AECOM

Reading Heat Network

Work Package 2 – Detailed Techno-economic Feasibility Study

Reading Borough Council

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Quality information

Prepared by	Checked by	Verified by	Approved by
Damien McCaul Senior Energy Engineer	Asad Kwaja Principal Engineer	Rob Boyer Regional Director	Cornelius Kelleher Principal Consultant

Revision History

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Prepared for:

Reading Borough Council

Reading Borough Council
Civic Office
Bridge Street
Reading
RG1 2LU

Prepared by:

Damien McCaul
Senior Energy Engineer
T: +44-(0)20-7061-7000
M: +44-(0)755-257-2241
E: damien.mccaul@aecom.com

AECOM Infrastructure & Environment UK Limited

Aldgate Tower

2 Leman Street

London E1 8FA

United Kingdom

aecom.com

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Executive Summary

This report and accompanying appendices are delivered as part of a Feasibility stage study funded by Reading Borough Council (RBC) and the Department for Business, Energy & Industrial Strategy (BEIS) as part of the Heat Network Delivery Unit (HNDU) plan of work. The goal of this study is to demonstrate to what extent heat networks are a viable proposition in Reading and what level of public funding would be needed, for example from the Green Heat Network Fund (GHNF) to make them so.

In this study, AECOM have identified an investable, low carbon and feasible district heating network within Reading. Referred to as "North of the Station", the initial core network is considered to be highly deliverable, with a small number of large anchor loads, comprising seven existing buildings and seven proposed new developments which are planned for completion within the next 3-4 years. The identified network meets the requirements of an initial network serving Reading by achieving the following:

Carbon Savings	Reduces emissions of connected sites by 83% over 40 years
Economic Viability	Up to 11.9% IRR over 40 years with the receipt of maximum grant funding Estimated 2.6% IRR without grant funding
Future Expansion	Attractive carbon intensity of heat to both existing and planned developments High potential for future expansion to other areas in Reading

Table 0-1 - Summary of Network Performance

The identified network has been designed as low temperature and low carbon to match the performance of on-site heat generation strategies proposed by the new developments. The majority of the low carbon heat generation would be sourced from the River Thames which forms the northern border of the boundary, and which is accessed via council owned land in Kings Meadow Park. Heat is also provided from air source heat pumps, with a small fraction coming from electric boilers. The network is estimated to reduce carbon emissions for the fourteen connected sites by **83%** over a 40-year network lifespan.

The network has been shown to achieve a positive Internal Rate of Return (IRR) of **2.6%** over 40 years without grant funding. This level of return is unlikely to be attractive to private sector investors, however the network has been designed to be compliant with the Green Heat Network Fund (GHNF), a capital grant fund which supports commercialisation and construction costs for the development of low carbon heat networks. With the addition of the maximum available grant funding, the predicted pre-tax IRR increases to **11.9%**. This may offer some level of margin for which discounts can be offered to proposed customers to encourage connection and still retain an IRR which would be attractive to private sector investors, generally considered to be 10% ± 2%.

The capital cost of the energy centre and core network serving the cluster is estimated to be **£19.6m**. As noted above, the maximum funding available from GHNF would be up to 50% of this cost. GHNF funding could also cover 100% of the project commercialisation costs, up to a limit of £1million, but this would be taken from the capped award limit of 50% of CapEx.

An energy centre location has been identified in close proximity to the connected key anchor loads on council owned land, adjacent to the Kings Meadow Car Park. This location removes any reliance on third parties or cost of land purchase and enables access to the River Thames as well as a number of other low carbon heat sources which are potential feasible for connection in future. This location and the energy centre design has high potential for expansion and addition of additional generation capacity which would enable future network expansion beyond the North of the Station cluster and into those clusters located further south towards Reading Town Centre. It is estimated that the available heat within the River Thames would be sufficient to provide >50% of Readings heat demand, currently met by combustion of natural gas. This could in turn contribute significantly towards the carbon reductions required to achieve Readings goal of being **net-zero by 2030**, as outlined in the council's Climate Emergency Strategy.

The core heat network includes a strategic section of pipework which crosses below and to the south of the railway lines, creating the opportunity for expansion of the network to Reading Town Centre. This pipework leg is made economically viable by the presence of two large new developments on Forbury Road and Kenavon Drive which are estimated to complete in 2025. Without the presence of large customers along a route than connects North of the Station to the rest of the town, it may not be economically viable to do so, hence, this is considered as a critical element in delivering a network that significantly contributes towards the carbon reduction that the Reading Climate Emergency Strategy aspires to achieve.

The preferred network solution (which includes electric boilers) has an estimated electrical grid demand of 6,450kVA. If gas boilers were utilised in lieu of electric boilers, this would be 2,550kVA. The electrical grid demand for the counterfactual decarbonisation solution, air source heat pumps at each site, has an electrical demand of 8,240kVA i.e., 127% and 323% of the network solutions respectfully. The network therefore may also alleviate stress in the electrical grid capacity in Reading, demand for which is anticipated to increase considerably in future years.

Soft Market testing with a range of stakeholders was undertaken. The proposed network was well received with no major technical issues raised by stakeholders. Common technical issues associated network routing, heat technology, river access, energy centre were raised but these would normally be mitigated through the detailed project development (DPD) and commercialisation stages.

The role of the council as a customer was seen as a key barrier and some responders would like to see the council as an early anchor load to de-risk the early stages of the scheme. Commercial matters such as procurement type, timeline and the role of the council were the main focus of discussion. Responders were interested in the use of alternative procurement routes or options to speed up the procurement process as well as which role or range of roles that RBC role would take in the network.

There are a range of potential ownership and delivery structure options that are available to RBC depending on the level of involvement, control, influence and risk that RBC is interested in taking. This ranges from a wholly owned and funded in house delivery option to a 3rd party ESCO option where RBC would have very little involvement. These options will need careful considered during the Detailed Project Development stage to ensure the outcome aligns with RBC strategy.

It is AECOMs recommendation that the scheme be taken forward to the next stage of design in accordance with the HNDU[1] programme of works, Detailed Project Development (DPD). Reading Borough Council can apply to HNDU for funding of up to 67% of the associated costs. The next funding round, round 12[2], is due to open for applications on 23/05/22, with the first funding wave ending on 01/07/22. Given the importance of new developments to the scheme's viability, and the proximity of their "heat on" date requirements, it is recommended that an application is submitted at the earliest possible convenience to reduce the risk of any project delays.

The identified scheme is conceptualised in Figure 0-1 overleaf.

[1] Heat Network Delivery Unit

[2] Round 12 will run from 23/05/22 – 30/12/22 and will comprise of 7 waves of approximately 1 month. Further information can be found a https://www.gov.uk/guidance/heat-networks-delivery-unit#the-process

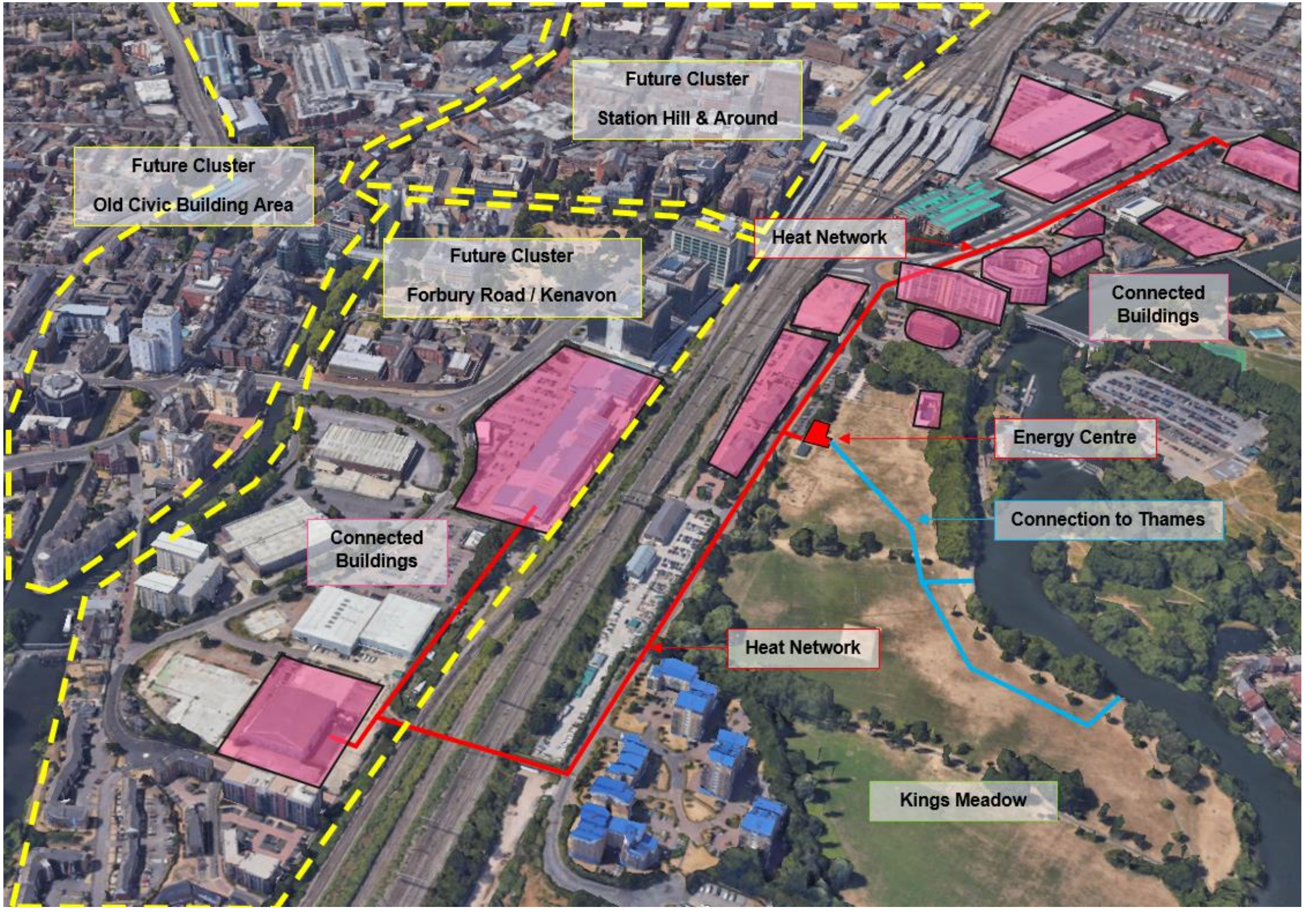


Figure 0-1 - Conceptualisation of the Identified Network

1. Introduction

AECOM has been commissioned by the Reading Borough Council (RBC) to undertake a Detailed Techno-economic Feasibility study to identify a feasible network serving a number of existing buildings and new developments in a cluster[3] of Reading referred to as “North of the Station”. This cluster was identified as being the most promising prospect for a network during the previous stages report in *Reading Heat Mapping and Masterplanning Report_Rev02 (December ’21*).

This report forms the key deliverable for the study which has been completed in line with the Heat Network Delivery Unit (HNDU) guidelines.

In February 2019, Reading Borough Council declared a climate emergency and made a commitment to the goal of a net zero carbon Reading by 2030[4]. One of the suggested measures in this declaration was “building a town centre district energy system which harnesses heat from local rivers or watercourses”.

In November 2020, The Reading Climate Emergency Strategy 2020-25 was published, which set out the actions required to be undertaken over the five-year period to work towards the objective of a net zero carbon Reading by 2030. In 2018, approximately 42% of Reading Boroughs CO_2 emissions came from the burning of natural gas, with 34% coming from electricity, 21% from transport and 3% from other sources. With the decarbonisation of the electrical grid through the addition of renewable sources of generation e.g. wind and solar, and the growth in electrical vehicle market, it is clear that solutions are being implemented to reduce emissions from electricity and transport. Using figures for the UK wide market, it is estimated that approximately 79% of natural gas is used for space heating and domestic hot water generation, which equates to 33% of Readings 2018 CO_2 emissions. District heating offers a low carbon alternative to the burning of natural gas for these uses.

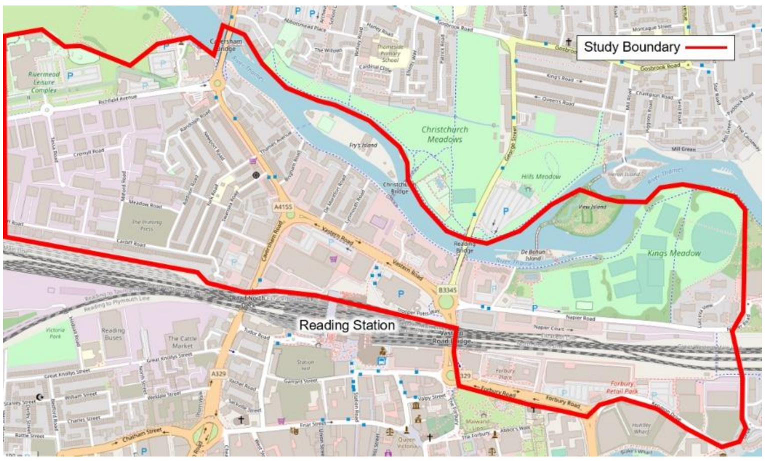
The boundary for this study is indicated in Figure 1-1.

The majority of the study area is bound to the south by the railway lines entering Reading Station and to the North by the River Thames. The exception to this being two new developments which are located immediately south of the railway lines to the east. The study boundary extends west to Rivermead Leisure Centre and east to Napier Road Underpass. It should be noted that the red line for this study was treated as a soft boundary and was expanded to explore any feasible opportunities within reasonable proximity.

The study area includes a number of existing buildings with large energy demand, a number large, mixed-use, residential led proposed new developments and smaller infill loads, including hotels and leisure facilities. The potential loads are located within close proximity to each other and are well connected along the A329 Vastern Road and Napier Road, which run northwest to east. Rivermead Leisure Centre is located to the western extremity of the boundary but represents a potential significant demand.

The boundary includes a large area of flat, open, council owned land to the east in Kings Meadow Park, which also offers access to the River Thames, the largest source of low-grade heat in the cluster.

Figure 1-1 - Red Line Study Boundary for North of the Station Cluster



[3] An area which comprises a number of buildings with a high energy demand located in close proximity to each other
[4] Reading Borough Council (26 Feb 2019), *Item No 11 – Climate Emergency – Towards a Zero Carbon Reading*

1.1. Objectives

The purpose of this study is to identify opportunities and assess the technical and commercial viability of a core, deliverable District Energy Network (DEN) for Reading Town Centre, with potential for future expansion.

The aspiration for the identified network was to offer an alternative to localised on-site low carbon heat generation to both existing buildings and planned developments. To do so, the network needed to be sufficiently low carbon so as to rival the performance of new generation plant that meets building regulations and local planning policy energy targets.

The network was designed to comply with CIBSE CP1(2020) and the Statement of Applicability from Reading Borough Council.

In the correct circumstances, DENs enable the decarbonisation of energy (primarily heat, but can also cover cooling) at a lower cost compared to building level solutions and with reduced plant space requirement at the building level, compared with the alternative low carbon solutions. The viability of these schemes depends on there being both:

- significant enough energy demands within an area to justify the capital expense of installing the distribution networks; and
- the availability of waste or ambient energy sources that can be harnessed to generate the required low or zero carbon energy.

Where this study identifies potentially viable schemes (in environmental and economic terns), it has been recommended that they be considered to proceed to the next HNDU stage of works: Detailed Project Development.

1.2. Methodology

The following steps were undertaken during this study. A detailed description of each of these steps is included in Appendix B.

1. Stakeholder Engagement
2. Data Collection & Energy Demand
3. Energy Demand Mapping
4. Low Carbon Heat Opportunities
5. Techno-economic Modelling of Preferred Solutions
6. Recommendations

2. Energy Demand

2.1. Stakeholder Engagement

A total of 23 potential customer sites were identified during Feasibility stage and stakeholder engagement was undertaken as part of this study. This engagement included issue of a Project Briefing Pack and requesting interested stakeholders to complete a Request for Information (RFI) with their site-specific details.

Details of the current status and recommended future engagement for each of these sites is included in Appendix A.

Of the 23 stakeholders:

- 4 returned completed RFI questionnaires and metered data
- For 12 of the sites, points of contact were established, and initial contact made, however completed RFI questionnaires or complete specific details were not obtained

- It was agreed with RBC that 3 were not to be engaged until a later date
- For 4 of the sites, no successful contact was made

2.2. Updates to Energy Demand

During feasibility stage, the energy demand estimates for potential connections were refreshed with new information received from the stakeholder engagement process, which included:

- Replacing previous benchmarked and outdated data with new metered consumption data provided by the stakeholders in response to the RFI;
- Using values for energy benchmarks that are based on real consumption data for similar buildings, where available;
- Using values for energy benchmarks that were agreed with the client team as being more reflective of the respective buildings with new information received from stakeholders;
- Removal of loads which were discovered to be infeasible, for example, where existing buildings were to be replaced with new developments;
- Using the latest information regarding the likely accommodation schedules for planned new developments.

The data quality of the annual heating and cooling demand is demonstrated in Figure 2-1. Metered data, the highest quality source, representing 1% of the annual heat demand energy with DEC data, the second highest quality source representing 6%. This should be targetted for improvement in future design stages, however given the percentage of total demand from planned developments (see Figure 2-2), for which no metered data will be available, there are limitations to the level of data quality that can be achieved.

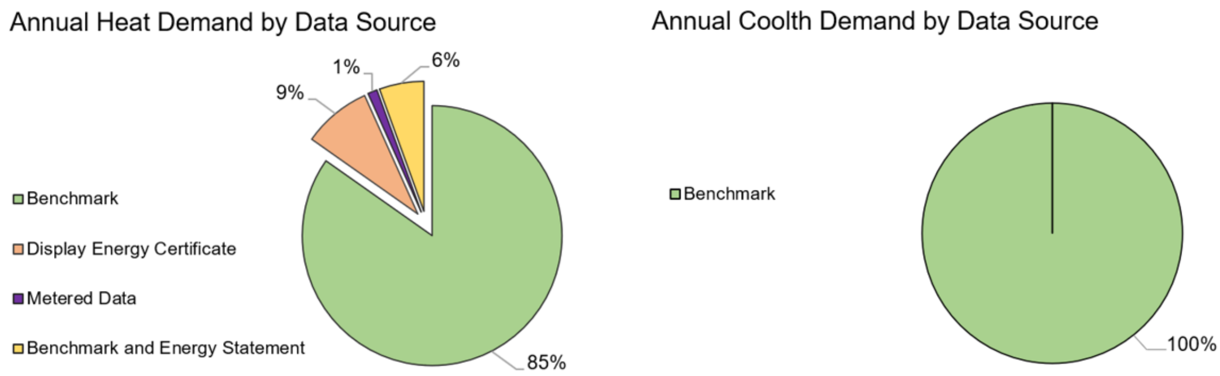


Figure 2-1 - Energy Demand by Data Source

For developments which are yet to be constructed, and therefore no metered data is available, energy demand was predicted based on information obtained from:

- Planning application drawings and accommodation schedule
- Engagement with developers and design teams for the site

2.3. Energy Demand

Ref	Building / Development	Estimated Heating Demand MWh/year	Estimated Cooling Demand MWh/year	Anticipated Existing / Planned Generation Plant
01	Aviva Development	4,823	542	100% Air Source Heat Pump Led Heat Network and DX Cooling
02	Former Royal Mail Development	4,345	369	100% Air Source Heat Pump Led Heat Network and DX Cooling
03	Forbury Retail Park Development	3,248	244	100% Air Source Heat Pump Led Heat Network and DX Cooling
04	Napier Court Development	900	0	100% Air Source Heat Pump Led Heat Network
05	Kodak & Ventello Development	900	0	100% Air Source Heat Pump Led Heat Network
06	Former SSE Development	752	0	Reported to be Hybrid Air Source Heat Pump and Gas Boiler Heat Network
07	Great Brigham Mead Development	396	0	Expected to be 100% Air Source Heat Pump Led Heat Network
08	Rivermead Leisure Complex	1,807	341	Reported to be Air Source Heat Pump Led System following Completion of Development Works
09	Thames Quarter	1,335	5	CHP Led and Gas Boiler Top-Up Heat Network
10	Crowne Plaza Hotel	1,317	165	Expected to be Gas Boiler Heating and Variable Refrigerant Flow Cooling
11	Reading Bridge House	731	405	Expected to be Gas Boiler Heating and Air-Cooled Chiller Cooling
12	Thames Lido	708	0	Expected to be Gas Boiler Heating
13	Clearwater Court	634	351	Expected to be Gas Boiler Heating and Air-Cooled Chiller Cooling
14	Shurgard Self Storage	487	0	Expected to be Gas Boiler Heating only
15	Premier Inn, Caversham Bridge	389	42	Expected to be Gas Boiler Heating and DX Cooling
16	2 Norman Place	302	167	Expected to be Gas Boiler Heating and Air-Cooled Chiller Cooling
17	Kings Meadow House	240	133	Expected to be Gas Boiler Heating and DX Cooling
18	Sovereign House	161	94	Expected to be Gas Boiler Heating and Air-Cooled Chiller Cooling
19	EP Collier Primary School	168	0	Expected to be Gas Boiler Heating
20	Reading Fire Station	151	0	Expected to be Gas Boiler Heating
21	Caversham Bridge House	122	69	Gas Fired DHW Heating and Gas Boiler Fed Common Parts Space Heating. VRF Space Heating and Cooling
22	Toby Carvery Caversham Bridge	96	0	Expected to be Gas Boiler Heating
23	Puregym Caversham Road	45	23	3 x 28kW Gas Boilers for DHW Generation and 135kW DX Space Heating and Cooling
	Total	**24,056**	**2,948**	

Table 2-1 - Summary of Estimated Heating and Cooling Demands and On-Site Generational Plant

As demonstrated in Figure 2-2, planned developments represent a considerable majority of the estimated annual heat demand given the high percentage of residential accomodation proposed. The total annual estimated cooling demand is considerably lower, at approximately 12% of annual heating demand. Due to the quantity of commercial office, existing buildings are estimated to represent a considerable majority of the total cooling demand.

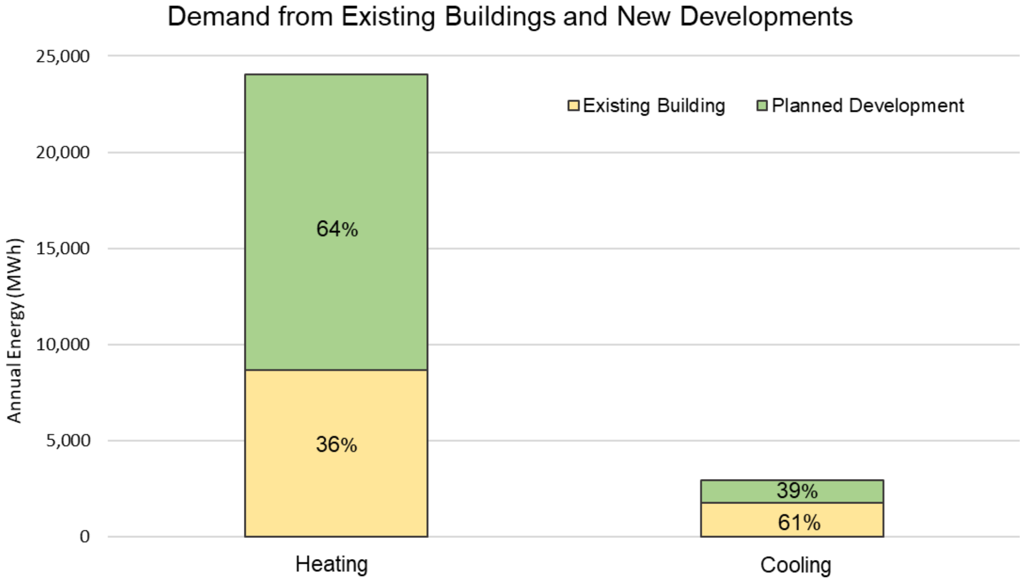


Figure 2-2 - Demand from Existing Buildings and New Developments

The annual energy demand split by building use type is demonstrated in Figure 2-3.

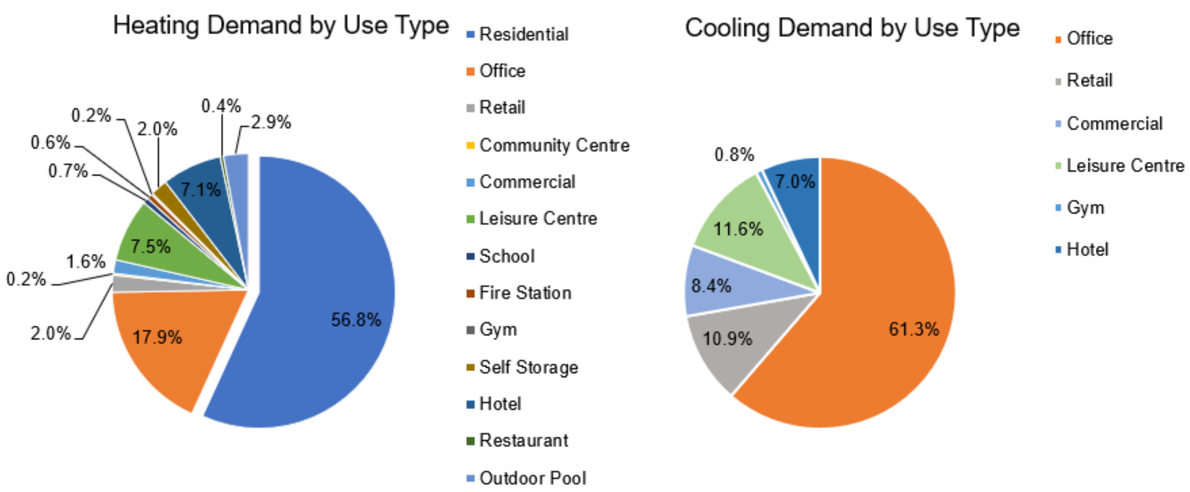


Figure 2-3 - Heating and Cooling Demand by Use Type

2.4. Demand Mapping

The estimated energy demands from Section 2.3 are mapped geographically in Figure 2-4 and Figure 2-5 to identify logical network sections and sub clusters within the boundary. Site references are included which correlate to Table 2-1.

