addition to the district heating pipework the network trenches can also be used for the distribution of utilities such as water, electricity and communications infrastructure. When multiple utilities are present in a trench it is important to ensure that they are positioned a safe/workable distance from each other. The NJUG Guidance for Buried Utilities outlines how this can be achieved. Figure 36 shows an example of a multi-utility trench.

Pipe lengths, CAPEX and layouts are based on site surveys, desktop utility surveys and GPR data to minimise the potential for unforeseen problems when installing the network. However, this data is not definitive and is subject to change.

# 6 BUILDING CONNECTIONS

All network connections are assumed to be indirect (where a heat exchanger separates the heat network hydraulically from the building space heating and hot water systems). All building connections will be a bulk supply model where the ESCo will provide heat via a single substation. The building owner/developer will be responsible for the secondary pipework, individual HIUs and tertiary systems to provide heat to the final user.

The substation packages will include:

- Supplier meter to meter all heat usage on the primary side of the connection.
- Two-port differential pressure control to control the supply flowrate and temperatures across the heat exchanger via two-port control methodology. Control valves can either be a single PICV or a DPCV with a separate two-port control valve.
- Plate heat exchanger (PHE) at which the district heat is transferred to the customer secondary side network. PHEs will be specified with a maximum 3°C approach temperature across the return lines and a maximum 80kPa pressure drop on the secondary side of exchanger.
- Means of flow measurement and test points on both sides for commissioning purposes.
- Filtration to protect the to protect the plate heat exchangers and valves from fouling.
- Flushing, filling and draining details for chemical flushing of all pipework on the primary and secondary side.
- Pressure relief, control and instrumentation to allow the supplier control and monitor of the supply of heat.

The substation can include one or more plate heat exchangers (PHEs) (two shown in the example in Figure 37), 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, provide a full thermal range, and some redundancy to permit service and maintenance periods. Larger substations may include more than two PHEs. Only the key functional features are shown in the simplified schematic in Figure 37.

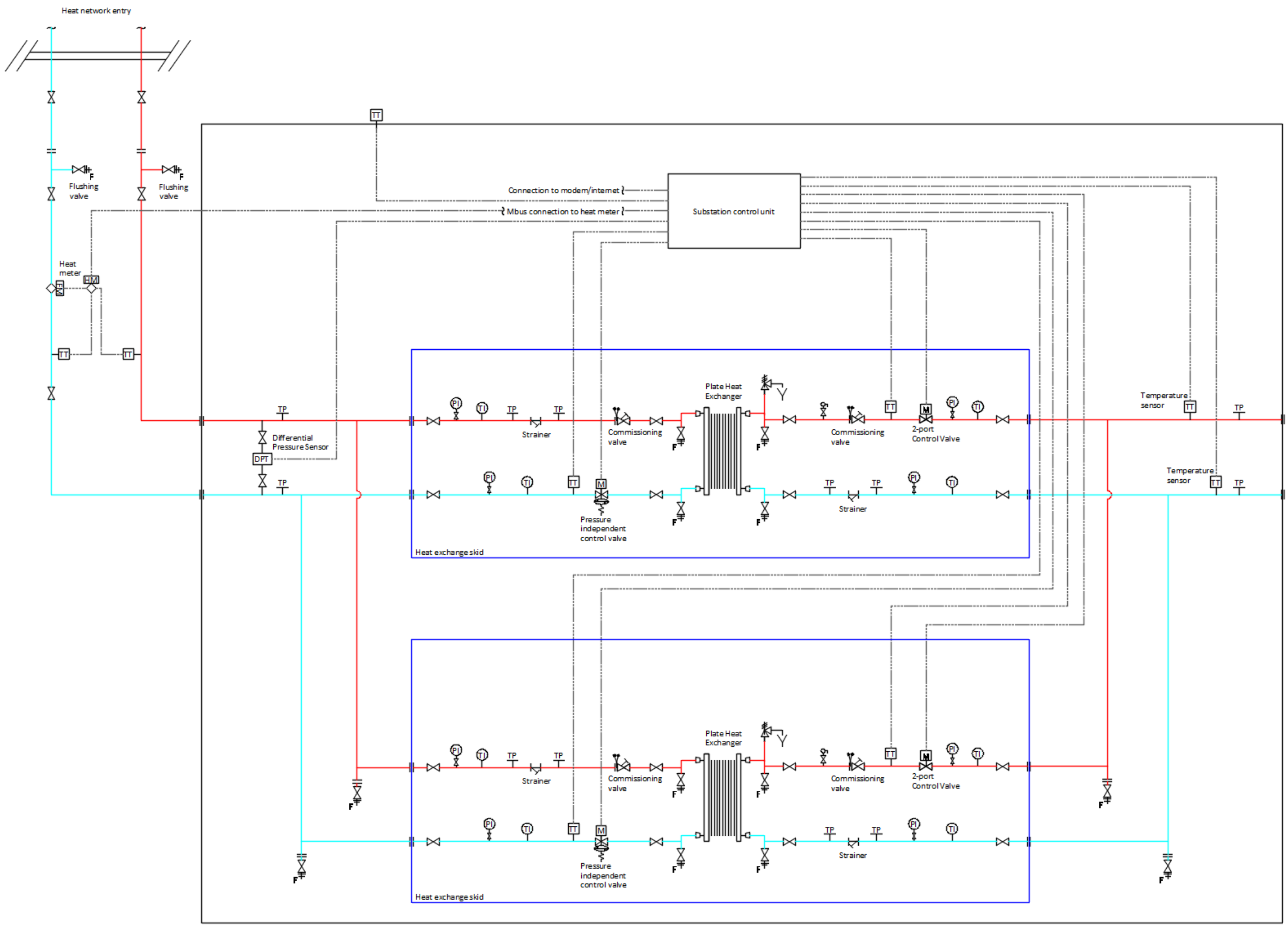


Figure 37: Example of typical substation connection for commercial development

# APPENDIX 1 – BOREHOLE RECORDS

# APPENDIX 2 – SHORT LIST OPTION DIAGRAMS

# APPENDIX 3 – UNITY PLACE STRUCTURAL REPORT

# APPENDIX 4 – UNITY PLACE ROOF PLATFORM DETAILS

# APPENDIX 5 – SEWER MONITORING REPORT

## APPENDIX 6 – MEDIUM PRESSURE GAS KIOSK

# APPENDIX 7 – AIR QUALITY ASSESSMENT FOR PROPOSED ENERGY CENTRE