2.4.1. Heat Demand Mapping

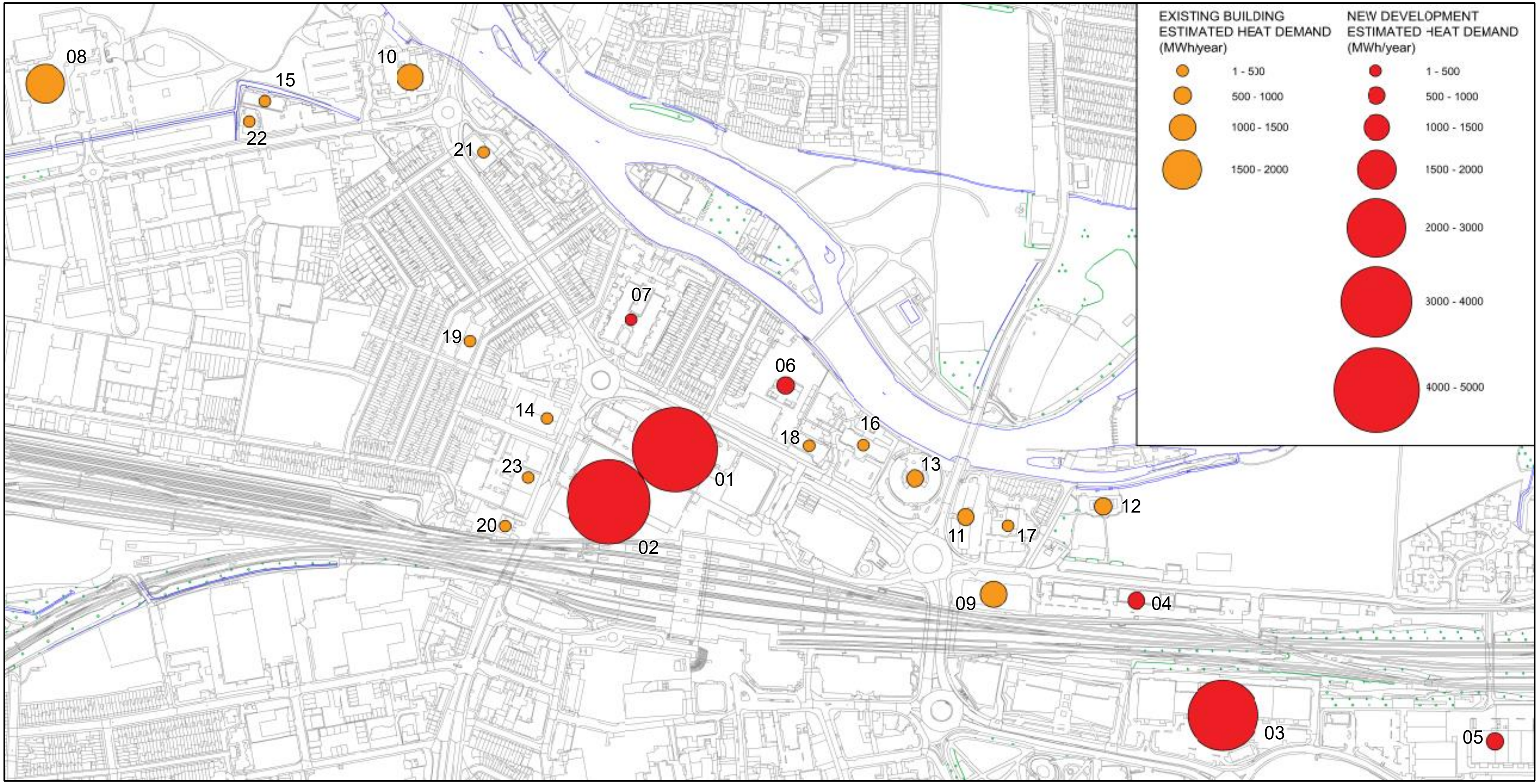


Figure 2-4 - Heat Demand Cluster Map

2.4.2. Coolth Demand Mapping

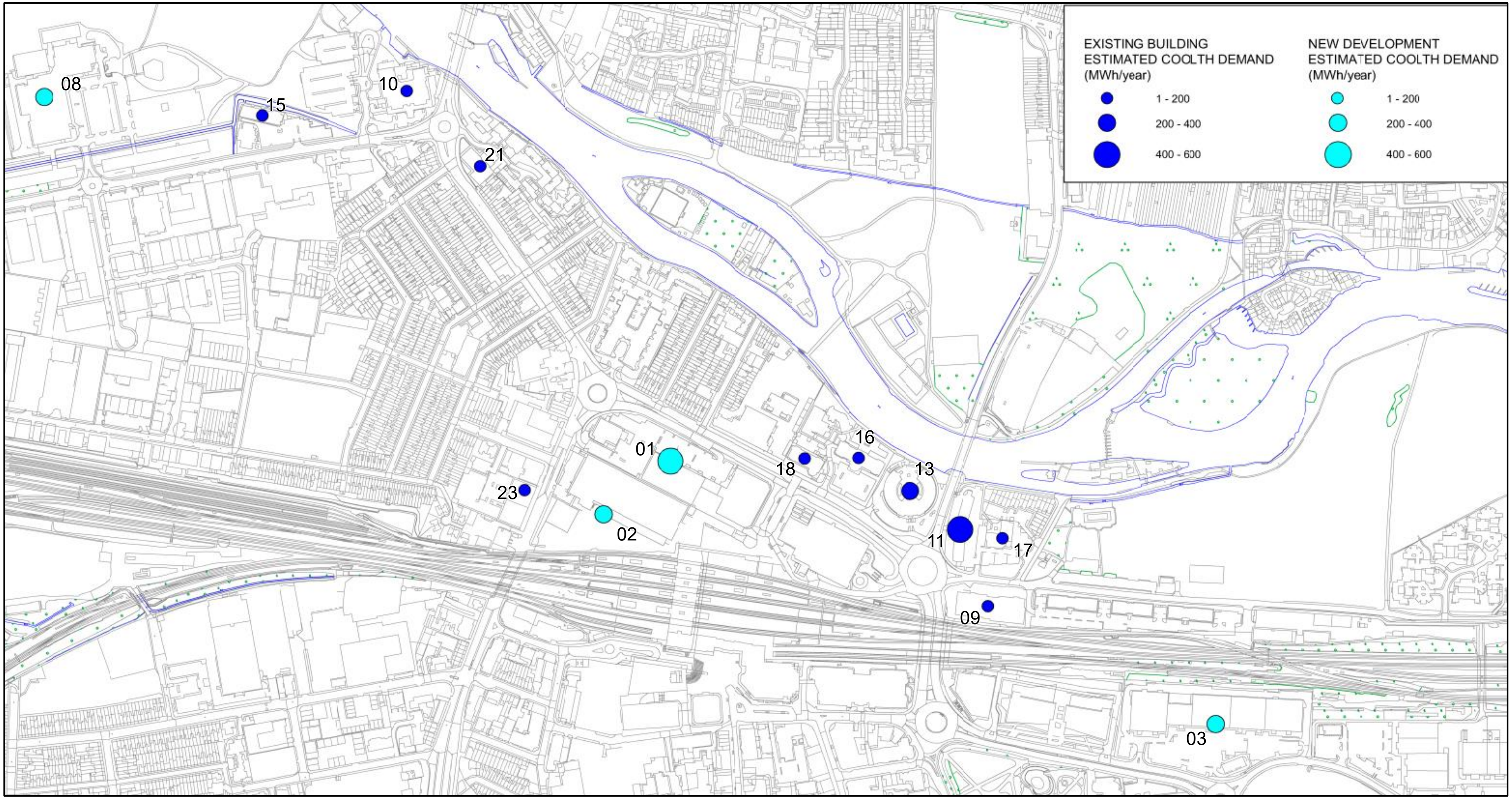


Figure 2-5 - Coolth Demand Cluster Map

2.4.3. Peak Demand

An accurate estimate of peak demand at each connected building is a critical element in the design of a network, as oversizing leads to larger network infrastructure, resulting in higher heat losses, decreased network efficiency and higher energy costs.

The estimated peak demands for each site are demonstrated in Table 2-2. The methodology followed to determine these is included in Appendix C.

Building / Development	Peak Heat Demand (kW)	Peak Cooling Demand (kW)
Aviva Development	2,676	401
Former Royal Mail Development	2,020	277
Forbury Retail Park Development	1,822	185
Napier Court Development	655	0
Kodak & Ventello Development	862	0
Former SSE Development	564	0
Great Brigham Mead Development	339	0
Rivermead Leisure Complex	450	251
Thames Quarter	768	4
Crowne Plaza Hotel	844	118
Reading Bridge House	341	294
Thames Lido	177	0
Clearwater Court	295	257
Premier Inn, Caversham Bridge	200	53
2 Norman Place	140	124
Kings Meadow House	112	52
Sovereign House	75	72
EP Collier Primary School	96	0
Reading Fire Station	72	0
Caversham Bridge House	57	53
Toby Carvery Caversham Bridge	37	0
Puregym Caversham Road	12[5]	17
Total Undiversified Peak	**12,614 kW**	**2,158 kW**

Table 2-2 - Peak Heating and Cooling Demands

The sum of the values in Table 2-2 gives the undiversified peak demand for the network. In reality, not all customers will require their peak demand at the same time, leading to some level of diversity. Using annual hourly demand profiles, the diversified peak demand has been determined to be **10,200kW** giving a diversity factor of 0.807[6]. For further details in the determination of the diversified peak demand, please refer to Appendix C.

It should be noted that the diversified peak demand stated above is for a network serving all 23 potential customers. In Section 8.2, the optimum network extent will be determined which does not include all sites. This would lead to a reduction in peak demand.

[5] Energy demand for Puregym is extremely low based on the metered data provided. It is recommended that a survey of building is undertaken in future stages, if deemed to be a viable connection

[6] Calculated by 10,200kW / 12,614kW i.e. diversified peak / undiversified peak

3. Counterfactual Systems Cost of Heat

To assess the techno-economic viability of a district energy project, the consideration of the counterfactual (or Business as Usual, BaU) energy generation and delivery scenario is critical as it will determine:

- The maximum energy tariff that can be applied to prevent any customer paying more for energy than they would otherwise; and
- The level of carbon savings that the implementation of a district energy network can offer.

Please refer to Appendix D for detailed analysis of the BaU systems. The counterfactuals used in this study for different customer types are included in Table 3-1.

Customer Type	Counterfactual Technology
New Build Development	Low Temperature Air Source Heat Pump
Existing Non-Residential	High Temperature Air Source Heat Pump
Existing Residential	Gas Boiler

Table 3-1 - Counterfactual Technologies

In order for the network to be a viable solution, the levelised tariff offered by a network should be less than the counterfactual cost of low carbon heat. This is known as the levelised cost of heat (LCoH)[7].

The BaU LCoH will vary under different scenarios, which will be tested in Section 8, however was found to range from **12.5p/kWh – 13.1p/kWh**. Section 9 will demonstrate the value of district heating against this.

4. Generational Technologies

4.1. Low and Zero Carbon Source

Low / Zero Carbon (LZC) technologies traditionally included some fossil fuel combustion options, such as combined Heat and Power (CHP) however, given the current and planned decarbonisation of the UK electricity grid, these are no longer carbon saving solutions. Electrically fuelled technologies, such as heat pumps, waste heat recovery, such as from data centres or from industrial buildings and renewable sources, such as solar thermal and photovoltaic panels are generally considered to be conducive with net-zero carbon pathways. Due to air quality concerns within urban settings, combustion technologies, such as biomass, are generally considered to be undesirable.

The principal low carbon technologies which are deemed to be a feasible lead heat sources in Reading are demonstrated in Figure 4-2 and are as follows:

- River Source Heat Pump (RSHP) using open-loop abstraction from the River Thames
- Ground Source Heat Pump (GSHP) using open-loop abstraction from the ground aquifer
- Air Source Heat Pumps (ASHP)
- Waste Heat Recovery from Scottish and Southern Electricity Networks Transformer

Also included in Figure 4-2 is the opportunity for waste heat recovery from Tesco cooling plant and the opportunity to use excess heat from ASHP (or oversized ASHP) installed as part of the redevelopment of Rivermead Leisure

[7] The sum of all project costs (capex, repex and opex) and non-heat related income discounted at the real pre-tax hurdle rate divided by the sum of all heat delivered to end customers discounted at the real pre-tax hurdle rate over a 40-year period

Centre. These are noted as opportunities but not investigated in detail as part of this assessment as, respectfully, it lies outside of the study boundary, and development plans were not available for review.

For further details of the assessment demonstrated in the following sections, refer to Appendix E.

4.1.1. River Source Heat Pump

Standard conservative practise for open loop river source heat pump (RSHP) systems in the UK has been to abstract and discharge no greater than 10% of the total volumetric flow rate of the river, and to take 3°C of temperature out of this water i.e. return the water back 3°C colder than the river water. During winter, when river water temperatures can drop below 2°C, it is not practical to reduce the water temperature by 3°C, due to the risk of freezing and damage to equipment.

Therefore, there will be periods of time when the RSHP will have reduced output and some periods when it will be non-operational and must be supplemented with alternative heat sources. CIBSE CP2[8] states that source water temperatures below 3°C or 4°C can cause risk of freezing in the evaporator. There are a number of operational RSHP schemes in the UK, however the majority are located in coastal regions where the water is more saline and at lower risk of freezing, which is not the case at Reading. To include a margin of risk in the analysis, at source water temperatures below 6°C, the output of a RSHP will be reduced, and at 3°C will be switched off.

Using these metrics, it is estimated that a minimum of 13.9MW of heat could be abstracted from the river Thames at Reading, and 295GWh/annum.

The Environment Agency (EA) rules[9] state that the difference between the inlet and outlet water must be no greater than 8°C. The same restrictions to avoid freezing will still apply, however outside of winter months, it would be possible to abstract more heat from the water. This would result in circulation pumps running at lower speed and significantly reducing electrical consumption. In addition, EA rules state that no greater than 25% of the 95% exceedance of the total volumetric flow rate of the river can be abstracted and discharged. The practical application of these rules must be discussed with the EA and verified through dispersion modelling, however, if strictly applied would indicate that minimum of 31.4MW of heat could be abstracted from the river Thames at Reading, and 382GWh/annum.

Parameters	Minimum Heat (MW)	Annual Energy (GWh)
Standard Conservative Practice	13.9	295
Based on EA Rules	31.4	382

Table 4-1 - Summary of Heat and Energy Availability within the River Thames

For the purposes of this assessment, it is assumed that standard practise principles will be applied, although it is recommended that engagement with the EA is held in subsequent design stages to enhance the opportunity.

It is possible to utilise the same abstraction and discharge system to supply coolth generating heat pumps for a district cooling system. The cooling system can therefore achieve the same capacity as the heating system and higher annual coolth energy generation due to the risk of freezing not being a realistic concern. In the scenario where district heating and cooling are operating simultaneously, this would serve to benefit both systems, with waste heat from the coolth generating system being prosumed to the heat generating system. The EA rules include a stipulation that the water discharge temperature shall not exceed 25°C. Assuming the heating system is entirely non-operational[10], and using a 3°C temperature rise for cooling, would mean that this would be at risk of being

[8] CIBSE Surface water source heat pumps: Code of Practise for the UK

[9] Refer to Appendix E for details

[10] Considered to be extremely unlikely to occur due to a baseload network heat loss and domestic hot water demand

breached when river water temperatures exceed 22°C. This occurs for an estimated 0.5% of the year and so is considered to be low risk.

4.1.2. Ground Source Heat Pump

AECOMs specialist hydrogeology team have completed a high-level feasibility study of the potential to installed open loop ground source heating and cooling schemes in the study area. This report also details the regulatory and licensing requirements associated with an open loop ground abstraction system and is included as an Appendix to this report.

Open loop ground source systems typically involve abstraction of groundwater from one or more boreholes which is passed through a heat exchanger, where heat is extracted or added, and the water then discharged to another borehole within the same aquifer, but sufficiently far away from the abstraction borehole so as to reduce the risk of recirculation, typically considered to be a minimum of 100m, and ideally significantly more. This is known as non-consumptive abstraction.

Under normal conditions, the water can be discharged up to 10°C hotter or colder than it was abstracted, but cannot exceed 25°C. Historical records from boreholes in the area indicated that a borehole is capable of providing sustainable yields in excess of 15l/s, however the yields and drawdown will vary across the area and so cannot be guaranteed within the study boundary. It is important to note that historical yields do not necessarily reflect the maximum which would be possible to obtain, as historical tests may have been intentionally limited to 15l/s and will not have incorporated modern solutions to improve yields such as acidisation. As such, they should be treated as a rough guide only, prior to borehole testing. Assuming a yield of 15l/s was available, this would equate to a heat capacity of approximately 0.63MW, which assuming no downtime due to relatively consistent and suitable groundwater temperatures, would equate to 5.5GWh/year. It is possible that yields in excess of this could be achieved from a single or multiple abstraction boreholes. This would need to be confirmed through subsequent design, including enhanced feasibility studies and trial borehole tests.

The two main constraints on any open loop ground scheme are the availability of sustainable abstraction rates from the aquifer and the ability to recharge the water back into the same aquifer, especially where the natural groundwater level is shallow with a limited unsaturated zone, as is the case within the study boundary where the groundwater level is estimated to be between 2m bgl[11] and 4m bgl. This groundwater level, along with the proximity to the major watercourses, Rivers Thames and Kennet, are significant constraints on the ability to discharge the abstracted water.

It may be possible to consider a consumptive use operation by abstracting from one borehole for use in the heating / cooling and then either a) discharge to the River Thames adjacent to the northern boundary of the site or b) discharge to the sewer network in the vicinity of the scheme area. Both these options require significant further investigations and impact assessment including early engagement with the EA to determine their position with respect to the proposal, in particular the potential for additional consumptive abstractions from the Chalk. Given that the surface watercourses in the scheme area are groundwater fed from the Chalk, discharge to surface waters may be a potential option subject to discussions with the EA.

As with RSHP, it is also possible to utilised open loop ground source to provide coolth for a district cooling network, and the same benefits for simultaneous heating and cooling operation are gained.

4.1.3. Air Source Heat Pumps

Drawing thermal energy from ambient air via air source heat pumps (ASHP) is a low carbon heating solution commonly used on sole developments and small community heating systems, however, the technology is less suitable for district heating networks, although there are some examples of ASHP led networks starting to be developed.

ASHP are unsuited to the cold and moist winter conditions found in the UK, which typically coincides with the largest heating demand from a heat network, due to simultaneous operation of the offtaker space heating systems. During these periods, the moisture within the can form a build-up of ice on the coils as it is drawn across them. This ice, if not removed, significantly impacts the effectiveness of the heat exchanger and so the heat pump will

[11] bgl = below ground level

employ a defrost cycle, where heat is diverted to the coil to melt the ice. In poor conditions, this could occur every 5-10 minutes and leads to efficiency and capacity drops for the heat pumps. Large arrays of ASHP in close proximity can lead to cold zones within towns and cities, where air movement and discharge is not sufficient, as the cold air is naturally less buoyant and sinks.

Ammonia fed ASHPs are more operationally and space efficient than other commonly used refrigerants but do require extensive fire proofing, explosion control and specialist ventilation measures that can prove costly when considering energy centre design.

In theory, ASHP have an unlimited capacity as the air they as the ambient heat source is delivered by fans included within the heat pumps in the volumes required. For this reason, they are well suited to act as a secondary LZC source and/or as peaking and redundancy plant where a natural gas free heat network is preferred.

4.1.4. Waste Heat Recovery – SSEN Electrical Substation

Within the study boundary and located adjacent to the proposed 'Former SSE' development is a Scottish and Southern Electricity Networks (SSEN) 60MVA 33/11kV electrical substation, known as Reading Town. In a report by Bowman Et Al[12], it was concluded that substations at capacities greater than 25MVA provide substantial quantities of heat at favourable temperatures and are sufficiently large to develop a business case for heat recovery. Reading Town meets this capacity criteria.

Using the methodology set out in the above report, and demonstrated in Appendix E, it is estimated that 0.15MW of heat could be recovered from Substation: Reading Town. The technical solution for recovering this heat will be dependent on the on-site cooling arrangement and if deemed to be a viable opportunity should be developed further following engagement with SSEN.

4.1.5. Potential Waste Heat Opportunities

The following are included as potential opportunities for the future and outside the study boundary.

4.1.5.1. Waste Heat Recovery – Tesco

Tesco Extra is a large supermarket located at RG1 8DF, outside of the study boundary but approximately 1km from the Kings Meadow Park. It is expected that there is a significant capacity of waste heat from onsite cooling equipment for food storage which may be possible to recover. The capacity is not currently known, however based on the visible cooling plant, could be in the region of 1-2MW at peak. Tesco has been considering investigating waste heat recovery from its assets[13], so this is considered to be a future opportunity that should be investigated.

4.1.5.2. Rivermead Leisure Centre – Heat Pumps

It is understood that Rivermead Leisure Centre, a potential network customer, are undertaking redevelopment plans, which includes investigating opportunities for low carbon heat generation via air source heat pumps (ASHP), however these were not available for review at the time of writing.

Rivermead Leisure Centre is a large complex with significant areas of roofspace and hard standing and is adjacent to open areas which provide an opportunity for expansion. There is an opportunity for any heat pumps installed in Rivermead to act as prosumers[14] to the heat network, during periods of low demand in Rivermead and high demand within the network. Equally, there is an opportunity for heat pumps to be installed in a capacity that is above Rivermead's demand which could provide low carbon heat to the network and/or acts as peaking and resilient plant to backup the lead LZC technology.

[12] Project SHOES: Secondary Heat Opportunities from Electrical Substations

[13] https://www.hvnplus.co.uk/news/industry-urged-to-rethink-waste-heat-as-part-of-net-zero-hvac-push-06-04-2022/

[14] A heat network customer which can also generate heat to be fed back to the network

4.1.6. Appraisal of Lead Heat Sources

In order to fairly appraise each technology, they have been scored against a range of criteria, which fall into four categories:

1. **Technical –** Different technologies have been assessed against their suitability to deliver the scale and the profile of the required heat supply, to operate under required supply temperatures and the technical feasibility of employing said technology.
2. **Environmental -** A range of environmental implications have been considered for each technology, including direct impacts such as pollution and changes to the local air quality. The scale of carbon savings has been approximated on the basis of both current and predicted carbon emission factors. Wider environmental impacts, such as indirect emissions from fuel delivery and the influence on local ecology are also considered.
3. **Financial -** The financial benefit of each technology has been assessed in relation to current and projected fuel prices, efficiency and the expected maintenance level required over the technology's lifetime. Long term financial risks were also taken into account.
4. **Deliverability -** Consideration has been given to the criteria that may affect deliverability of the technology, such as reliance on third parties, and implications on space requirement and energy centre size/design.

Details of the full appraisal for all LZC technologies and scoring methodology can be found in Appendix E.

The methodology was conducted for two scenarios:

1. 0-15 years of operation (to reflect the likely first date for plant replacement)

2. 15+ years of operation (considered a "future" horizon)

The appraisal scores and ranking of each of the nine technologies assessed are demonstrated in Figure 4-1 below.

0 - 15 Year Assessment		
Rank	**Technology**	**Score**
1	River Source Heat Pump	86
2	Air Source Heat Pump	84
3	Ground Source Heat Pump	84
4	Chilled Water Waste Heat Recovery	79
5	Gas CHP	73
6	Gas Boiler	71
7	Electrical Transformer	69
8	Hydrogen Fuel Cell	68
9	Biomass Boiler	67

Year 15 Assessment		
Rank	**Technology**	**Score**
1	River Source Heat Pump	89
2	Air Source Heat Pump	86
3	Ground Source Heat Pump	85
4	Chilled Water Waste Heat Recovery	80
5	Hydrogen Fuel Cell	73
6	Gas Boiler	71
7	Gas CHP	69
8	Electrical Transformer	69
9	Biomass Boiler	67

Figure 4-1 - Appraisal of Lead Heat Source Technologies

River Source Heat Pump is the highest scoring technology in both the short and long term, followed by Air Source Heat Pump. These are considered as the two leading technologies. These two ambient heat sources, as discussed earlier, are compatible with both district heating and district cooling and thus enable the opportunity for the third highest scoring heat source, Chilled Water Waste Heat Recovery. This technology also scores well, however is only a feasible opportunity if a district cooling network is implemented, and would need to be supplemented with another LZC as the baseload cooling demand is significantly less than the heat demand.

Due to the limitation on capacity and anticipated technical and licensing issues, Ground Source Heat Pump is not deemed to be a leading technology. Heat recovery from the SSEN electrical transformer scores poorly, largely due to the reliance on a third party, security of supply and the incompatibility of heat capacity with the network demand. It is, however, a waste and largely carbon neutral source of heat so could potentially be integrated to supplement an alternative lead heat source.

The remaining technologies also score poorly due to poor environmental performance associated with gas fired technologies, cost and immaturity of technology for Hydrogen fuelled technologies, and air quality concerns for Biomass fuelled systems.

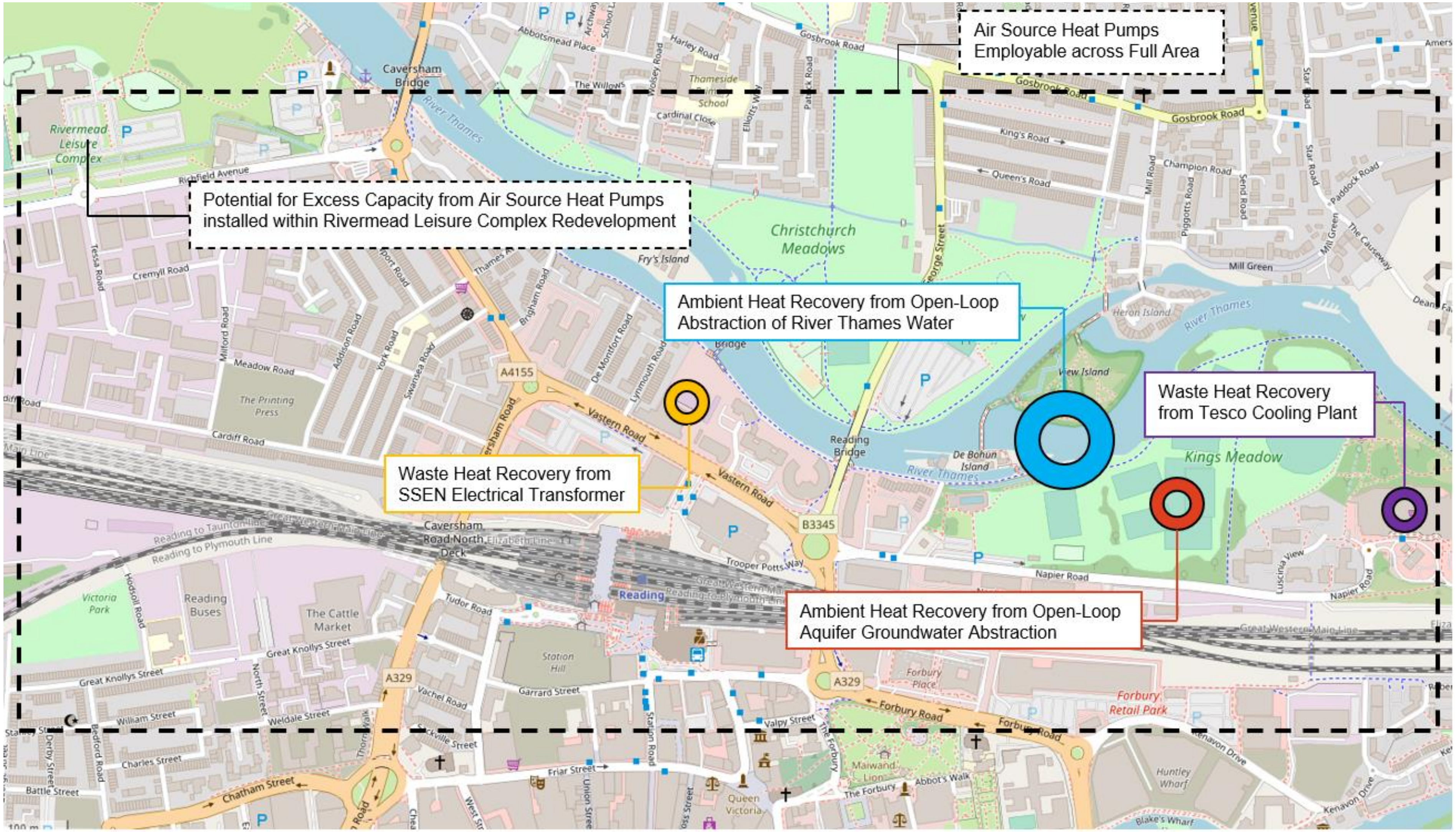


Figure 4-2 - Opportunities for Low and Zero Carbon Heat Sources

4.2. Top up and Standby Sources

Of the technologies assessed, only gas boilers, electrode boilers and air source heat pumps can economically provide resilient and peaking plant[15] solutions.

Due to disparities in fuel and technology prices, gas boilers offer the lower cost solution for providing peaking and standby heat. The use of air source heat pumps will result in lower carbon intensity heat, however the heat tariff, energy centre space and cost requirements will be higher as a result.

It is proposed that the resilient plant would be installed within the energy centre, with no requirement for distributed plant or for connected buildings to retain their existing generation plant, unless desired by the customer for disaster recovery and agreed with the network operator.

In the scenario when the LZC plant is inoperable, the resilient plant shall be activated to supply the required heat to the network. Upon the LZC plant returning to functionality, normal control priority shall resume with the thermal storage and LZC plant acting as lead heat sources.

In the event of the thermal stores having been depleted, LZC plant is operating at full capacity and is unable to match the network demand resulting in the network flow temperature dropping below the desired set-point, the resilient plant shall be activated to provide top-up heat to the network to match demand. Upon the network demand dropping such that it can be met by the LZC plant, the resilient plant deactivate, and normal control priority shall resume with the thermal storage and LZC plant acting as lead heat sources.

An option for retaining heating solutions which include gas may also wish to be retained as action may yet be undertaken to minimise gas carbon factors or economic considerations required in producing cost effective heat in periods of high cost electrical procurement.

5. Energy Centre Locations

5.1. Potential Sites

A number of potential locations were considered for the energy centre serving a network in the North of the Station cluster. Assuming a gas boiler resilient solution, it was estimated that a space of approximately 800m^2 and 4.5m high would be required for the energy centre equipment. For an ASHP resilient solution, an additional area of approximately 800m^2 that is open to atmosphere in a well-ventilated location would be needed. In addition, in both scenarios, a space of approximately 60m^2 and 10m high would be required for thermal storage.

A key element of the study was to assess the potential integration of the network with the planned new developments in the area. Therefore, the locations considered include new development sites, as demonstrated in Figure 5-1.

[15] Plant that provides a small fraction of annual heat generation but operates to satisfy brief periods of peak demand. As such, economical plant e.g. boilers are recommended for this function

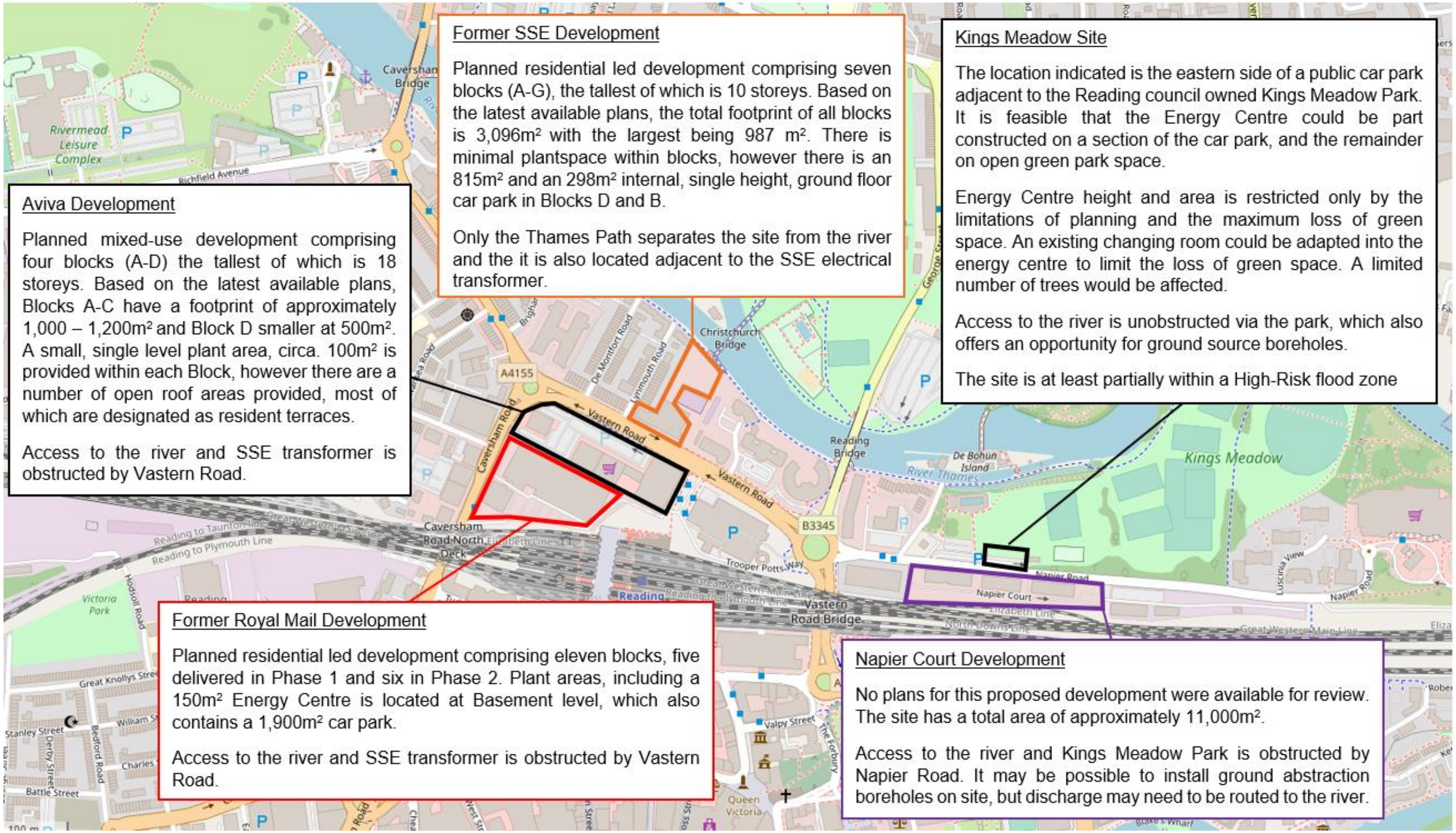


Figure 5-1 - Potential Energy Centre Locations within the North of the Station Cluster

5.2. Site Appraisal

In order to fairly appraise each potential energy centre location, they have been scored against the range of criteria demonstrated in Figure 5-2 below. Each criterion has been assigned a weighting in accordance with its importance to the scheme. Each potential site has been scored from 1 – 5 against each of the criteria, resulting in a score out of 100%.

		King's Meadow Site	Napier Court Development	Former SSE Development	Aviva Development	Former Royal Mail Development
Criteria	**Weighting**	**Score**	**Score**	**Score**	**Score**	**Score**
Access to Energy Centre	6%	5	4	3	3	4
Utility Connections	3%	3	3	5	4	4
Implications for Current & Planned Use	3%	2	4	4	4	4
Suitability for Flueing	2%	4	3	3	3	3
Flood Risk	5%	1	4	4	4	4
Access to LZC Sources	11%	5	3	5	2	2
Land ownership	9%	5	1	1	1	1
Reliance on 3rd parties	6%	5	1	1	1	1
Future expansion capability	13%	5	1	1	1	1
Proximity to Heat Offtakers	6%	4	4	5	5	5
Space Availability	9%	5	3	1	2	3
Visual Impact	2%	3	5	5	5	5
Environmental Impact	3%	3	4	4	4	4
Potential to achieve fully electrified solution	9%	5	2	2	3	3
Deliverability	6%	4	3	1	2	2
Programme Implications	6%	5	3	2	2	2
Total Score (%)	100%	89%	52%	51%	48%	52%
Rank		1	2	3	4	2

Figure 5-2 - Appraisal of Potential Energy Centre Locations

As is demonstrated, the Kings Meadow Site scores significantly higher than the other four options and is considered to be the preferred Energy Centre location, in spite of some poor scoring criteria, which includes flood risk and visual and environmental impact linked to the loss of green space.

A high-level flood risk assessment has been undertaken and is included in Appendix G. It is noted that raising sensitive equipment within the energy centre to 38.5m AOD[16] will provide protection during the design flood event. The energy centre is considered by AECOM to be classified as “essential infrastructure” and so can be constructed within the flood risk zone, subject to passing the “exception test”[17]. Early engagement should be held with RBC planning department and the Environment Agency to agree vulnerability classification, appropriate mitigation measures and suitable consideration of the impact of the developing an energy centre it this site on the risk of flooding to the surrounding area.

Napier Court is the second highest scoring option, given that the design of the development is understood to be at a sufficiently early stage to allow for an energy centre to be incorporated without causing significant abortive works and delays to the designers.

Locations on proposed developments on which the design is well advanced score poorly due to issues related dependency on third party developers and anticipated resistance to the design changes need to incorporate an energy centre. It may be possible to include an obligation on developments which are pre-planning stage to include an energy centre within their development. Further engagement with RBC planning department should be undertaken to understand whether this is feasible, should the preferred location not be pursued

The rationale behind each of the scores from Figure 5-2 is detailed in the following tables.

[16] Above ordnance datum

[17] See Appendix G for details

Criteria	Kings Meadow Site	Napier Court Development	Former SSE Development	Aviva Development	Former Royal Mail Development
Access to Energy Centre	Can be designed to use car park as access bay and closed off to public when required. Easily accessed from Napier Road.	With cooperation from the development client and design team, this can be designed to allow EC access, maintenance & plant removal & replacement.	Site landscaping and block phasing is well progressed so the development team may be more resistant to altering the design to allow EC access, maintenance & plant removal & replacement.	Site landscaping and block phasing is well progressed so the development team may be more resistant to altering the design to allow EC access, maintenance & plant removal & replacement.	While developed, the site layout includes basement car parking and plantroom spaces which would be well suited to the requirements of an energy centre. The modifications required may be more acceptable to the developer
Utility Connections	Electrical supply will likely be taken from the Reading Town substation, approximately 600m away.	Electrical supply will likely be taken from the Reading Town substation, approximately 600m away.	Electrical supply will likely be taken from the Reading Town substation, which is adjacent to the site	Electrical supply will likely be taken from the Reading Town substation, approximately 200m away.	Electrical supply will likely be taken from the Reading Town substation, approximately 150m away.
Implications for Current & Planned Use	Possible loss of several parking spaces and/or green space. Planned closure of car park during plant delivery & replacement	Requires significant space take in ground floor or basement of new development, however no plans are currently understood to have been developed.	Requires significant space take in ground floor of new development, which is not allowed for in the current plans.	Requires significant space take in ground floor of new development, which is not allowed for in the current plans.	Requires significant space take, likely at basement or ground floor of new development, which is not allowed for in the current plans.
Suitability for Flueing	Not located in close proximity to a building or structure which would have implications on the flue design.	Can be designed to be outside of the proximity zone of Thames Quarter if the Napier Court development is not equally as tall.	Flues may need to be routed to the tallest building on the development which may impact the current strategy and general arrangements.	Flues may need to be routed to the tallest building on the development which may impact the current strategy and general arrangements.	Flues may need to be routed to the tallest building on the development which may impact the current strategy and general arrangements.
Flood Risk	Is located within Flood Risk Zone 3 (High Risk) and Zone 2	Is located within Flood Risk Zone 2 (Medium Risk).	Is located within Flood Risk Zone 2 (Medium Risk).	Is located within Flood Risk Zone 2 (Medium Risk).	Is located within Flood Risk Zone 2 (Medium Risk).
Access to LZC Sources	In close proximity to river, with soft dig between energy centre and river. On Kings Meadow Park where a number of open loop boreholes could be installed.	Requires river abstraction pipework to cross Napier Road and if ground source is used, will likely required ground abstraction or discharge pipework to cross it also.	Separated from the river by only the Thames Path. Located adjacent to the SSEN Reading Town Substation, a potential waste heat source.	Access to the river is via privately owned land and required pipework to cross Vastern Road. It may be feasible to install abstraction boreholes on site but discharge may be problematic.	Access to the river is via privately owned land and required pipework to cross Vastern Road. It may be feasible to install abstraction boreholes on site but discharge may be problematic.

Land ownership	Land is owned by Reading Borough Council.	Privately owned.	Privately owned.	Privately owned.	Privately owned.
Reliance on 3rd parties	None	Entirely reliant on the cooperation of the developer.	Entirely reliant on the cooperation of the developer.	Entirely reliant on the cooperation of the developer.	Entirely reliant on the cooperation of the developer.
Future expansion capability	No physical restrictions on reasonable future expansion other than limitation of planning permission and the allowable loss of green space if expanding horizontally into Kings Meadow. Vertical expansion is also feasible.	Once site is constructed, it is likely that there will be limited opportunity to expand.	Once site is constructed, it is likely that there will be limited opportunity to expand.	Once site is constructed, it is likely that there will be limited opportunity to expand.	Once site is constructed, it is likely that there will be limited opportunity to expand.
Proximity to Heat Offtakers	Close to the large developments to the north of the station and also well located for expansion south through the Napier Road Underpass.	Close to the large developments to the north of the station and also well located for expansion south through the Napier Road Underpass.	On and near to the large developments to the north of the station.	On and near to the large developments to the north of the station.	On and near to the large developments to the north of the station.
Space Availability	Ample space available in park and car park.	Presumed that enough space will be allocated by developers, pending further discussions.	No suitable space is currently allowed, and it may be difficult to reasonably obtain.	No suitable space is currently allowed, and it may be difficult to reasonably obtain, although the blocks are of reasonable footprint.	No suitable space is currently allowed although there is potential to repurpose the basement level if acceptable to the developer.
Visual Impact	Will be visible as a standalone energy centre, however it can be designed to meet the planning department requirements.	Likely to be in basement, or discrete at ground level within the envelope of the main building.	Likely to be in basement, or discrete at ground level within the envelope of the main building.	Likely to be in basement, or discrete at ground level within the envelope of the main building.	Likely to be in basement, or discrete at ground level within the envelope of the main building.
Environmental Impact	Air quality impacts associated with gas boilers, if included. Potential loss of green space. Potential impact on existing trees.	Air quality impacts associated with gas boilers, if included.	Air quality impacts associated with gas boilers, if included.	Air quality impacts associated with gas boilers, if included.	Air quality impacts associated with gas boilers, if included.
Potential to achieve fully electrified solution	Can be designed to incorporate a roof plant area for future installation of air	Entirely reliant on the allocation of suitable plantspace by the	Entirely reliant on the allocation of suitable plantspace by the developer or obtaining another	Entirely reliant on the allocation of suitable plantspace by the developer or obtaining another	Entirely reliant on the allocation of suitable plantspace by the developer or obtaining another

	source heat pumps to replace gas boilers.	developer or obtaining another suitable space in close proximity.	suitable space in close proximity.	suitable space in close proximity.	suitable space in close proximity.
Deliverability	Approval for planning and potential loss of car parking space to be obtained. Is highly constructable with limited site restrictions.	Constructed as part of development. No major complications are currently known.	Constructed as part of development. Existing SSEN Reading Town substation and incoming outgoing HV cables provides an obstruction.	Constructed as part of development. No major complications are currently known.	Constructed as part of development. No major complications are currently known.
Programme Implications	Not reliant on the development programme of others.	Heavily reliant on the development programme of others.	Heavily reliant on the development programme of others.	Heavily reliant on the development programme of others.	Heavily reliant on the development programme of others.

Table 5-1 - Rationale Behind the Energy Centre Location Appraisal

6. Energy Distribution Strategy

6.1. Network Technology

With the presence of both heating and cooling demand from potential connected loads, there are a number of network technologies that could be implemented. The technical parameters of these configurations are demonstrated in Table 6-1 overleaf.

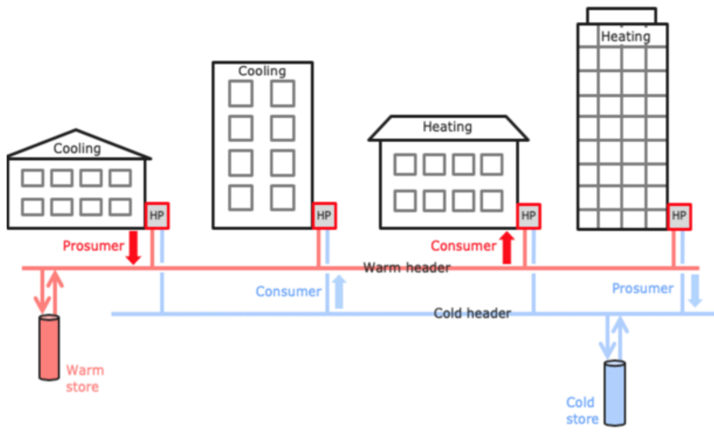
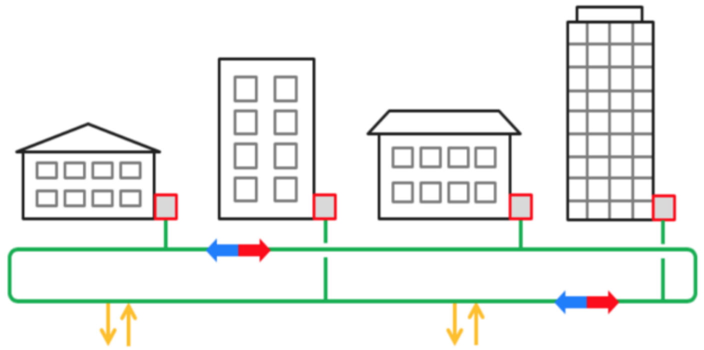
Solution ID	Description	Illustration	System Requirements	'Typical' Operational Temperatures
Third Generation	Heating and cooling is distributed in two different pipework networks, which operate in isolation from one another.		Can serve either one of or both heating and coolth to any site, including buildings operating with 'historical' heating temperatures of 82/71°C flow and return. If temperature modifications are required, these can be minor.	85-55°C heating network 6-12°C cooling network.
Fourth Generation	Fourth generation heating networks operate at reduced temperatures to enable improved heat pump performance whilst still enabling the storage of domestic hot water at 60ºC.		Buildings' heating systems need to operate at lower than 'historical' ones. May require some secondary side conversion works to be undertaken in existing facilities.	60-30°C heating network 6-12°C cooling network.
Fourth Generation with Prosuming	A variant on the fourth-generation system described above, albeit with an element of the generational plant having to be heat pump based to "couple" the heating and cooling. When a heat pump operates in heating mode, waste coolth energy is generated, and vice versa. In a 'prosuming' system, this waste energy is recovered within the EC and distributed via the appropriate network, increasing the effective efficiency of the heat pump plant.		Requires both a heating and cooling network in operation, and plant for each system located within the same Energy Centre(s). Can remain suitable even when the heating and cooling loads are unbalanced, i.e. the annual cooling requirements are less than 50% of the heating requirements. Buildings' heating systems need to operate at lower than 'historical' ones. May require some secondary side conversion works to be undertaken in existing facilities.	60-30°C heating network 8-16°C cooling network.
Fifth Generation (Dual Pipe)	This system also includes separate heating and cooling distribution networks, but only of a single pipe. These networks tend to be of a very low temperature, leading to them being referred to as "Ambient Network". The plant can be two tier in nature; centralised thermal energy generating plant and decentralised (local) prosuming plant. This local prosuming plant can generate heat and coolth at the temperatures required within the building. The rejected heat and coolth from the operation of the local prosuming heat pumps is captured within the appropriate network for use within other sites. Long term 'inter-seasonal' storage can be included to share energy across the typical heating and cooling seasons. The centralised plant acts as 'top-up' plant within centralised energy centre(s). These are able to maintain network temperatures once inter seasonal storage maximum capacities are reached.		Requires both a heating and cooling network in operation. Suitable when the heating and cooling loads are well balanced, i.e. the annual cooling requirements are more than 50% of the heating requirements. Buildings' heating systems need to operate at lower than 'historical' ones. May require some secondary side modification or conversion works to be undertaken in existing facilities.	20°C heating network 15°C cooling network.
Fifth Generation (Single Pipe)	Same generational plant arrangement as above dual pipe fifth generation system, with building-based heat pumps and balancing plant in energy centre(s) if required. However, this system is based on a single pipe solution, which provides the temperature sink for the building-based heat pump when operating in either heating or cooling mode. All rejected energy from heat pump operation can be captured in within the network loop as required.			15-20°C shared heating and cooling network

Table 6-1 - Details of Technical Network Configurations

As demonstrated in Section 2.3, the estimated heating demand from the potential loads is 24,057MWh/year, with an estimated cooling demand of 2,948MWh/year, giving a ratio of heating to cooling demand of 8.5:1. As stated in CIBSE CP1(2020), the advantages of 5th Generation networks "are most strongly seen where there are simultaneous heating and cooling demands across different buildings/dwellings, allowing prosuming (heat exchange) between these". It is generally considered that a heating to cooling demand ratio of no greater than 2:1 is required for a 5th Generation network to be optimal.

3rd Generation networks operate at traditional temperatures of approximately 85°C flow. These temperatures are highly likely to be compatible with existing building heating systems which have traditionally been designed for 82°C flow 71°C return, without any requirement for upgrade works to existing emitter systems. However, new buildings will typically operate at much lower temperatures, with any that are subject to the new proposed Part L, having flow temperatures that do not exceed 55°C. As demonstrated in Section 2.3, planned developments represent an estimated 64% of the annual heating demand. The LZC technology is likely to be a heat pump, which are generally not capable of achieving flow temperatures in excess of 80°C without significant impact on operational efficiency and plant cost. In general, the higher the network temperature the worse the efficiency of the heat pump and the higher the chance of some fraction of heat demand having to be met by non LZC plant, such as gas boilers. In addition to this, the heat loss from a 3rd generation networks can be significantly higher than a 4th generation network due to the elevated temperatures.

4th Generation networks operate at temperatures that are compatible with new buildings with reduced heat losses due to lower temperatures and higher generation plant efficiency. It is possible that 4th Generation network temperature are also compatible with existing buildings, however some rebalancing or potentially upgrading of heating systems within these buildings may be required. It should be noted that should an existing building choose to use an alternative decarbonisation strategy, such as on-site ASHP, it would need to carry out similar modifications to the heating systems, as commercially available, building level air source heat pumps can typically only achieve flow temperatures of 50 - 55°C. It is possible to "weather compensate" a 4th Generation heat network to provide higher flow temperatures only when needed, which is typically during winter. In this case, the network operates at the lowest required temperature for most of the year, maximising generation plant efficiency and minimising heat losses, then during winter, flow temperatures can be increased when needed by running the LZC generation plant at a slightly lower efficiency and/or using non LZC plant to top-up. In this way, only a small percentage of the annual heat is provided at low efficiency or from the non-LZC plant.

District heat provides the most carbon savings when replacing building level generation systems that are fossil fuel based, such as gas boilers. When replacing generation plant that is electrically fuelled, such as heat pumps and chillers, the carbon savings are significantly less. It is anticipated that the cooling systems for both existing and new buildings will be electrically fuelled, in the form of chillers of variable refrigerant flow (VRF/VRV) systems. For this reason, district cooling networks are not considered to be as environmentally beneficial as district heating. A benefit of district cooling is that when used in conjunction with district heating, it is possible to share heat between the networks, which increases the efficiency of both. For a 4th Generation network, this benefit can be achieved even when the scale of the heating and cooling demands does not align. It is important to consider this increase in efficiency against the additional embodied carbon associated with the installation of a district cooling network, which utilises larger infrastructure than district heating to deliver the same magnitude of energy, due to smaller temperature differentials.

For these reasons, 4th Generation and 4th Generation with prosuming network technologies will be considered in the Technoeconomic analysis.

6.2. Operating Temperatures

The choice of an operating temperature for a district heating network is a key aspect that must ensure that the required service level is provided to customers whilst limiting heat loss from the network and operating heat generation plant at high efficiency.

It is important to note that surveys of existing heating systems must be undertaken in order to understand the impact of lowering temperatures and make an informed selection of a network operating temperature regime. Engagement must also be undertaken with the designers of new developments. Detailed below is the logic behind the selection of an aspirational network temperature for Feasibility stage, however this should be continuously reviewed through the subsequent stages of design.

In new residential developments, the most common strategy to generate domestic hot water is instantaneously at a Heat Interface Unit (HIU) within each residential unit. The minimum hot water temperature set point at a HIU is

50°C. At every hydraulic separation, such as a HIU or a thermal substation there is a temperature drop between the primary and secondary side circuits, known as an approach temperature. CIBSE CP1 (2020) requires that this approach temperature be no greater than 5°C and good practise would achieve 3°C. In addition to approach temperature losses, pipework heat loss can result in temperature drops across the length of the primary and secondary networks. A potential scenario where a heat network provides a bulk heat supply to a building or site, which then distributes via a secondary network to multiple end-users is depicted in Figure 6-1. As the strategy for many of the new developments is not currently known, it is recommended that a network flow temperature of at least 60°C is targeted.

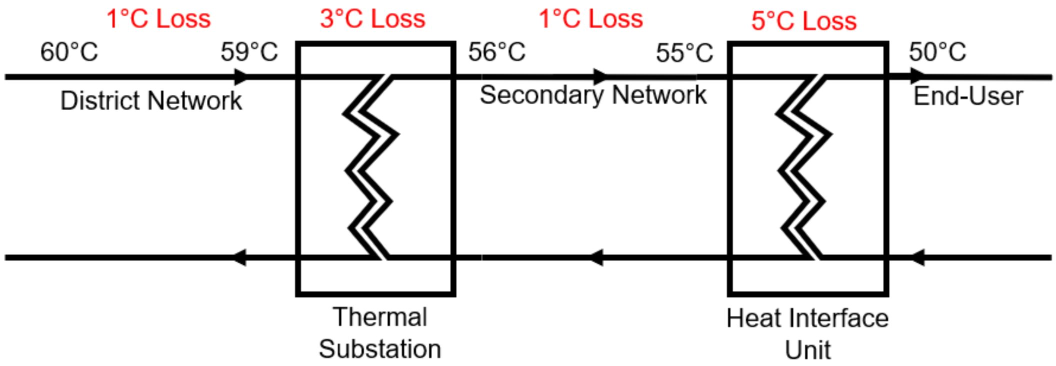


Figure 6-1 - Potential Temperature Drop from Generation to End-User[18]

The delivery of 55°C at the extremities of the secondary network within a connected building also aligns approximately with what would have been achieved had the building explored an alternative decarbonisation strategy, such as building level air source heat pumps (ASHP) which can typically only achieve flow temperatures of 50 - 55°C. It is clear therefore, that any network temperature above ~60°C is likely to have a lesser impact on the requirement to upgrade building level heating systems, than building level ASHP.

Existing heat emitter systems have historically been installed with stacked margins, meaning that they are oversized. As demonstrated indicatively in Figure 6-2, these stacked margins could be more than 30%. With the stated assumptions, a district heating network flow temperature of 65°C would result in a 19% shortfall in output from existing heat emitter systems during the coldest weather, which may still be within the required capacity.

If required, network temperature can be periodically increased during coldest periods to bridge this gap, for example the network could operate at 65°C for the majority of the year, then during some winter days, increase to 75°C to meet peak demand. Equally, existing emitters could be upgraded to operate on lower temperatures. See Section 7.4.

[18] It is recommended to omit hydraulic breaks in series wherever possible to avoid temperature drops as indicated, and is considered as a worst case for this study. Future design stages, with liaison with developers and ESCos should seek to design these out.

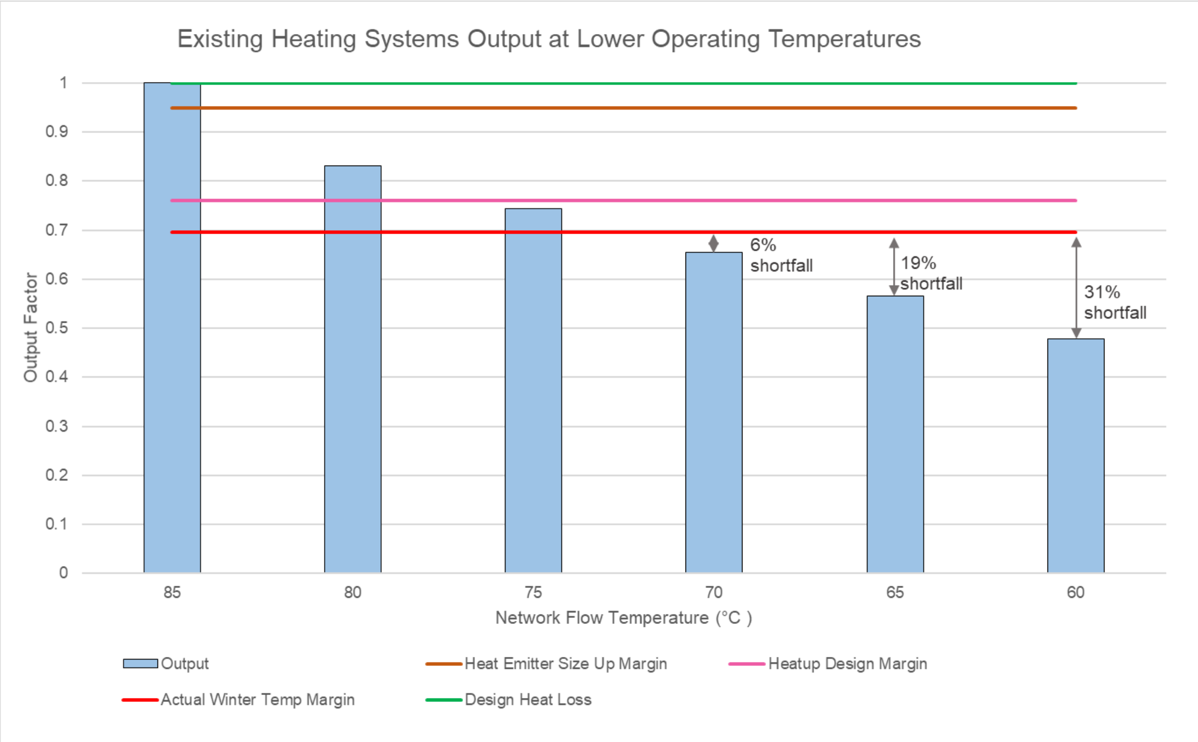


Figure 6-2 - Output of Existing 82F/71R Heating Systems at Lower Operating Temperatures and the Typical Historical Stacked Margins

Table 3 of CIBSE CP1 (2020) provided recommended maximum flow temperatures for new and replacement building services systems. Exclusive of some specific exceptions, the highest recommended temperature is 70°C. Assuming a 1°C temperature drop across the network and a 3°C approach temperature across the thermal substation gives an upper limit of 74°C network temperature. It can be concluded therefore, that a flow temperature between 60°C - 74°C is optimal.

Based on the above, the aspirational heating network flow temperature is 65°C.

The return temperature will be dynamic depending on the fraction of heat being used for space heating or domestic hot water, which operate under different ΔT, typically in the region of 20°C and 40°C respectfully. At peak demand, the ΔT shall be greater than 30°C for new developments and 25°C for existing buildings, in accordance with CIBSE CP1(2020).

For existing buildings which utilise a stored domestic hot water strategy, which typically requires a stored temperature of 60°C to reduce the risk of legionella which in turn require an LTHW temperature of at least 65°C in order to generate this, may need to consider alternative strategies or additional measures. These could include:

- Replacing the stored solution with an instantaneous hot water generation plate heat exchanger, which can operate at lower temperatures; or
- Using electrical immersion heaters to provide the final degrees of temperature rise from that which can be generated by district heating; or
- Using electrical immersion heated pasteurisation cycles.

District cooling network temperatures are more constrained that district heating. For this assessment, 6°C and 12°C Flow and Return temperatures have been selected to align with the anticipated regimes in existing buildings, which represent 61% of the estimated demand. Future consideration should be given to using a wider ΔT to reduce district cooling pipework sizes, following surveys and assessments into the potential impact on the existing emitter systems.

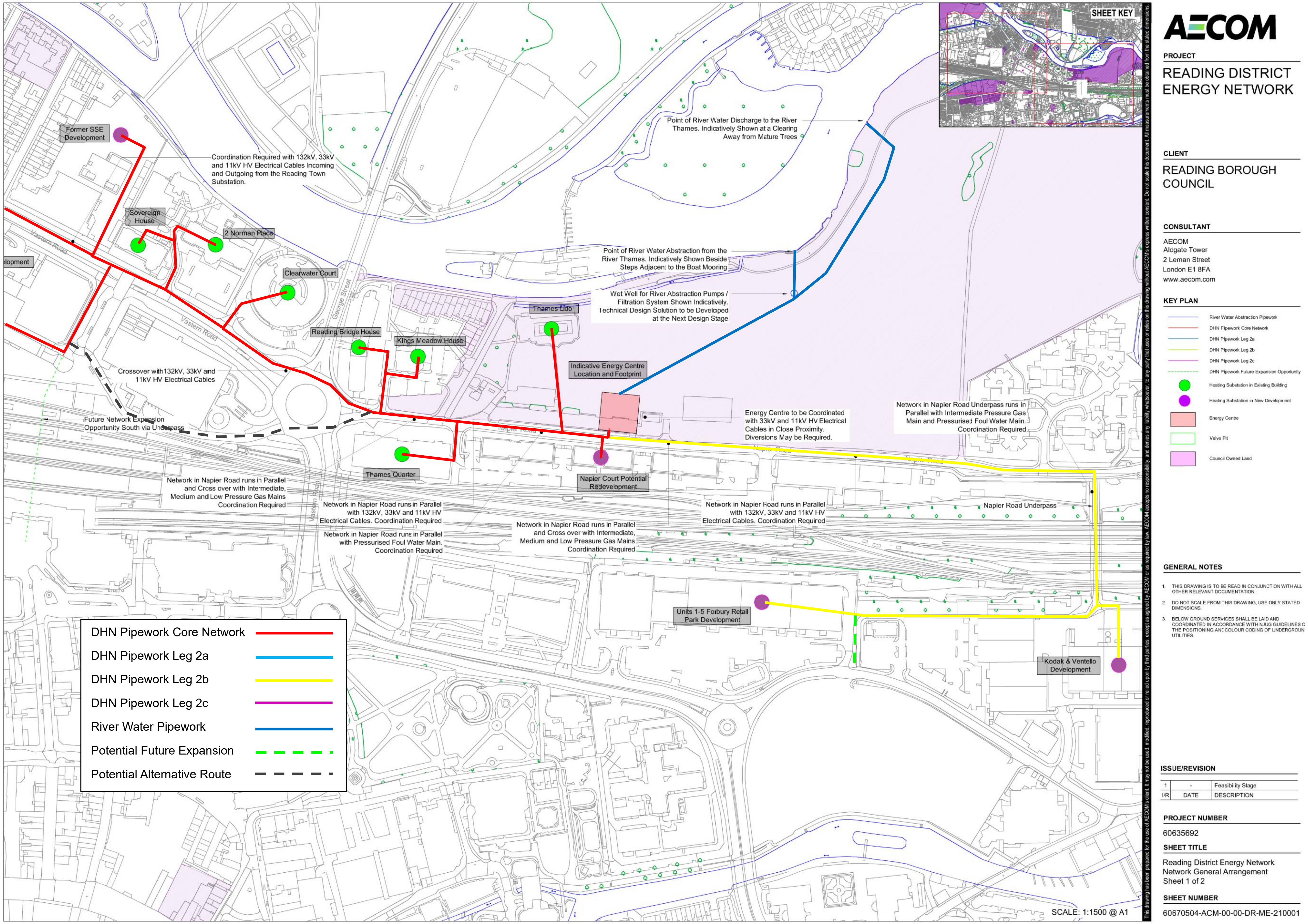
6.3. Network Route Plan

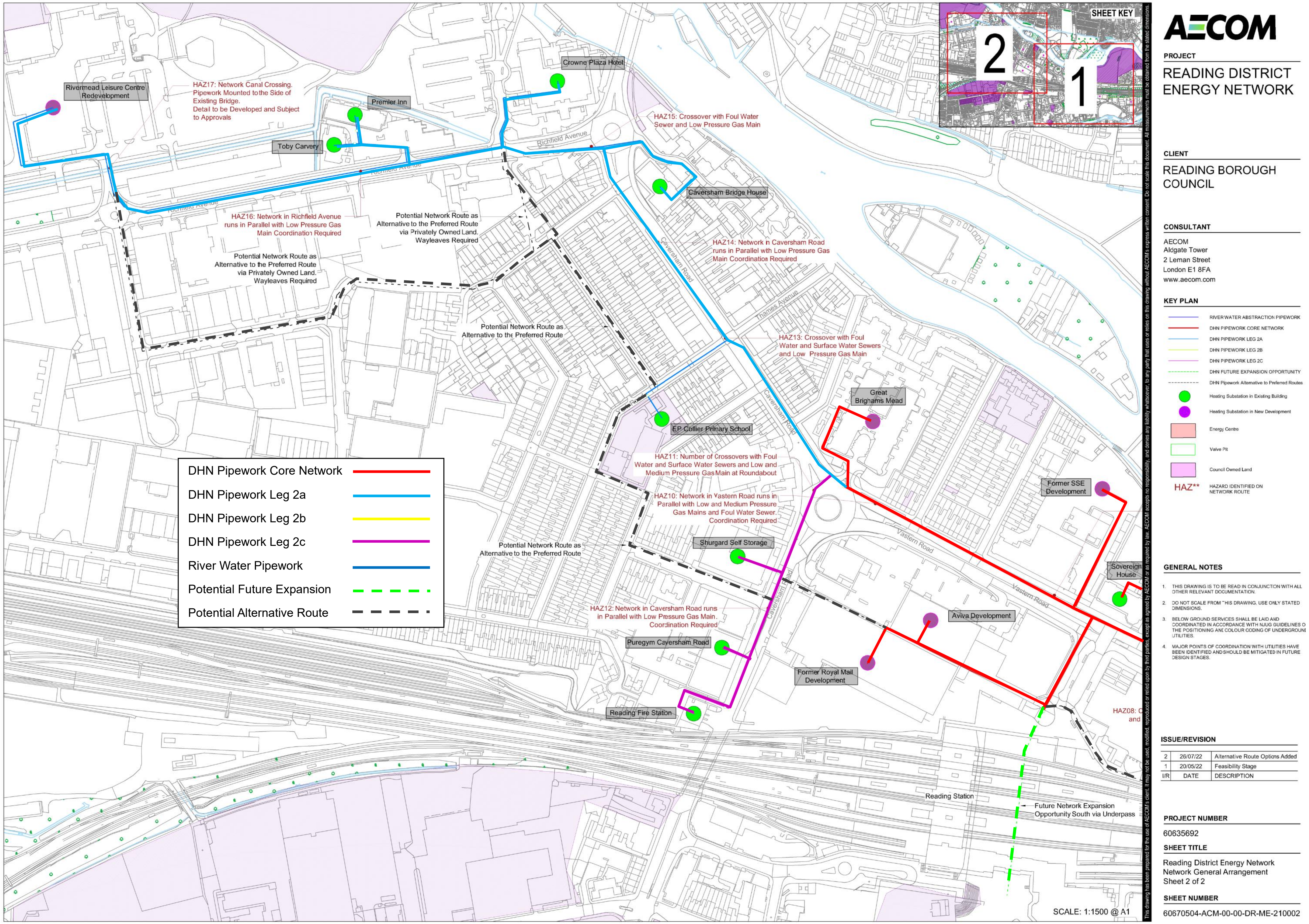
The network route plan is demonstrated in drawings 60670504-ACM-00-00-DR-210001 and 60670504-ACM-00-00-DR-210002 overleaf, which are included as appendices to this report.

It should be noted that three possible extensions of the core network are included, 2a, 2b and 2c. The optimum network extent has been determined through the analysis in Section 8.2.

A PAS 128 C2 - Utility Search has been undertaken as part of this study and is included as an appendix to this report. Major crossings and points of coordination with existing utilities have been highlighted on the network drawing. Ground penetrating radar (GPR) surveys should be undertaken in future design stages to enable further coordination of the network to be undertaken and potential hazards to be identified. Some of the major points of coordination with utilities includes:

- Intermediate Pressure Gas Mains in Napier Road and the Napier Road Underpass;
- Medium Pressure Gas Mains in Napier Road and Vastern Road;
- Low Pressure Gas Mains throughout the network route;
- 132kV and 33kV High Voltage Cables incoming and outgoing from the SSEN Reading Town substation;
- 132kV, 33kV and 11kV High Voltage Cables in Napier Road;
- 132kV, 33kV and 11kV High Voltage Cables in Vastern Road;
- Low Pressure Gas Main in Caversham Road;
- Low Pressure Gas Main in Richfield Avenue;
- Pressurised Foul Water Main in Napier Road and the Napier Road Underpass;
- Foul and Surfacewater sewers throughout the network route.


SHEET KEY
AECOM
PROJECT
READING DISTRICT ENERGY NETWORK
CLIENT
READING BOROUGH COUNCIL
CONSULTANT
AECOM
Aldgate Tower
2 Leman Street
London E1 8FA
www.aecom.com
KEY PLAN
GENERAL NOTES
ISSUE/REVISION
1 - Feasibility Stage
I/R DATE DESCRIPTION
PROJECT NUMBER
60635692
SHEET TITLE
Reading District Energy Network
Network General Arrangement
Sheet 1 of 2
SHEET NUMBER
60670504-ACM-00-00-DR-ME-210001
SCALE: 1:1500 @ A1
Former SSE Development
Coordination Required with 132kV, 33kV and 11kV HV Electrical Cables Incoming and Outgoing from the Reading Town Substation.
Sovereign House
2 Norman Place
Clearwater Court
Reading Bridge House
Kings Meadow House
Thames Lido
Point of River Water Discharge to the River Thames. Indicatively Shown at a Clearing Away from Mature Trees
Point of River Water Abstraction from the River Thames. Indicatively Shown Beside Steps Adjacent to the Boat Mooring
Wet Well for River Abstraction Pumps / Filtration System Shown Indicatively. Technical Design Solution to be Developed at the Next Design Stage
Indicative Energy Centre Location and Footprint
Crossover with 132kV, 33kV and 11kV HV Electrical Cables
Future Network Expansion Opportunity South via Underpass
Energy Centre to be Coordinated with 33kV and 11kV HV Electrical Cables in Close Proximity. Diversions May be Required.
Network in Napier Road Underpass runs in Parallel with Intermediate Pressure Gas Main and Pressurised Foul Water Main. Coordination Required
Thames Quarter
Napier Court Potential Redevelopment
Network in Napier Road runs in Parallel and Cross over with Intermediate, Medium and Low Pressure Gas Mains Coordination Required
Network in Napier Road runs in Parallel with 132kV, 33kV and 11kV HV Electrical Cables. Coordination Required
Network in Napier Road runs in Parallel with Pressurised Foul Water Main. Coordination Required
Network in Napier Road runs in Parallel and Cross over with Intermediate, Medium and Low Pressure Gas Mains Coordination Required
Network in Napier Road runs in Parallel with 132kV, 33kV and 11kV HV Electrical Cables. Coordination Required
Napier Road Underpass
Units 1-5 Forbury Retail Park Development
Kodak & Ventello Development
DHN Pipework Core Network
DHN Pipework Leg 2a
DHN Pipework Leg 2b
DHN Pipework Leg 2c
River Water Pipework
Potential Future Expansion
Potential Alternative Route


SHEET KEY
2
1
AECOM
PROJECT
READING DISTRICT ENERGY NETWORK
CLIENT
READING BOROUGH COUNCIL
CONSULTANT
AECOM
Aldgate Tower
2 Leman Street
London E1 8FA
www.aecom.com
KEY PLAN
RIVER WATER ABSTRACTION PIPEWORK
DHN PIPEWORK CORE NETWORK
DHN PIPEWORK LEG 2A
DHN PIPEWORK LEG 2B
DHN PIPEWORK LEG 2C
DHN FUTURE EXPANSION OPPORTUNITY
DHN Pipework Alternative to Preferred Routes
Heating Substation in Existing Building
Heating Substation in New Development
Energy Centre
Valve Pit
Council Owned Land
HAZ**
HAZARD IDENTIFIED ON NETWORK ROUTE
GENERAL NOTES
1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DOCUMENTATION.
2. DO NOT SCALE FROM THIS DRAWING. USE ONLY STATED DIMENSIONS.
3. BELOW GROUND SERVICES SHALL BE LAID AND COORDINATED IN ACCORDANCE WITH NJUG GUIDELINES ON THE POSITIONING AND COLOUR CODING OF UNDERGROUND UTILITIES.
4. MAJOR POINTS OF COORDINATION WITH UTILITIES HAVE BEEN IDENTIFIED AND SHOULD BE MITIGATED IN FUTURE DESIGN STAGES.
ISSUE/REVISION
2 26/07/22 Alternative Route Options Added
1 20/05/22 Feasibility Stage
I/R DATE DESCRIPTION
PROJECT NUMBER
60635692
SHEET TITLE
Reading District Energy Network
Network General Arrangement
Sheet 2 of 2
SHEET NUMBER
60670504-ACM-00-00-DR-ME-210002
SCALE: 1:1500 @ A1
DHN Pipework Core Network
DHN Pipework Leg 2a
DHN Pipework Leg 2b
DHN Pipework Leg 2c
River Water Pipework
Potential Future Expansion
Potential Alternative Route
Rivermead Leisure Centre Redevelopment
HAZ17: Network Canal Crossing. Pipework Mounted to the Side of Existing Bridge. Detail to be Developed and Subject to Approvals
Premier Inn
Toby Carvery
Crowne Plaza Hotel
HAZ15: Crossover with Foul Water Sewer and Low Pressure Gas Main
Richfield Avenue
Caversham Bridge House
HAZ16: Network in Richfield Avenue runs in Parallel with Low Pressure Gas Main Coordination Required
Potential Network Route as Alternative to the Preferred Route via Privately Owned Land. Wayleaves Required
Potential Network Route as Alternative to the Preferred Route via Privately Owned Land. Wayleaves Required
HAZ14: Network in Caversham Road runs in Parallel with Low Pressure Gas Main Coordination Required
Caversham Road
Thames Avenue
Potential Network Route as Alternative to the Preferred Route
HAZ13: Crossover with Foul Water and Surface Water Sewers and Low Pressure Gas Main
Great Brighams Mead
EP Collier Primary School
HAZ11: Number of Crossovers with Foul Water and Surface Water Sewers and Low and Medium Pressure Gas Main at Roundabout
HAZ10: Network in Vastern Road runs in Parallel with Low and Medium Pressure Gas Mains and Foul Water Sewer. Coordination Required
Former SSE Development
Vastern Road
Shurgard Self Storage
Potential Network Route as Alternative to the Preferred Route
Sovereign House
Aviva Development
HAZ12: Network in Caversham Road runs in Parallel with Low Pressure Gas Main. Coordination Required
Puregym Caversham Road
Former Royal Mail Development
Reading Fire Station
Reading Station
Future Network Expansion Opportunity South via Underpass

6.4. Distribution Network

Figure 6-3 demonstrates the total network trench length associated with each of the network sections; the core network and three potential extensions. A pipework schedule of the preferred network extent, determined during the optioneering study is be included in Section 8.2.

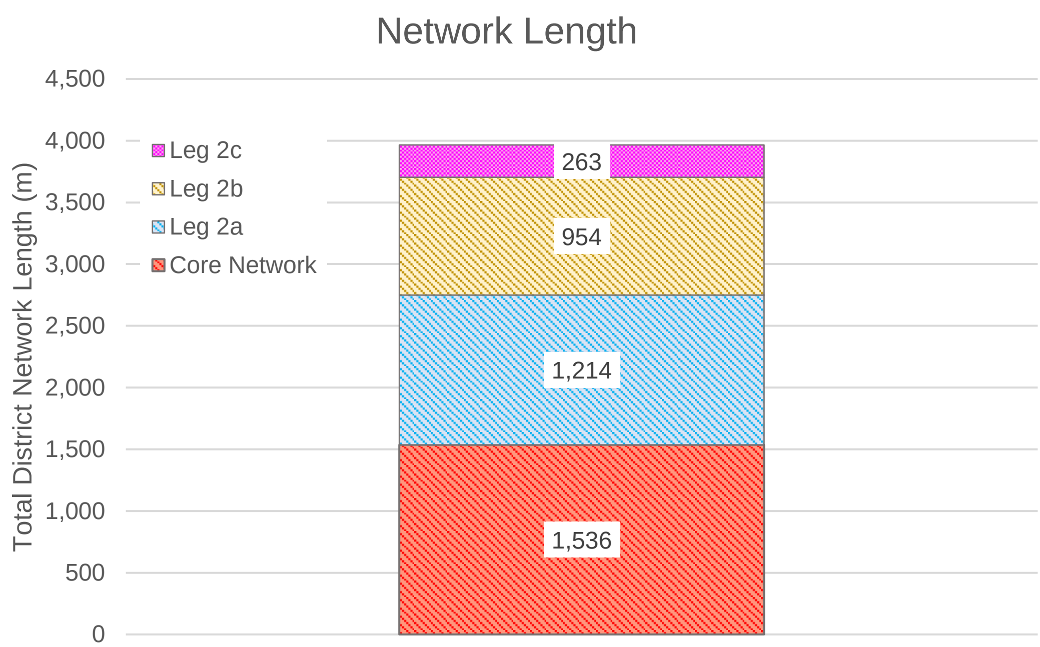


Figure 6-3 - Pipe Length for Network Sections

7. Building Connection and Adaption Works

The reader should read this section in conjunction with *Reading Heat Network District Heating Readiness* report, which highlights design measures to be considered by prospective network customers, and is included as an appendix to this report.

7.1. Building Connection Strategy

Surveys of all existing building plantrooms should be undertaken in future design stages to develop the connection strategy for each building. Typically, existing buildings have a single plantroom which contains the heat generation plant and all distribution circuits radiate from this point, however this is not always the case and there may be multiple plantrooms serving a single building. In the case of the latter, multiple connections from the network may be required or on-site adaptions made by the building owner to enable a single point of connection from the network to be made.

For new developments, it is typical to have a single plantroom, however even where there are a number of plantrooms, it is typically a required to have connectivity between all buildings on the site via an on-site distribution network. Reading Borough Council Planning expects consideration of decentralised energy on site for developments over 20 dwellings and/or over 1,000m^2 and to make provision for future connection from a district network. While this doesn't stipulate a single point of connection, this is likely to be the case.

If the point of connection is at a thermal substation within a plantroom, this will typically form the point of heat sale from the network to the site. The network operator will include a heat meter at this substation and will bill the landlord / site network operator for all heat consumed at this point. If this heat is then distributed to customers on site, further submetering and billing of this would be the responsibility of the site network operator. This is demonstrated in Figure 7-1 below.

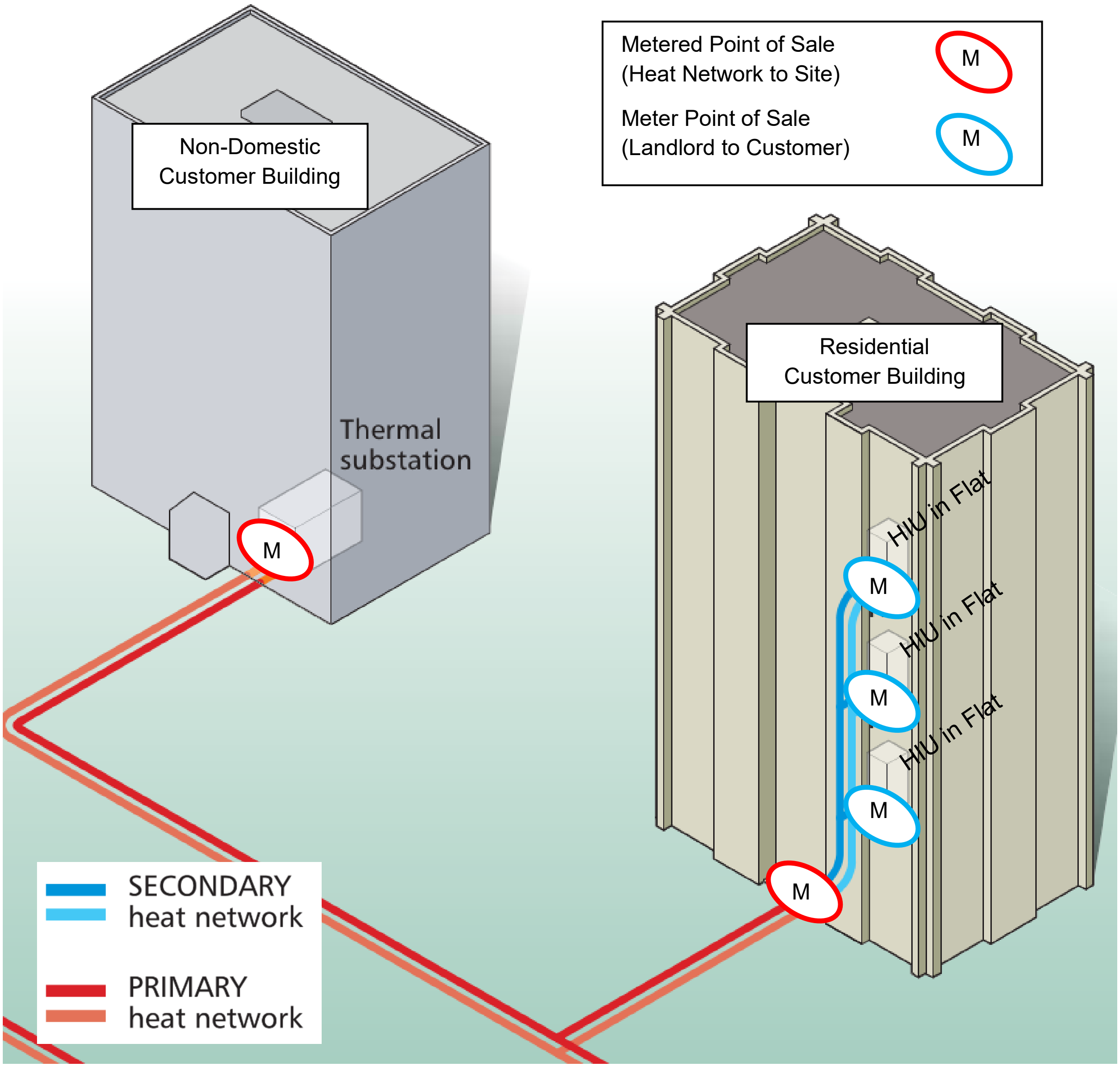


Figure 7-1 - Potential Metering Strategy for Bulk Sale to Multi-Residential Building

For new developments, there is another potential connection strategy where the on-site distribution network becomes part of the district network. In this scenario, a thermal substation to provide separation between the district and on-site networks will typically not be required in a plantroom. Instead, the point of separation between the customer and the network operator will be the HIU within dwellings or commercial units. The network operator would typically be responsible for the network distribution within the building up to and including the HIU, known as the secondary network. The HIU will form the point of heat sale from the network to the customer. The network operator will include a heat meter at this HIU and will bill customer for all heat consumed at this point. This is demonstrated in Figure 7-2 below.

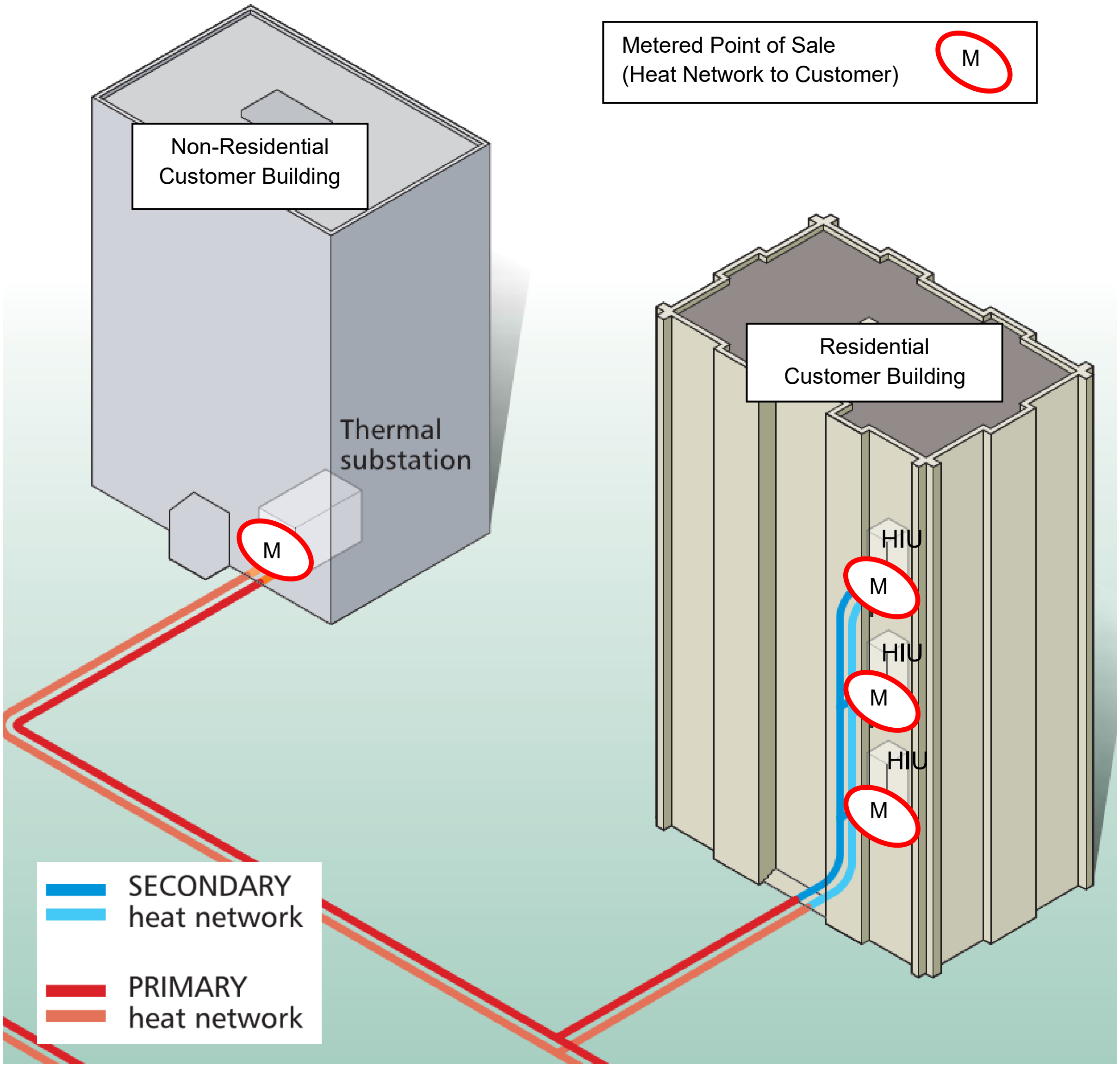


Figure 7-2 Potential Metering Strategy for Individual Sale to Multi-Residential Building

In this study it is assumed that there will be a single point of connection to each existing building and each proposed development. The location of this single point of connection has been estimated, but should be refined through site surveys.

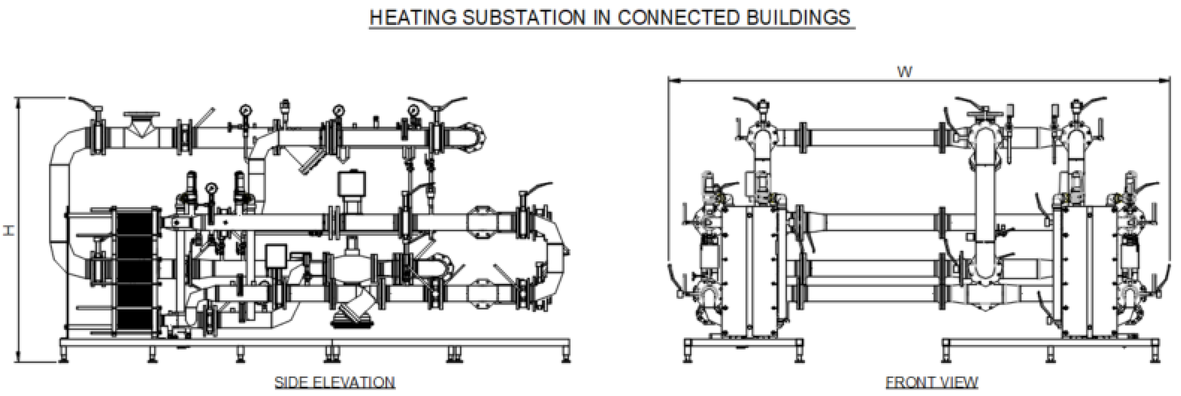
7.2. Direct / Indirect Connections

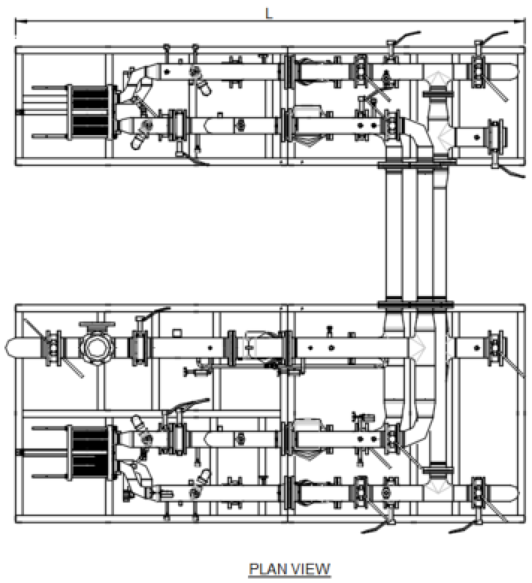
In this study it has been assumed that all connections to customer buildings will be indirect, i.e., water from the primary pipework network cannot mix with any secondary or tertiary pipework. This assumption is the more conservative in terms of customer level space requirements and network efficiency, both of which would be improved with a direct connection. Direct and indirect connections from a district network have positives and negatives to consider. Furthermore, these will have slightly different implications depending on whether they apply to existing or new buildings.

A description of these systems and the advantages and disadvantages of each is discussed in Appendix M.

7.3. Typical Connection and Substation Details

A typical heating substation[19] is demonstrated in Figure 7-3. Cooling substations are of a similar form to that indicated. Thermal substations can be provided as a packaged, skid mounted unit to minimise the amount of on-site fabrication and hot works required, which can provide significant benefit and reduce CDM risk when connecting to existing buildings in plantrooms containing live services. The size of the thermal substation is related to the peak demand as indicated. It is recommended that twin plate substations are sized on a 50%/50% duty basis, with each plate capable of provide half of the peak demand. This principle will likely reduce space requirements but more significantly reduces capital cost but also improves the heat transfer within the plate at low flow condition. Typically, peak demand occurs for approximately 3% of the year[20], so should a single plate fail, the remaining plate will be capable of satisfying demand for approximately 97% of the year.





CAPACITY	APPROXIMATE DIMENSIONS (mm)			WEIGHT
kW	L	W	H	kg
300	2350	2200	1077	490
500	2600	2500	1174	967
800	2900	2800	1171	1140
1200	3220	3150	1854	1280
1800	3650	3400	1948	1530
2500	3961	3550	2221	2640

Figure 7-3 - Typical Heating Substation in Connected Buildings

There are a number of potential details for connecting district network to a building and each will be bespoke to the specific situation. Surveys of all existing building plantrooms should be undertaken in future design stages to develop the connection detail for each building. Engagement with the design team should also be undertaken to achieve the same for new developments. Typical details for above ground entry into a ground level plantroom and below ground into a basement plantroom as indicated in Figure 7-4 and Figure 7-5 below.

[19] An assembly containing plate heat exchanger(s) which hydraulically separates the district heating network pipework from customer pipework. Also contains controls, valves and typically a heat meter for billing purposes.

[20] This will be specific to each building and its demand profile

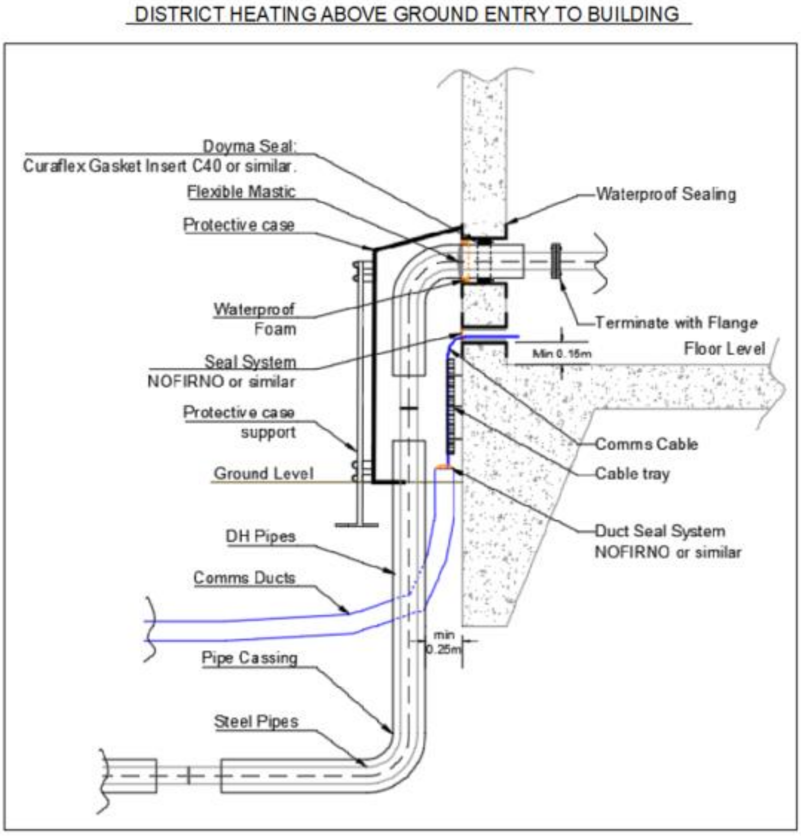


Figure 7-4 - Typical Above Ground Connection Detail

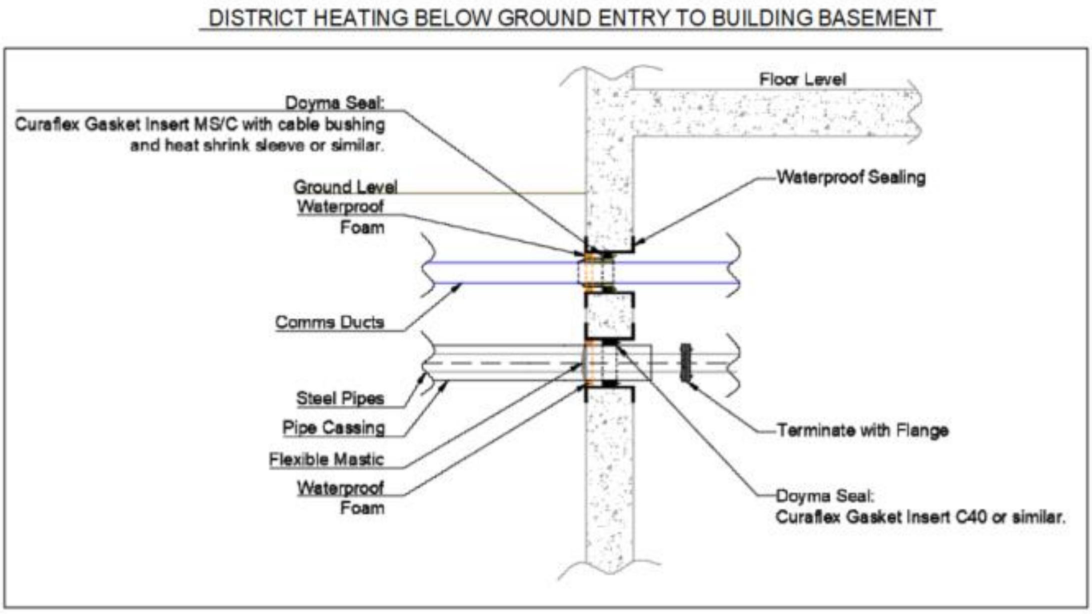


Figure 7-5 - Typical Basement Connection Detail

7.4. Impact on Connected Buildings

For new developments, which should be designed to accord with Reading Planning Policy to include a decentralised energy on site and make provision for future connection from a district network, it is anticipated that no significant impact on the design strategy would result from a connection to district heating, however some of the following may occur:

- Basement and rooftop space that was designating for on-site generation plant becomes available as it is replaced by a district heating connection;
- The specific requirements of an ESCo / network operator require modifications to the proposed on-site services specifications, such as pipework, HIUs etc.;
- Services specification changes may have an impact on the current riser and plant space allowances.

For existing buildings, there is a range of potential interventions to heating systems that may be required to connect to a district network. The final solution will be bespoke to the respective building and will only be fully understood once surveys have been undertaken and detailed designs completed. Two potential solutions at the extremities of this range may be:

Option 1 – No upgrades to existing systems. Rebalancing for different operating temperature undertaken.

Option 2 – Emitter upgrade[21] and rebalancing for different operating temperature undertaken.

The estimated capital costs associated with these interventions are included in Table 7-1 below. It should be noted that these costs are indicative estimates only, not based on information obtained for the specific building systems, and include assumptions detailed in Appendix F. There is the potential for unforeseen issues with existing systems to arise, which would affect the information stated in this report, and would only be understood following detailed surveys of customer buildings.

Any costs associated with adapting existing heating systems for connection to district heating would also be required for the alternative decarbonisation strategy, such as ASHP, as discussed in Section 0.

Existing Building	Option 1 Cost	Option 2 Cost
Rivermead Leisure Complex	£20,000	£115,000
Thames Quarter	£46,000	£45,000[22]
Crowne Plaza Hotel	£17,000	£96,000
Reading Bridge House	£31,000	£188,000
Thames Lido	£5,000	£18,000
Clearwater Court	£27,000	£163,000
Premier Inn, Caversham Bridge	£7,000	£62,000
2 Norman Place	£14,000	£79,000
Kings Meadow House	£12,000	£63,000
Sovereign House	£9,000	£45,000
EP Collier Primary School	£8,000	£83,000
Reading Fire Station	£4,000	£33,000
Caversham Bridge House	£13,000	£70,000

[21] Building fabric upgrades could instead be completed to achieve the same goal and are preferred to emitter upgrades due to the consequential reduction in demand which does not occur with emitter upgrades only

[22] Given the recent completion date of Thames Quarter, it is assumed that existing heating systems will be suitable for lower temperatures without upgrades.

Toby Carvery Caversham Bridge	£3,000	£21,000
Puregym Caversham Road	N/A[23]	£37,000
Total	**£214,000**	**£1,116,000**

Table 7-1 - Estimated Costs of Potential Works to Existing Buildings

7.5. Building Connection Charge

Connection charges can be obtained for the provision of a district heating connection to their building or site as it offsets their requirement to install heat generation plant on-site, thus saving a considerable capital cost. For new developments who have to comply with Building Regulations and Local Plan Requirements, the plant that they would otherwise have installed, and therefore the cost, can be well estimated.

For existing buildings which utilise gas combustion plant, there are generally two potential alternatives which they can pursue for on-site generation: replacing gas combustion plant with like-for-like or retrofitting a low carbon alternative, typically air source heat pumps.

Should the strategy of the building to be carry out a like-for-like replacement, they may be reluctant to pay a connection charge, or only be willing to pay an equivalent amount as they would for replacement gas combustion plant, in spite of no carbon savings being realised. Alternatively, should the organisation responsible have decarbonisation targets, or become mandated to connect under potential future heat network zoning policy, they may be willing to pay an equivalent amount to the low carbon alternative.

Counterfactual cost data used in this analysis is included in Appendix D.

The following counterfactuals have therefore been used to determine the connection charge for each customer.

- Low Temperature Air Source Heat Pump for New Developments
- High Temperature Air Source Heat Pump for Existing Buildings

The resultant connection charge for the preferred network solution equates to an average of **£603/kW**[24] for the network. Sensitivity analysis will be conducted in later sections to assess the impact of offering discounts on this charge to encourage customers to connect, and in particular existing buildings. Refer to Section 9 for details.

In practise a network operator may choose to offer a blanket £/kW connection charge to all customers. It is recommended that customers are encouraged to request a connection capacity that is measured in kg/s rather than kW, which will encourage them to consider the wider temperature differential for hot water generation to avail of a lower connection charge. This may help avoid oversizing of pipework and infrastructure, reducing heat losses and improving the primary network efficiency, providing a cost saving to the operator and a carbon to all customers.

7.6. Building Counterfactual Plant Space

All buildings which employ a low carbon on-site generation system rather than connecting to district heating will require plant space to locate the associated plant and equipment. Connection to district heating does require some plant space for connections and to locate thermal substations, as demonstrated in Section 7.3, however this is typically much less than would be required for an on-site generation system. Assuming the on-site low carbon technology is air source heat pumps, additional space would be required for the following[25]:

Rooftop or external plantspace for:

- Air Source Heat Pumps

Basement or ground plantroom space for:

[23] Existing emitters are understood to be VRF so are unsuitable for use with district energy.

[24] This equates to an average of approximately £2,000/apartment across the network

[25] There are some plant items which would be required with both on-site generation and connection to a district network. As these are common across both solutions, they are not considered in this comparison.

- Thermal Stores (double/triple height space required)
- Additional Electrical Switchgear for Heat Pumps and associated Plant
- Additional Electrical Transformers[26]
- Heat Pump Primary Circulation Pumps
- Resilient Heat Generation Plant (Gas or Electric Boiler)[27]
- Gas Meter Room (if gas boilers are included)

Using the estimates of peak demand from Section 2.4.3, indicative counterfactual plant selections and plant space requirement drawings were undertaken for five of the planned new developments, and two generic sites with a peak demand of 200kW and 400kW. The potential rooftop/external plantspace saving from connection to district heating is demonstrated in Figure 7-6.

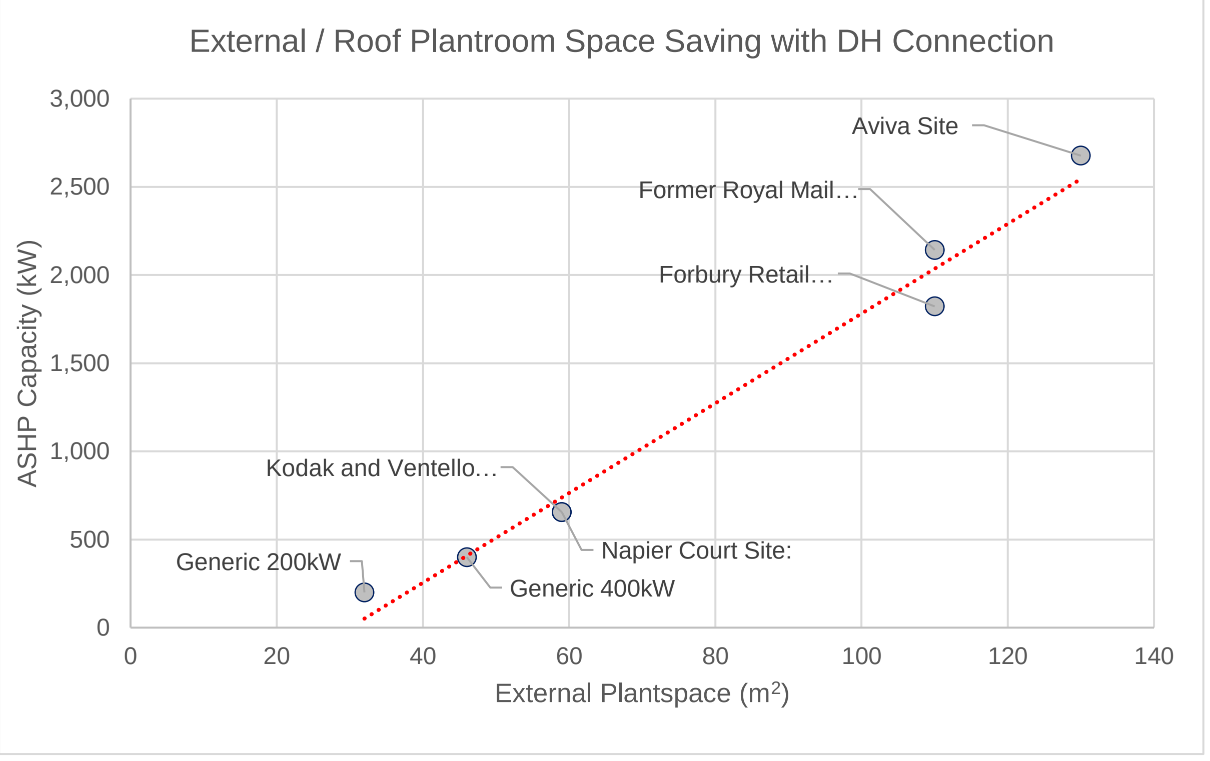


Figure 7-6 - Potential External / Roof Space Saving with Connection to District Heating

This has been based on estimated peak demand, assuming a 100% ASHP solution and using indicative plant selections, which may differ for the actual site once detailed design has been completed.

Using the same principle, the potential internal plantspace saving from connection to district heating is demonstrated in Figure 7-7. This is demonstrated for two scenarios, a) inclusion of gas boiler resilient plant and b) omission of boilers and using air source heat pumps as the only heat generating plant.

[26] Requirement is dependent on the spare capacity of existing supply.

[27] Subject to Client requirements for resilience.

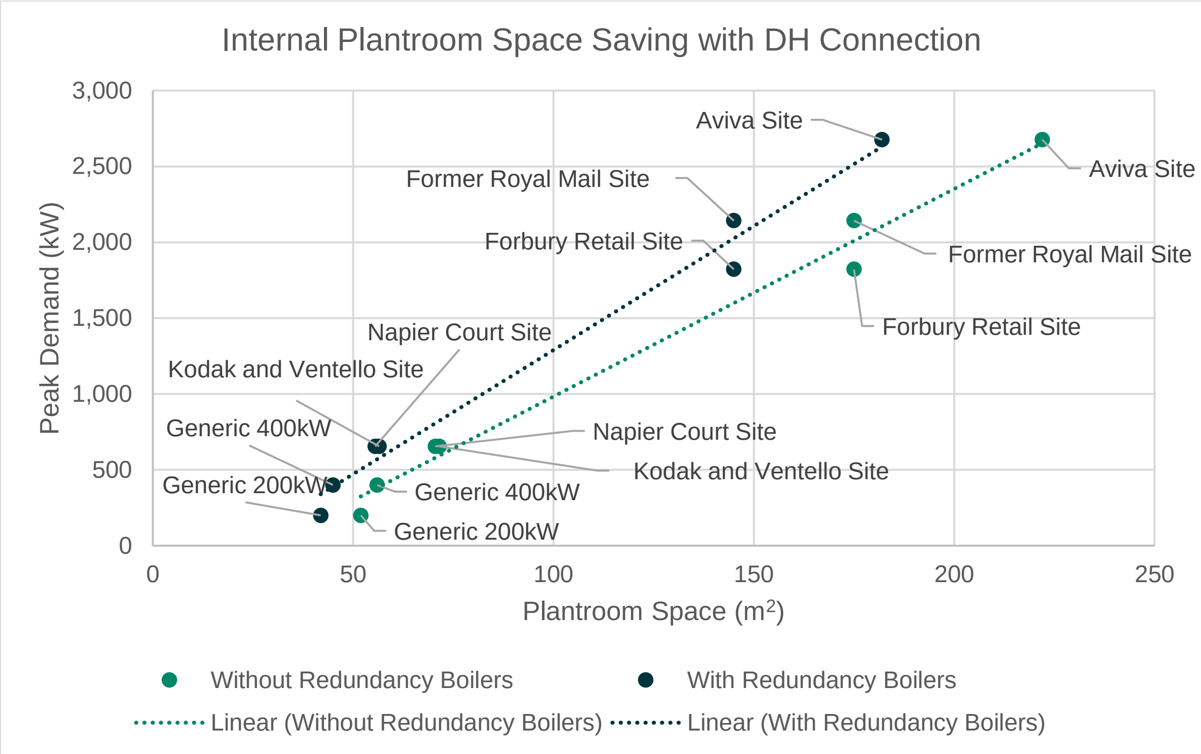


Figure 7-7 - Potential Internal Plantroom Space Saving with Connection to District Heating

7.7. Valuation of Space Saving

The potential space savings, demonstrated in Section 7.6, could be utilised for a number of uses, such as resident amenity space, cycle storage or others which may be preferred or required by the specific development. For the purposes of providing an economic valuation on this space saving in this assessment, however, it is assumed that:

- Ground / Basement Plantspace will be used as Retail Space[28]
- External / Rooftop Plantspace will be utilised for solar PV

Retail space within a recent development within the study boundary has an anticipated rental value of £157/m^2/annum[29].

Installation PV panels on the External / Roof plant space that otherwise would have been used to located ASHP could provide cost savings by generating electricity that would otherwise be purchased from the grid, and the carbon savings could potentially reduce any S106 carbon offset payments.

The potential savings that can be obtained through connection to district heating for a range of development sizes is demonstrated in Figure 7-8.

Further details, including the calculation methodology is included in Appendix I.

[28] Should the space saving be at basement level, it is assumed that other low value space such as cycle or refuse storage could be moved from ground level to basement

[29] 1,370 Sq Ft ground floor retail space in Thames Quarter, RG1 8DQ

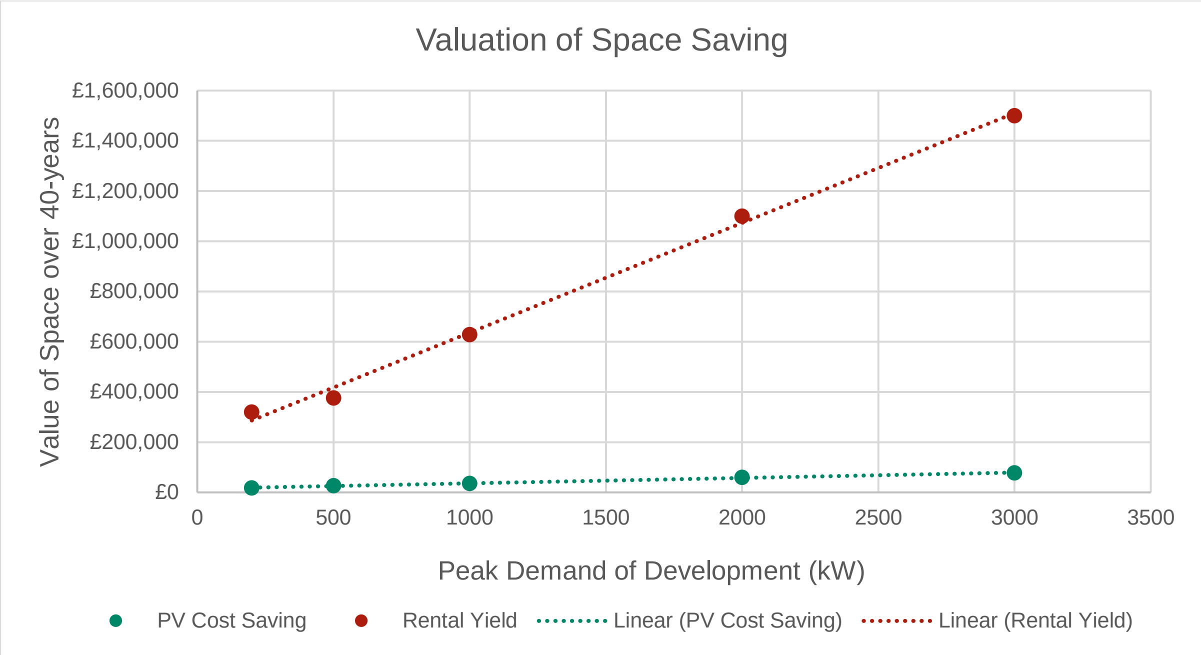


Figure 7-8 - Valuation of Space Saving with Connection to District Heating

8. Optioneering Study

8.1. Counterfactual Scenarios

The potential counterfactual scenarios are described in detail in Section 3.

For the Technoeconomic analysis, the counterfactuals used are:

- Low Temperature Air Source Heat Pump for New Developments
- High Temperature Air Source Heat Pump for Existing Non-Residential Buildings
- Gas Boiler for Existing Residential Buildings[30]

There is a risk that existing buildings which are currently operating on lower gas boiler tariff may be reluctant to pay more for their energy, in spite of the carbon and space savings and air quality improvements that it provides. Potential discounts that could be offered to encourage connection are explored in sensitivity analysis.

8.2. Optimisation of Network Extent

The first step in identifying a preferred scheme is to optimise the phase 1 network extent. As demonstrated in Section 6.3, there is a core network focused on the large new build developments in the cluster. In addition, there three potential extensions of this network, referred to as 2a, 2b and 2c, described below:

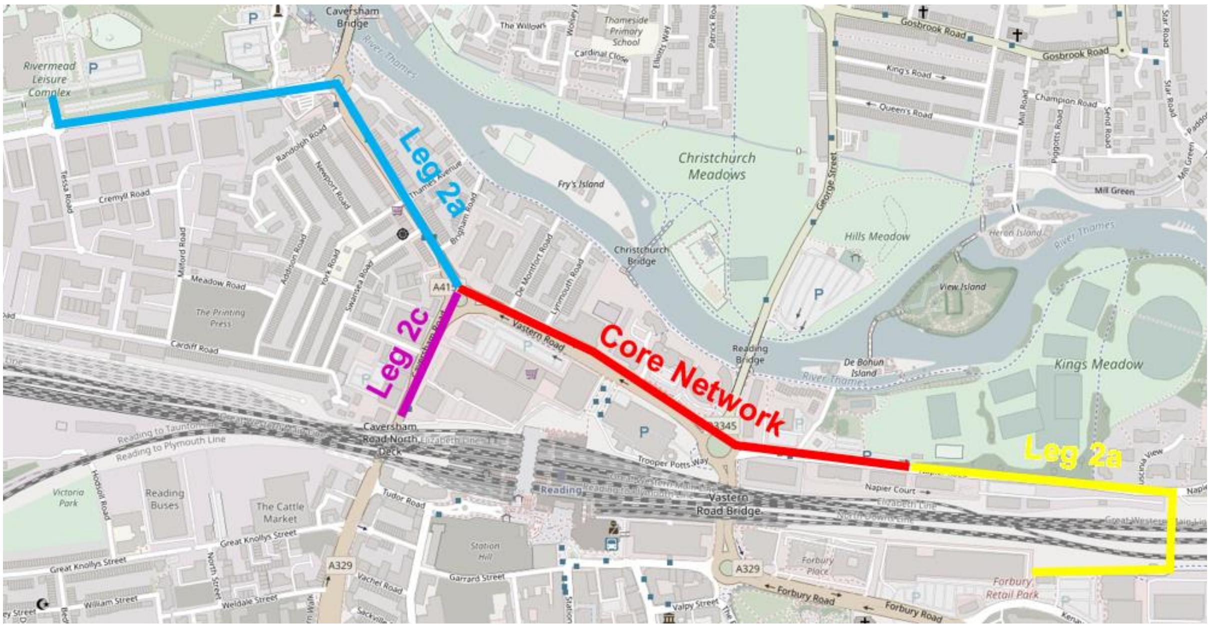


Figure 8-1 - Network Extent Options

The choice of an optimum network will be made both quantitatively using Technoeconomic analysis and qualitatively, using information obtained from stakeholder engagement. These different extents have been combined under 5 scenarios (A1-A5) as detailed below.

[30] To align with GHNF Customer Detriment Metric

8.2.1. Quantitative Analysis

The five scenarios in Table 8-1 below were analysed.

Scenario	A1	A2	A3	A4	A5
Network Extent	Core Only	Core + 2b	Core + 2a + 2b	Core + 2b + 2c	Core + 2a + 2b + 2c

Table 8-1 - Variations of Network Extent

The results of the analysis are demonstrated in Figure 8-2 and Figure 8-3.

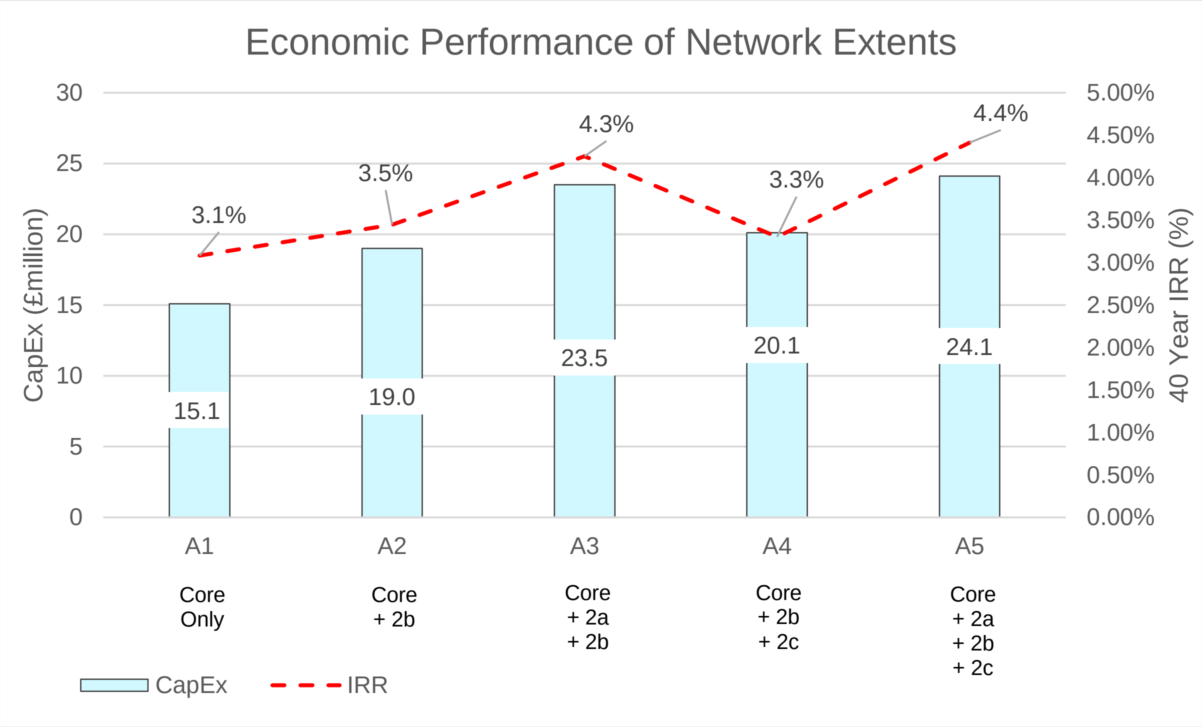


Figure 8-2 - Economic Performance of Network Extents

A general trend can be observed where an increased network extent increases CapEx but also leads to an increase in IRR due to an uplift in heat sale revenue.

The addition of Leg 2a has a 0.80% - 1.11% benefit on the IRR (Scenario A2 to A3 – A4 to A5) but is a considerable initial capital outlay at £4.0 - £4.5m.

The addition of Leg 2b has a 0.37% benefit on the IRR (Scenario A1 to A2) but is also a considerable initial capital outlay at £3.9m.

In scenario A4, Leg 2c is added to scenario A2 which results in a reduction in IRR of 0.15%. In scenario A5, Leg 2c is added to scenario A3, which results an increase in IRR of 0.16%. It can be deduced that Leg 2c has a negative impact on the network economics when Leg 2a is excluded, and a marginal benefit when it is included.

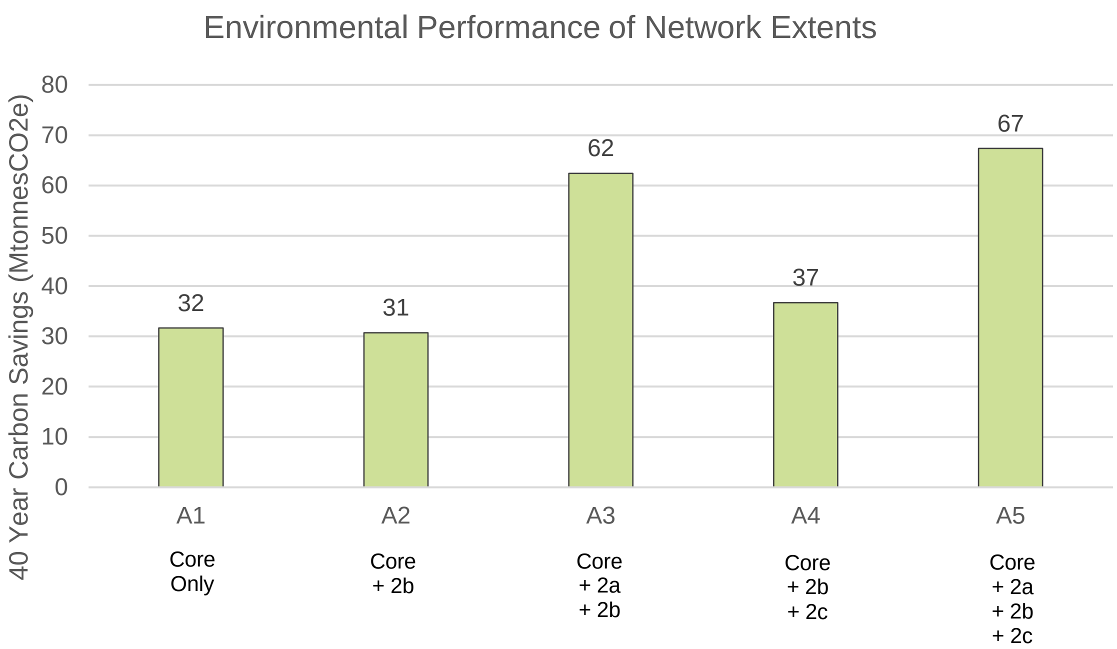


Figure 8-3 - Environmental Performance of Network Extents

It should be highlighted that the carbon savings achieved through connecting to existing buildings are significantly greater than those achieved by connecting to new developments. This is due to the savings for existing buildings being compared to a gas fired counterfactual vs an air source heat pump counterfactual for new developments.

The addition of Leg 2a (Scenario A2 to Scenario A3) significantly increases the carbon savings as the loads are existing buildings. It should be noted that almost 50% of these savings can be attributed to Rivermead Leisure Centre, which is reported to be considered its own decarbonisation strategy.

The addition of Leg 2b (Scenario A1 to Scenario A2) leads to a reduction in carbon savings i.e. it generates carbon vs the counterfactual. This is due to the loads on Leg 2b being entirely new developments.

The addition of Leg 2c (Scenario A3 to Scenario A5) results in a minor increase in carbon savings as the loads are existing buildings.

8.2.2. Qualitative Analysis

Extension 2a is a considerable distance, at approximately 1,200m at supplies only 6no. buildings. The largest of these are Rivermead Leisure Centre and Crowne Plaza Hotel which represent 46% and 34% of the demand respectfully. Through engagement, it is known that Rivermead is planned for redevelopment, which would include the installation of large scale heat pumps, meaning it would likely not obtain any significant carbon savings from connection to a network should the development proceed along those plans. The Crowne Plaza Hotel have not engaged with the project team in spite of a number of attempts and therefore carry a significant risk of not wishing to connect to the network. Beyond these loads, there is little opportunity for expansion of the network.

Extension 2b involves a crossing below the railway, which represents a technical risk and will require engagement with Network Rail and close coordination with existing utilities along the route. Representatives of both of the new developments that are proposed to connect to the network have responded positively to the scheme during engagement. This extension offers an opportunity for further expansion of the network to the south of the railway into Reading Town Centre and the Station Hill Cluster and could enable decarbonisation of the existing buildings in the area.

Extension 2c is a short leg, at approximately 260m at supplies only 3no. buildings. Of these, Shurgard were unwilling to engage and whilst Puregym responded positively to the scheme, the vast majority of their heat demand is met by existing VRV/VRF systems, so would likely not obtain any significant carbon savings from connection to a network. This leg is along a busy section of Caversham Road, close to the railway bridge so may involve complex road closures to install a network.

8.2.3. Network Extent Conclusion

The addition of Leg 2a provides both an economic and environmental benefit, however this is highly dependent on Rivermead Leisure Centre and Crowne Plaza Hotel which together represent 80% of the demand for the leg. Both of these loads are considered to be high risk and the loss of either or both would have a significant negative impact on the viability of this leg. This leg also offers little opportunity for future expansion. Given the uncertainty, it is recommended that this leg is considered only as a future opportunity to be explored once more details of Rivermeads development plans are understood and the Crowne Plaza Hotel are willing to engage with the project.

With the exclusion of Leg 2a, Leg 2c has a negative impact on the economic performance of the network. The marginal carbon savings are also subject to further reduction should one or more of the proposed connections be lost. It is recommended that this leg is considered as a future opportunity to expand the network to the south of the railway line.

Leg 2b has a marginal impact on the network carbon savings, but a slight positive impact on the IRR. However, it is worth considering this leg as a strategic means to expand the network to the south of the railway to access existing buildings in the town centre and offer significant carbon savings over their existing heating systems. Without including this leg in the phase 1 network, it is likely that both of the proposed new developments will pursue on-site generation and cease to be feasible connections for a significant number of years, thus limiting the potential for this expansion south to be undertaken economically in future.

It is recommended that the phase 1 network comprises the core network and Leg 2b. The optioneering studies that follow are based on this network extent.

A pipework schedule for a network extent comprising the core network and Leg 2b is demonstrated in Figure 8-4.

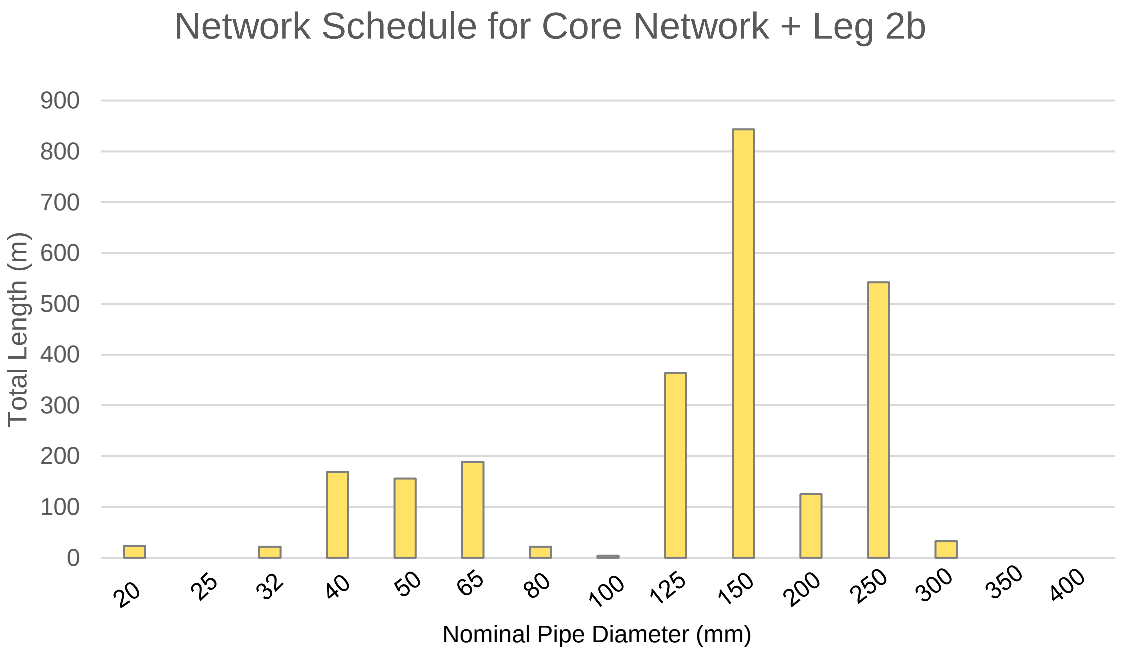


Figure 8-4 - Network Schedule for Core Network + Leg 2b

8.3. Base Network Scenarios

The scenarios in Table 8-2 have been modelled to identify a preferred solution to take forward for refinement into detailed and sensitivity analysis.

In these scenarios, the environmental metric that was targeted was a carbon intensity of heat of 50gCO_2e/kWh in 2025, the anticipated first year of heat sale. This was chosen to align with the carbon intensity of the counterfactual solution that had been proposed by new developments in planning applications[31] and to achieve carbon reductions for existing buildings. It should be noted that this carbon intensity could not be achieved in all cases.

The exception to this carbon intensity target a fully electric solution which was explored in scenario B9.

In some scenarios, due to limitations on the Primary LZC plant, such as river temperatures being too cold to operate a river source heat pump, a secondary LZC technology has been introduced to achieve the target carbon intensity.

In this analysis in this section of the report, which seeks to identify a preferred solution, the relative performance of each of the scenarios against the stated criteria is more important than the absolute values, which will be explored in greater detail in Section 9.

[31] In the 2021 Edition of the Approved Document L - Conservation of fuel and power the carbon emission factor for grid supplied electricity is proposed to be an annual average of 138gCO_2/kWh. In SAP 10.1, this is 136gCO_2/kWh. The efficiency of a heat pump for the notional building is 264%. Developments have stated up to 280% in their planning application energy strategy. This gives a range of 48.6gCO_2e/kWh – 52.3gCO_2e/kWh.

Scenario	B1	B2	B3	B4	B5	B6	B7	B8	B9
Brief Description	River Only	River and Air	River and Air with Cooling	Ground and Air	Ground and Air with Cooling	Air Only	Hybrid River and Ground	Hybrid River and Ground with Air	Fully Electric
Heat Network	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Coolth Network	No	No	Yes	No	Yes	No	No	No	No
Primary LZC Technology[32]	RSHP 4MW	RSHP 2.1MW	RSHP 2.1MW	GSHP 0.65MW	GSHP 0.65MW	ASHP 6.0MW	RSHP & GSHP[33] 3.6MW	RSHP & GSHP[33] 2.1MW	RSHP 2.1MW
Secondary LZC Technology[34]	None	ASHP 2.6MW	ASHP 2.6MW	ASHP 4.8MW	ASHP 4.8MW	None	None	ASHP 2.1MW	ASHP 3.2MW
Peaking and Resilient Technology	Gas Boilers 11.2MW	Gas Boilers 8.6MW	Gas Boilers 8.6MW	Gas Boilers 6.5MW	Gas Boilers 6.5MW	Gas Boilers 5.2MW	Gas Boilers 11.2MW	Gas Boilers 9.1MW	Electrode Boilers 7.9MW
Thermal Storage (m^3)	4,000	270	270	270	270	270	270	270	270
Project CapEx (£'million)	26.3	19.0	23.6	18.6	23.1	19.1	20.3	20.2	19.6

Table 8-2 - Base Network Scenarios Tested

[32] RSHP = River Source Heat Pump, GSHP = Ground Source Heat Pump, ASHP = Air Source Heat Pump

[33] Heat pumps are supplied from one of two sources, river or ground. River is the source when the river water is warmer than the ground water and vice versa.

[34] Required where the capacity of the primary technology is assessed as being not sufficient to meet the target carbon intensity due to capacity limitations or restricted operation due to low source water temperatures

8.3.1. Economic Results

Figure 8-5 below demonstrates the 40-year real IRR without any state aid funding for the 9 scenarios tested. Results are ordered **best to worst** from **top to bottom**.

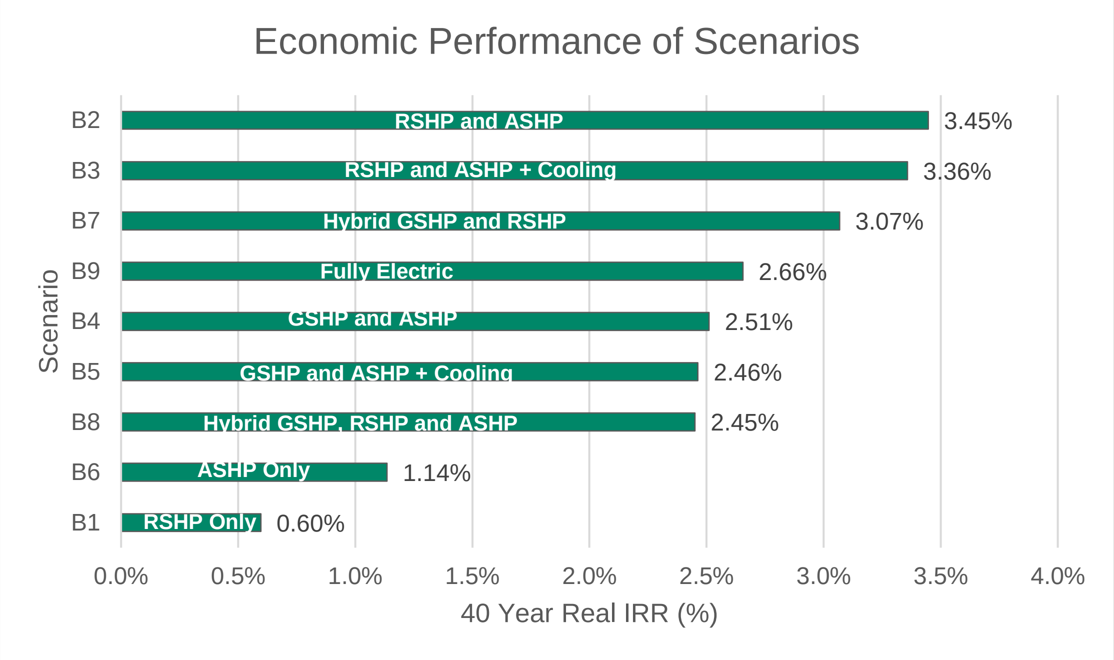


Figure 8-5 - Economic Performance of Base Scenarios

The following can be summarised from these results:

- RSHP + ASHP + Gas Boiler based schemes perform best (B2 and B3)
- Hybrid GSHP and RSHP source performs third best and offers a potentially feasible solution to overcoming cold river temperatures in winter
- The capacity of plant needed to aspire towards the target carbon intensity[35], using only RSHP as the LZC, results in poor IRR performance (B1).
- The addition of cooling networks has a negative IRR impact (B3 and B5)
- The fully electric solution i.e. no gas boilers performs fourth best

[35] The target carbon intensity for this scenario could not be achieved due to the down time of LZC plant that occurred due to river water temperatures being too col

8.3.2. Environmental Results

Figure 8-6 below demonstrates the 40-year accumulative carbon savings against the counterfactual for the 9 scenarios tested. Results are ordered **best to worst** from **top to bottom**.

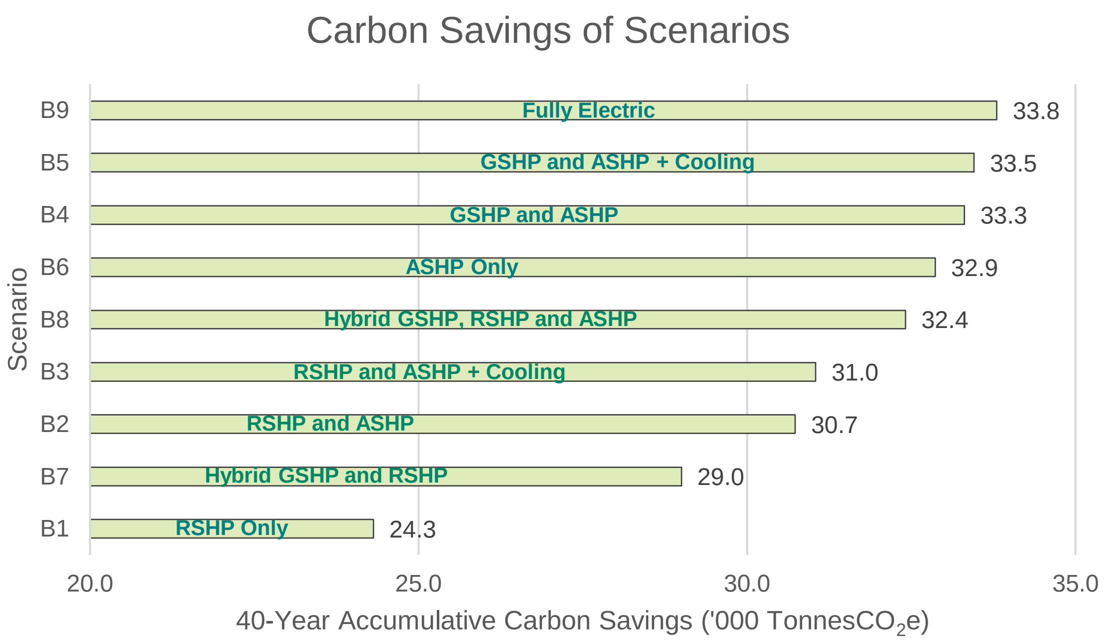


Figure 8-6 - Accumulative Carbon Savings of Scenarios

The following can be summarised from these results:

- The fully electric solution offers the highest carbon savings over 40 years (B9), however this is only a minor improvement on the next four best performing (B5, B4, B6 and B8)
- The inclusion of some ASHP capacity improves the carbon savings over 40 years (change from B1 to B2, change from B7 to B8)
- Open loop ground boreholes can be retrofitted to scenario B2 to become scenario B8 and improve carbon savings if they are found to be feasible during detailed analysis
- The addition of cooling networks offers only marginal carbon improvements (B3 and B5)
- A solution with RSHP as the only LZC source offers the worst carbon savings, due to down time of the LZC plant when river temperatures are too cold to operate

8.3.3. Optioneering Conclusions

The overall ranking of the scenarios, taken as the average of its economic and environmental performance is detailed in Table 8-3.

Scenario	Description	Average Rank	Economic Rank	Environmental Rank
B9	Fully Electric	2.5	4	1
B2	RSHP and ASHP	4	1	7
B3	RSHP and ASHP + Cooling	4	2	6
B5	GSHP and ASHP + Cooling	4	6	2
B4	GSHP and ASHP	4	5	3
B7	Hybrid GSHP and RSHP	5.5	3	8
B8	Hybrid GSHP, RSHP and ASHP	6	7	5
B6	ASHP Only	6	8	4
B1	RSHP Only	9	9	9

Table 8-3 - Overall Ranking of Scenarios

The fully electric solution, B9, scores best and shall be taken forward for detailed analysis in Section 9.

Four scenarios are tied for the second-best score. These are RSHP and GSHP led schemes, with and without district cooling networks. The addition of a cooling network increases the project CapEx by approximately £4.5m, without significantly improving performance. For this reason, B3 and B5 are not deemed to be optimal and will not be considered further.

As outlined in Section 4.1.2, there are some concerns regarding the technical viability of a GSHP led scheme in the study area, whereas there is less risk associated with a RSHP. For this reason, it is recommended that scenario B2 is taken forward for detailed analysis rather than B4. However, should the viability of open loop boreholes be proven during detailed design, there is potential for this to be incorporated into the B2 design concept, which would improve the carbon savings.

All other scenarios are deemed to be sub optimal and will not be considered further.

9. Developed Options

The two most technically viable scenarios identified in Section 8, B2 and B9, will be assessed in more detail in the following sections.

9.1. Scenario B2

Scenario B2 is a river source heat pump led network, with air source heat pumps as a secondary LZC source and natural gas fired boilers as peaking and resilient plant.

9.1.1. Concept System Design

The concept energy generation system for Scenario B2 is demonstrated in Figure 9-1. This includes a potential future addition of open loop ground abstraction system to enhance carbon savings if it is found to be a feasible and desirable option during future design stages.

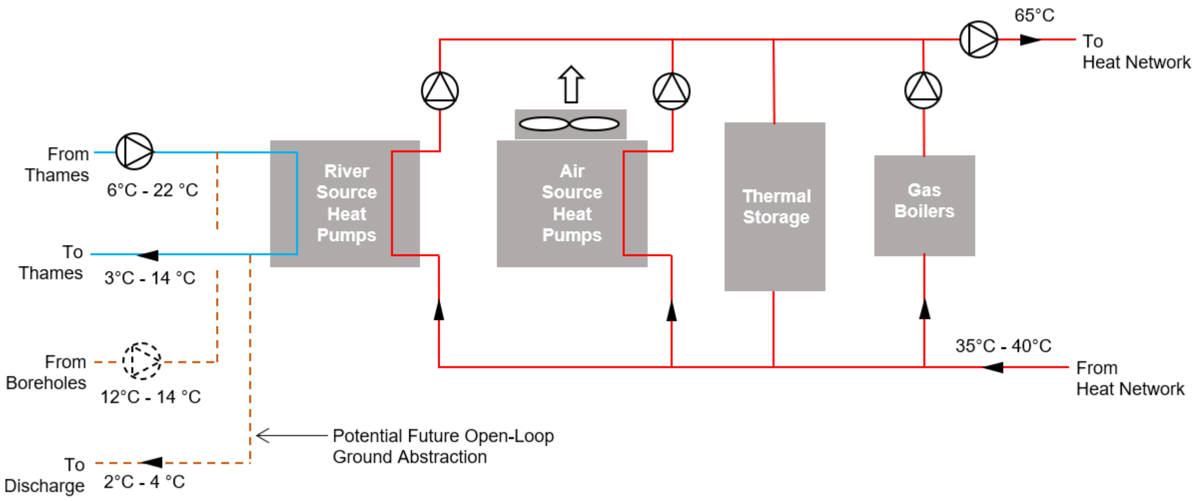


Figure 9-1 - Scenario B2 Concept System Design

9.1.2. Futureproofing for Environmental Improvement

It is important to consider strategies to improve the carbon savings from the initial concept design and to allow for expansion of the network in future. Given the low proposed carbon intensity of the heat, significant carbon benefit can be achieved by extending the network to more existing, gas heated buildings. While the proposed solution offers carbon savings, the optimal solution is to consider it as a first phase enabler for establishing a low carbon heat network in Reading which can grow over time. For scenario B2, the following futureproofing strategies are available:

- Design the network hydraulics, such that open-loop groundwater abstraction can be retrofitted to supplement the river source abstraction when temperatures are low.
- Design in spare space for additional air source heat pumps, which can be added as the network grows to limit the amount of boiler generation, potentially phasing this out over time.
- Enhance the capacity of the river abstraction system by ‘oversizing’ infrastructure in the initial phase and adding supplementary circulation pumps when required.

9.1.3. Plant Sizing & Energy

An outline plant and equipment schedule for Scenario B2 is included in Appendix O. All selections are subject to validation during detailed design stage.

The diversified peak demand for the Scenario B2 network extent has been determined to be 9,213kW. A combination of ASHP and gas boilers as peaking and resilient plant has been used to meet this requirement, with ASHP acting as a secondary LZC source and primary resilient plant. Boilers have been specified with approximately n+1 resilience, which equates to 24% spare capacity.

The resultant annual energy generation split by technology is demonstrated in Figure 9-2.

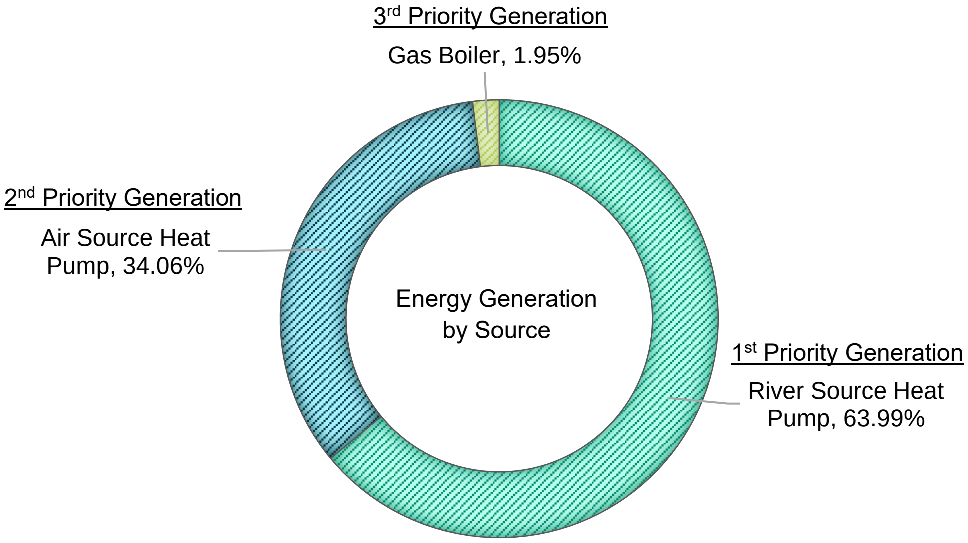


Figure 9-2 – Annual Energy Generation by Source Technology for Scenario B2

The estimated annual heat sales and primary network losses for Scenario B2 are demonstrated in Figure 9-3. CIBSE CP1(2020) best practise CP3.5a is to limit losses from the primary network to no greater than 10% of the heat supplied from the Energy Centre. For Scenario B2, the losses equate to approximately 6.5% and so is compliant with CP3.5a.

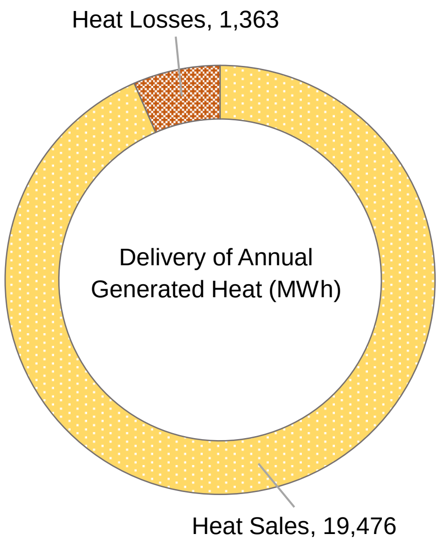


Figure 9-3 - Heat Sales and Losses for Scenario B2

9.1.4. Energy Centre Layout

The proposed scenario B2 Energy Centre Ground and Roof level layouts are included below. It is proposed to integrate the Energy Centre plant delivery and replacement hard standing with the existing car park on Napier Road, to minimise the loss of green space in Kings Meadow Park.

To ensure there is 24/7 unobstructed access to the incoming electrical substation, required by the DNO, it is estimated that of the most north easterly car parking spaces would be lost. The remaining car parking spaces could be retained, however during planned replacement and delivery of plant to the Energy Centre, a number would need to be closed. However, this could be planned in advance of the works. The indicated space requirements for utilities are subject to confirmation by the DNO during detailed design.

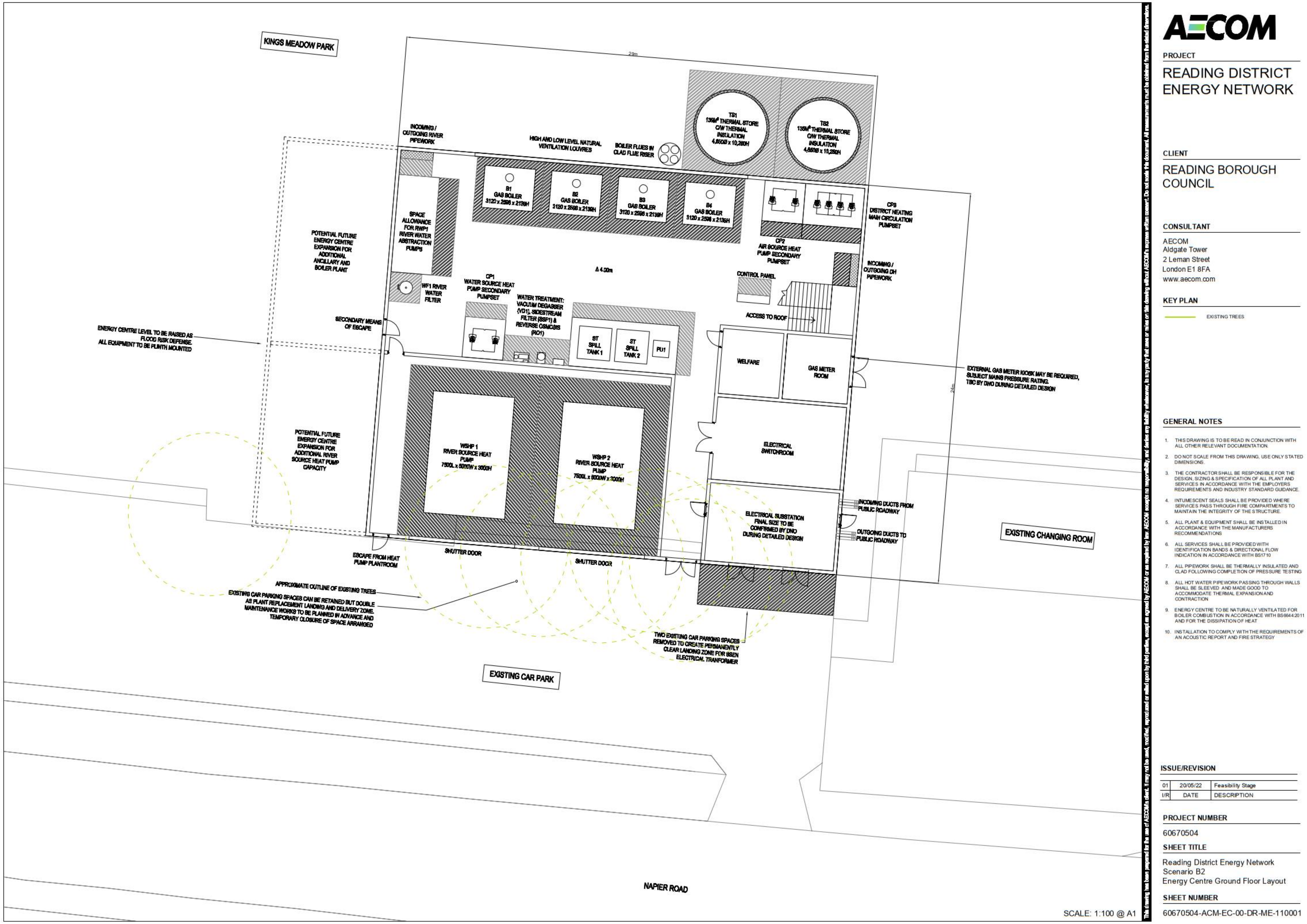
Figure 9-4 - Proposed B2 Energy Centre Arrangement

The ground level of the Energy Centre / the mechanical and electrical equipment would need to be raised to approximately 38.5m AOD to protect against flooding (see Appendix G for more information). A topographical survey will be required to confirm the level increase required in the proposed location but is estimated to be 0.5-1.5m.

The proposed energy centre has an approximate footprint of 762m^2 taken from green space with Kings Meadow Park. The height above the raised ground level is approximately 7m, inclusive of acoustic and visual screens for the air source heat pumps at roof level. The thermal stores and boiler flues protrude above this, terminating at a height of approximately 10.25m.

With the proposed footprint, there is potential to install additional air source heat pump capacity in future to further decarbonise the generated heat or to expand the network. There is sufficient space at roof level for an additional, circa 6MW of ASHP capacity, however if added, this may require additional space for the associated electrical equipment. There is also an opportunity to expand the footprint of the energy centre if desired in future, again enabling expansion of the network.

Feasibility drawings are also included below and also as an appendix to this report.


KINGS MEADOW PARK
INCOMING / OUTGOING RIVER PIPEWORK
HIGH AND LOW LEVEL NATURAL VENTILATION LOUVRES
BOILER FLUES IN CLAD FLUE RISER
TS1 136M³ THERMAL STORE C/W THERMAL INSULATION 4,850Ø x 10,260H
TS2 136M³ THERMAL STORE C/W THERMAL INSULATION 4,850Ø x 10,260H
B1 GAS BOILER 3120 x 2596 x 2139H
B2 GAS BOILER 3120 x 2596 x 2139H
B3 GAS BOILER 3120 x 2596 x 2139H
B4 GAS BOILER 3120 x 2596 x 2139H
CP3 DISTRICT HEATING MAIN CIRCULATION PUMPSET
CP2 AIR SOURCE HEAT PUMP SECONDARY PUMPSET
SPACE ALLOWANCE FOR RWP1 RIVER WATER ABSTRACTION PUMPS
POTENTIAL FUTURE ENERGY CENTRE EXPANSION FOR ADDITIONAL ANCILLARY AND BOILER PLANT
Δ 4.00m
INCOMING / OUTGOING DH PIPEWORK
CONTROL PANEL
WF1 RIVER WATER FILTER
CP1 WATER SOURCE HEAT PUMP SECONDARY PUMPSET
WATER TREATMENT: VACUUM DEGASSER (VD1), SIDESTREAM FILTER (SSP1) & REVERSE OSMOSIS (RO1)
ACCESS TO ROOF
SECONDARY MEANS OF ESCAPE
ENERGY CENTRE LEVEL TO BE RAISED AS FLOOD RISK DEFENSE. ALL EQUIPMENT TO BE PLINTH MOUNTED
ST SPILL TANK 1
ST SPILL TANK 2
PU1
WELFARE
GAS METER ROOM
EXTERNAL GAS METER KIOSK MAY BE REQUIRED, SUBJECT MAINS PRESSURE RATING. TBC BY DNO DURING DETAILED DESIGN
POTENTIAL FUTURE ENERGY CENTRE EXPANSION FOR ADDITIONAL RIVER SOURCE HEAT PUMP CAPACITY
WSHP 1 RIVER SOURCE HEAT PUMP 7500L x 5000W x 3000H
WSHP 2 RIVER SOURCE HEAT PUMP 7500L x 5000W x 3000H
ELECTRICAL SWITCHROOM
INCOMING DUCTS FROM PUBLIC ROADWAY
ELECTRICAL SUBSTATION FINAL SIZE TO BE CONFIRMED BY DNO DURING DETAILED DESIGN
OUTGOING DUCTS TO PUBLIC ROADWAY
EXISTING CHANGING ROOM
ESCAPE FROM HEAT PUMP PLANTROOM
SHUTTER DOOR
SHUTTER DOOR
APPROXIMATE OUTLINE OF EXISTING TREES
EXISTING CAR PARKING SPACES CAN BE RETAINED BUT DOUBLE AS PLANT REPLACEMENT LANDING AND DELIVERY ZONE. MAINTENANCE WORKS TO BE PLANNED IN ADVANCE AND TEMPORARY CLOSURE OF SPACE ARRANGED
TWO EXISTING CAR PARKING SPACES REMOVED TO CREATE PERMANENTLY CLEAR LANDING ZONE FOR 66KV ELECTRICAL TRANFORMER
EXISTING CAR PARK
NAPIER ROAD
SCALE: 1:100 @ A1
AECOM
PROJECT
READING DISTRICT ENERGY NETWORK
CLIENT
READING BOROUGH COUNCIL
CONSULTANT
AECOM
Aldgate Tower
2 Leman Street
London E1 8FA
www.aecom.com
KEY PLAN
EXISTING TREES
GENERAL NOTES
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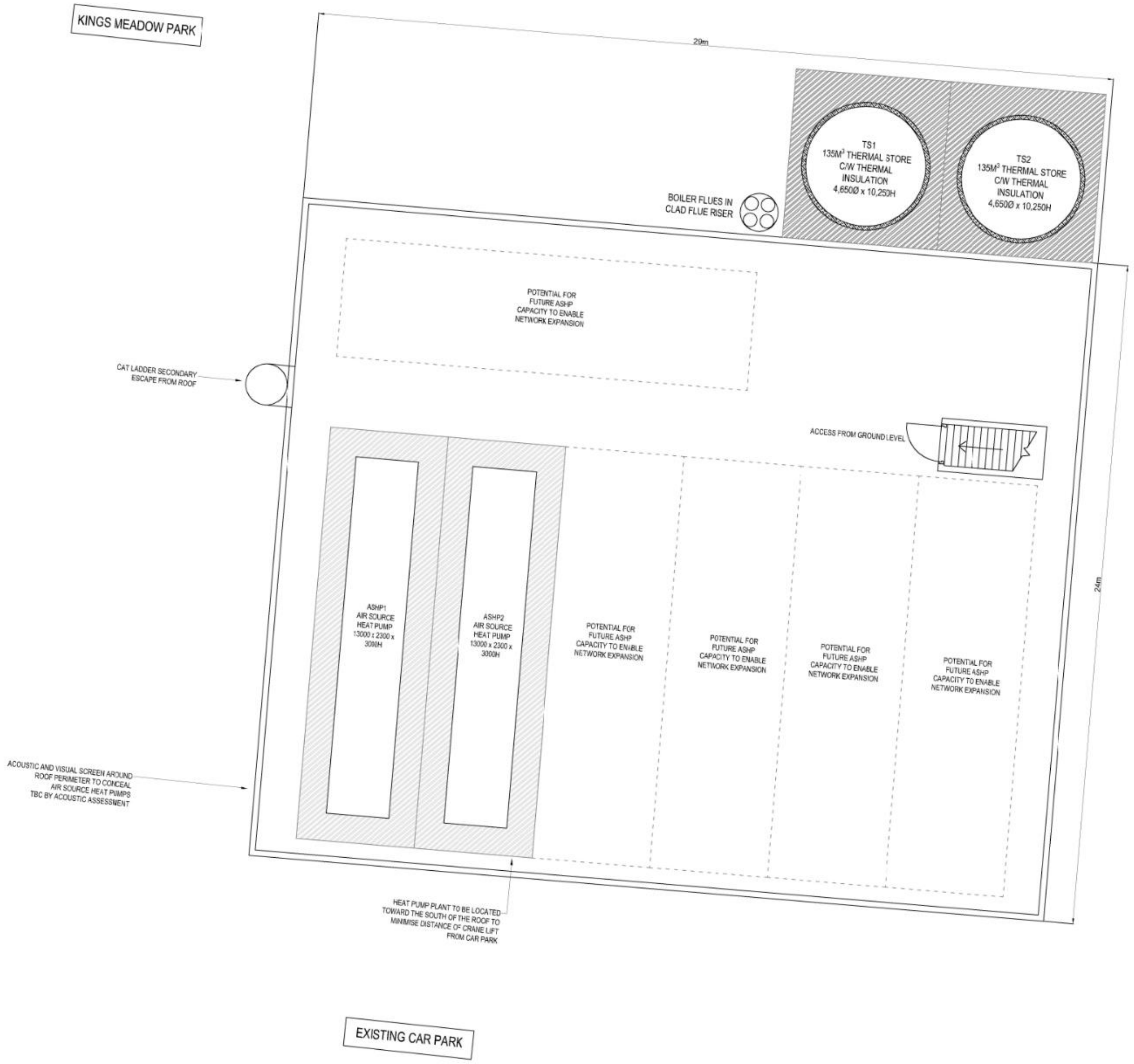
2. DO NOT SCALE FROM THIS DRAWING, USE ONLY STATED DIMENSIONS.
3. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DESIGN, SIZING & SPECIFICATION OF ALL PLANT AND SERVICES IN ACCORDANCE WITH THE EMPLOYERS REQUIREMENTS AND INDUSTRY STANDARD GUIDANCE.
4. INTUMESCENT SEALS SHALL BE PROVIDED WHERE SERVICES PASS THROUGH FIRE COMPARTMENTS TO MAINTAIN THE INTEGRITY OF THE STRUCTURE.
5. ALL PLANT & EQUIPMENT SHALL BE INSTALLED IN ACCORDANCE WITH THE MANUFACTURERS RECOMMENDATIONS
6. ALL SERVICES SHALL BE PROVIDED WITH IDENTIFICATION BANDS & DIRECTIONAL FLOW INDICATION IN ACCORDANCE WITH BS1710
7. ALL PIPEWORK SHALL BE THERMALLY INSULATED AND CLAD FOLLOWING COMPLETION OF PRESSURE TESTING
8. ALL HOT WATER PIPEWORK PASSING THROUGH WALLS SHALL BE SLEEVED AND MADE GOOD TO ACCOMMODATE THERMAL EXPANSION AND CONTRACTION
9. ENERGY CENTRE TO BE NATURALLY VENTILATED FOR BOILER COMBUSTION IN ACCORDANCE WITH BS6644:2011 AND FOR THE DISSIPATION OF HEAT
10. INSTALLATION TO COMPLY WITH THE REQUIREMENTS OF AN ACOUSTIC REPORT AND FIRE STRATEGY
ISSUE/REVISION
01 20/05/22 Feasibility Stage
I/R DATE DESCRIPTION
PROJECT NUMBER
60670504
SHEET TITLE
Reading District Energy Network
Scenario B2
Energy Centre Ground Floor Layout
SHEET NUMBER
60670504-ACM-EC-00-DR-ME-110001



SCALE: 1:100 @ A1

AECOM

PROJECT

READING DISTRICT ENERGY NETWORK

CLIENT

READING BOROUGH COUNCIL

CONSULTANT

AECOM
Aldgate Tower
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London E1 8FA
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ISSUE/REVISION

01	29/05/22	Feasibility Stage
I/R	DATE	DESCRIPTION

PROJECT NUMBER

60670504

SHEET TITLE

Reading District Energy Network
Scenario B2
Energy Centre Roof Layout

SHEET NUMBER

60670504-ACM-EC-RF-DR-ME-110001

9.1.5. Economic Performance

The economic performance values in the following section are stated using the parameters outlined in Table 9-1 below. In addition, the impact of obtaining the maximum grant funding (£9.5million) from GHNF will be assessed. Please refer to Appendix P for details of GHNF compliance.

Parameter	Variable	Resultant Value
Connection Charge	0% Discount on Counterfactual [36]	£603/kW – All Buildings Average £678/kW – Existing Buildings £2,000 / Dwelling – New Build
Heat Tariff Discount	5% Discount on Counterfactual [36]	9.93p/kWh
Grant Funding	0% Funding and Max Funding	£0

Table 9-1 - Parameters for the Base Case Scenario B2 Economic Performance

The resultant IRR for Scenario B2 with no grant funding and maximum grant funding is demonstrated in Figure 9-5.

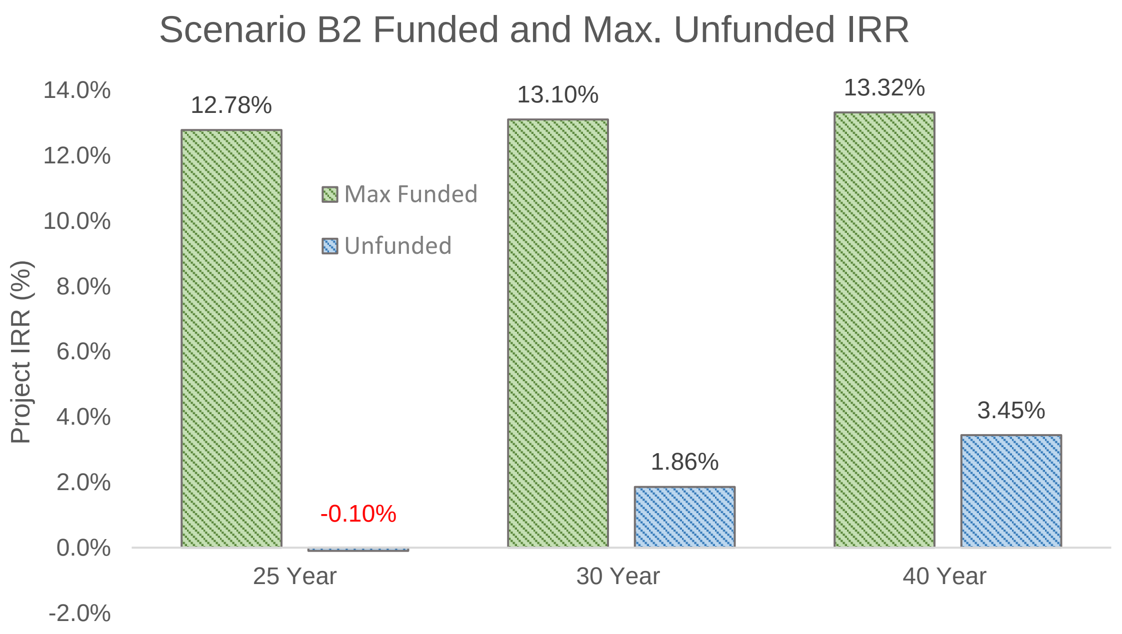


Figure 9-5 - Unfunded and Max Funded Project IRR for Scenario B2

The capital cost of the Scenario B2 network has been estimated using cost data from cost plans and tender returns for recent, real-life projects and estimates from manufacturers. A breakdown of this cost estimate is detailed in Figure 9-6. An unlocked Technoeconomic model (TEM), which details the cost breakdown in further granularity is included as an appendix to this report.

[36] See Section 8.1 Counterfactual Scenarios for details

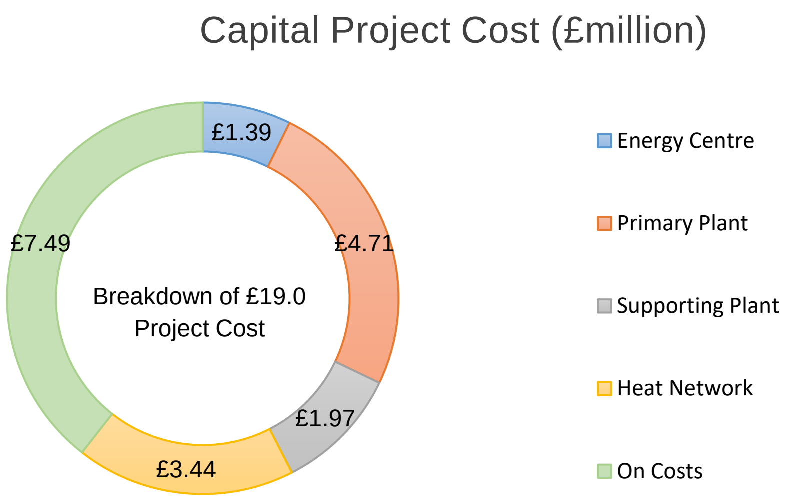


Figure 9-6 - Breakdown of Project Cost Estimate for Scenario B2

The balance of the main annual costs and revenues for Scenario B2 are detailed in Figure 9-7 below. Operational costs include Maintenance, Management, Staffing and Billing. In this, replacement of major plant items that have reached the end of their economic lifespan has been included as an annual sinking fund on a 40-year term.

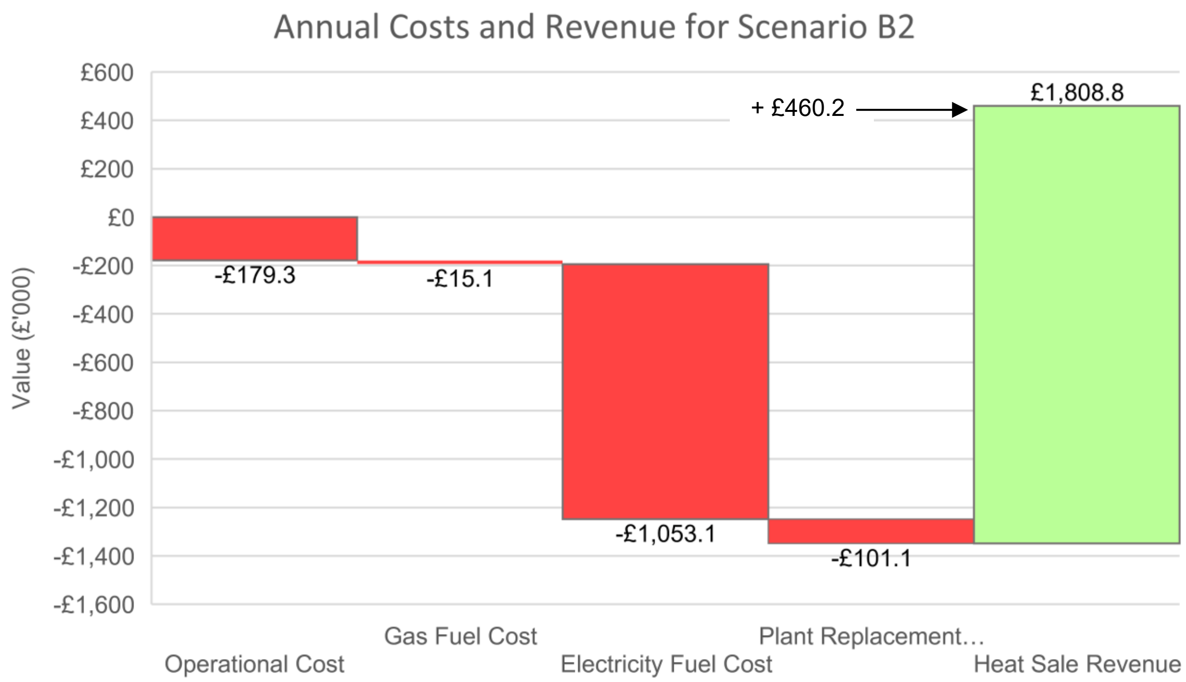


Figure 9-7 - Annual Costs and Revenue for Scenario B2

The cumulative, non-discounted, cash flow for the Scenario B2 Base Case is demonstrated in Figure 9-8. The network is predicted to turn and stay positive in 2049, following the first major plant replacement in 2045.

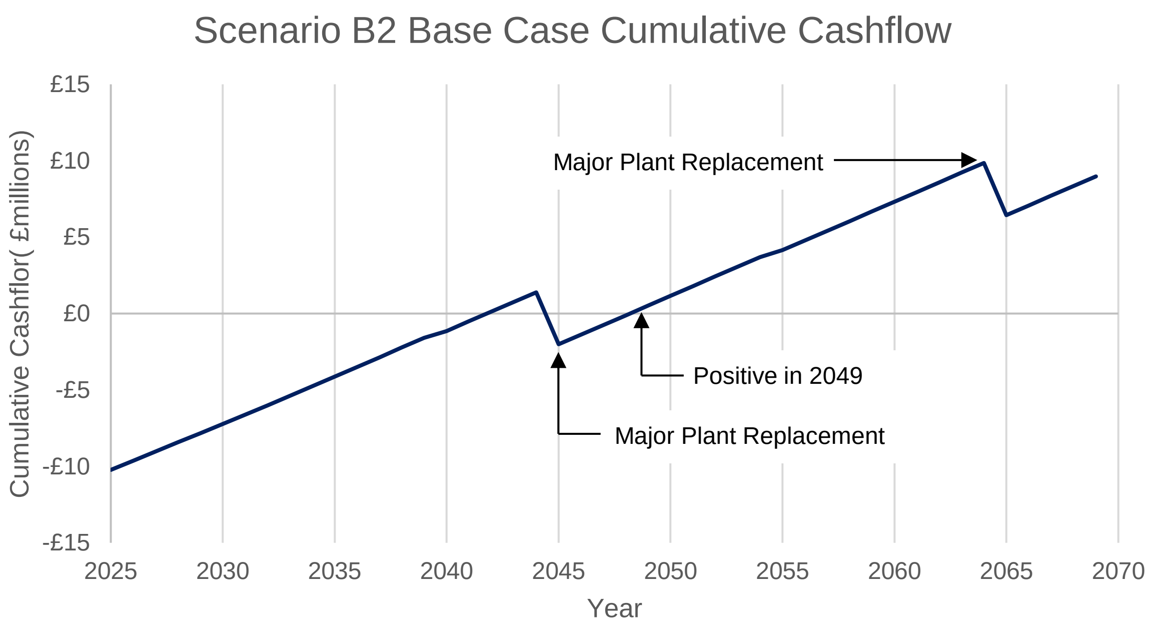


Figure 9-8 - Scenario B2 Base Case Cumulative Cashflow

9.1.6. Levelised Cost of Heat (LCoH)

The indicative[37] LCoH for Scenario B2 network against the counterfactual systems is demonstrated in Figure 9-9. District heating offers a lower cost solution for decarbonisation for the proposed customer buildings.

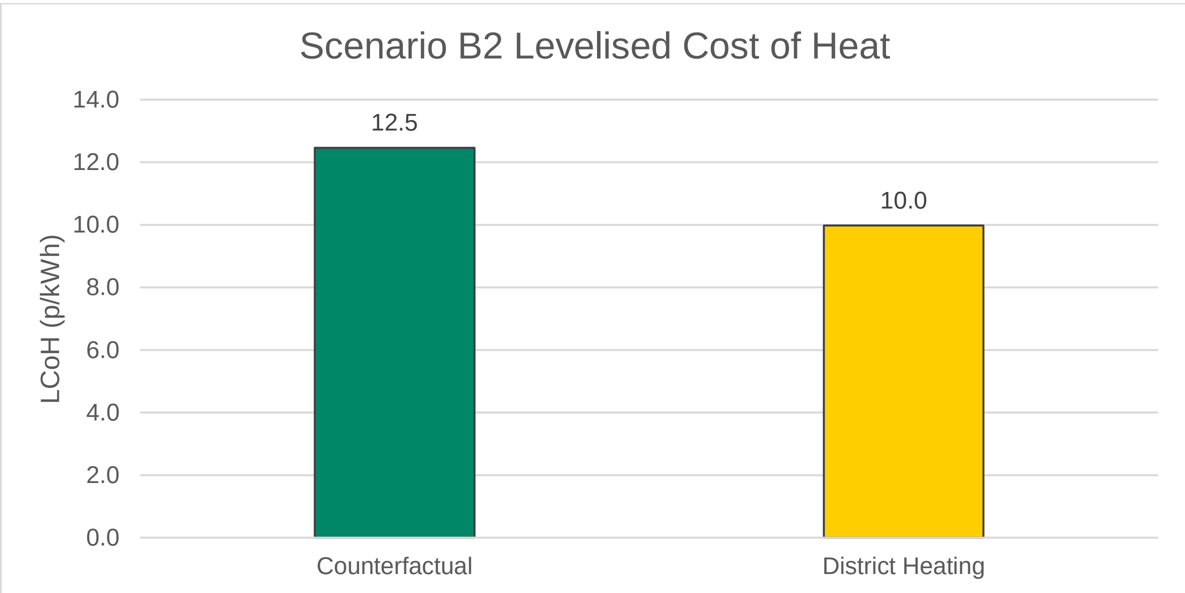


Figure 9-9 - Scenario B2 Levelised Cost of Heat

[37] By AECOMs Technoeconomic assessment only. To be determined by a financial consultant.

9.1.7. Environmental Performance

The carbon savings provided by the network over the counterfactual heat generation system[38] have been calculated using predictions of future electricity and gas fuel intensity from BEIS Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal[39].

Whilst the majority of the network heat demand comes from new build developments, the carbon savings realised from these connections is marginal due to the counterfactual being ASHP. The majority of the carbon savings of the network come from existing buildings which are taken to utilise natural gas combustion for heat generation[40].

The network achieves an average carbon intensity of heat of **16.3gCO_2e/kWh** over a 40-year lifespan. The annual carbon savings vs the counterfactual for Scenario B2 is demonstrated in Figure 9-10 at year 25, 30 and 40.

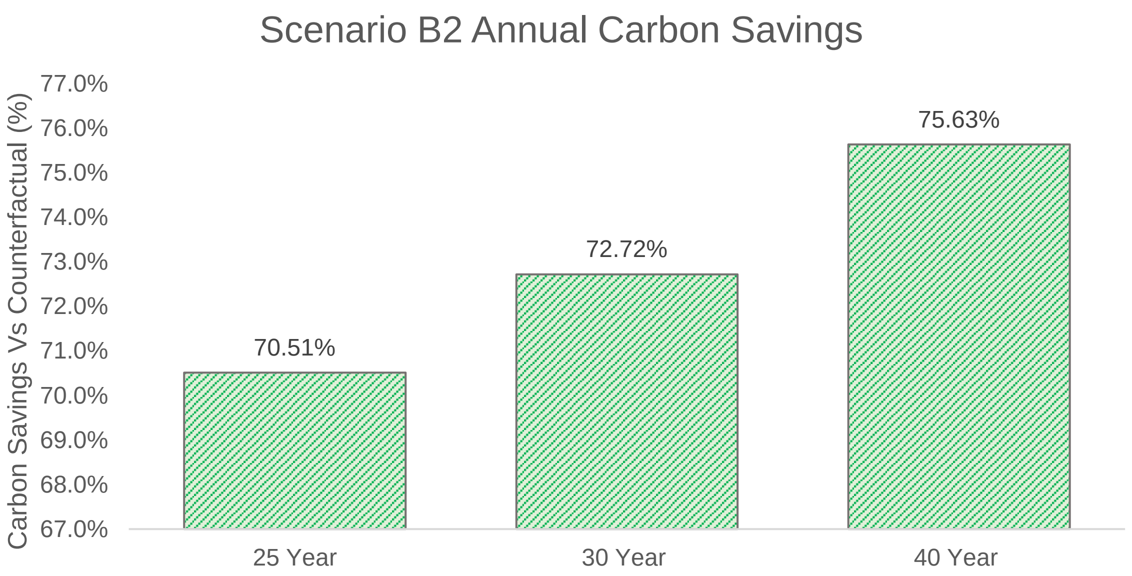


Figure 9-10 - Scenario B2 Annual Carbon Savings vs Counterfactual

The accumulative carbon savings over 40 years for Scenario B2 is **30,733** tonnesCO_2e. The proposed network should be considered as an initial step to harness low grade heat and establish a core heat network, enabled economically by the new developments in the area but aspiring to expand to the high number of existing buildings in the Town Centre and offer further carbon savings.

9.1.8. Sensitivities

9.1.8.1. Discounted Heat Supply

It is recognised that to encourage some customers to connect, negotiations may be undertaken and discounts to connection charges and/or heat tariffs agreed. Existing buildings may be more reluctant than new developments to pay for low carbon heat, given their existing system is on a lower natural gas tariff, however existing building also represent the majority of carbon savings, so it may be considered beneficial to offer them a lower tariff.

The following sensitivities test discounted charges whilst maintaining the 40-year project IRR at a level which would be attractive to private sector investors. It was agreed with RBC that this target IRR would be 10%. The capital grant funding in these sensitivities was set to 45% of the total CapEx.

In the first sensitivity, discounts were applied evenly to existing buildings and new developments. In the second, discounts to existing buildings was prioritised.

[38] Refer to Section 8.1 for details

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

[40] Information about the existing heating systems is not known for all proposed connected existing buildings

Table 9-2 demonstrates the level of discount that could be offered whilst retaining the target IRR for Scenario B2.

Metric	Sensitivity 1	Sensitivity 2
Connection Charge – Existing Buildings	22% Discount	100% Discount
Connection Charge – New Developments	22% Discount	0% Discount
Heat Tariff – Existing Buildings	5% Discount	17% Discount
Heat Tariff – New Developments	5% Discount	5% Discount
40-Year IRR	10%	
Grant Funding (% of CapEx)	45%	

Table 9-2 - Discounted Heat Supply Sensitivities for Scenario B2

9.1.8.2. HNDU Sensitivities

The following sensitivities include those recommended by the HNDU scope of works in addition to project specific sensitivities.

Figure 9-11 demonstrates the impact of decrease and increase in the estimated project CapEx on the 40-year IRR[41]. The IRR remains positive at a 30% increase in the estimated total CapEx. At a 30% decrease in the estimated total CapEx, the IRR approaches levels which would be attractive to private sector investors without grant funding.

[41] With no grant funding

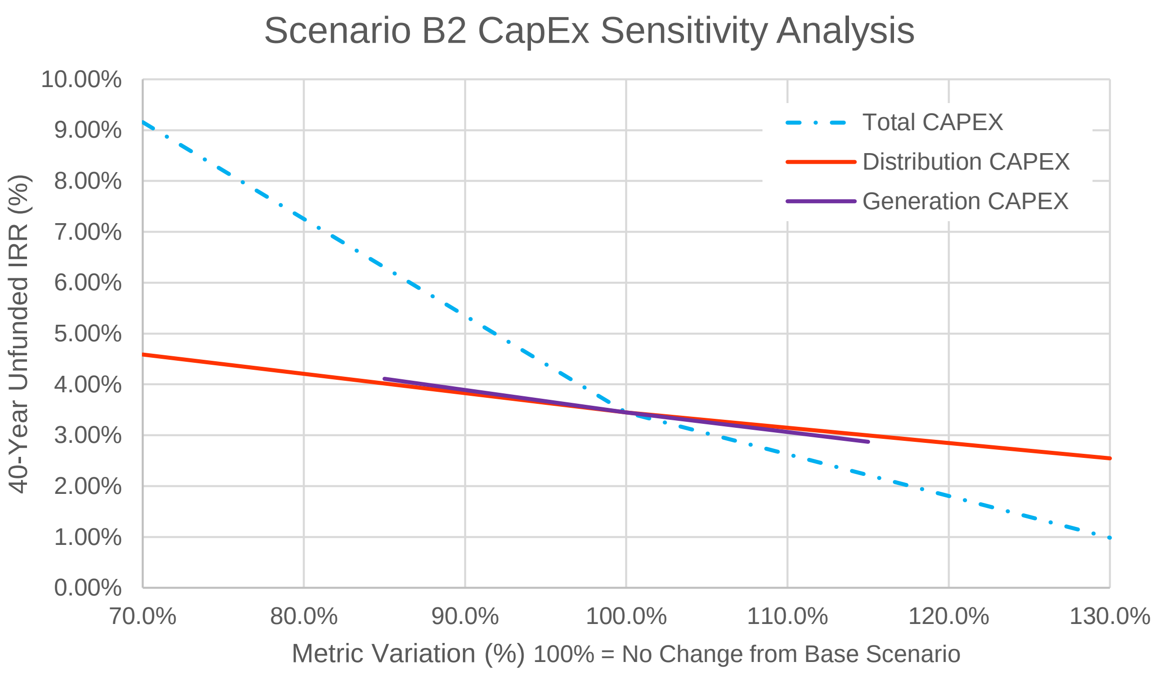


Figure 9-11 - Scenario B2 CapEx Sensitivity Analysis

Figure 9-12 demonstrates the impact of the remaining parameters on the 40-year IRR[41]. The project is most sensitive to discount to energy tariffs and cost of fuel purchase prices, which cause the IRR to turn negative at a 13% discount and 23% increase respectfully.

Increase in the network heat loss has only a marginal impact on the IRR, with a 50% increase (80% to 130%) resulting in a 0.34% drop in IRR.

A 30% reduction in estimated heat demand from the network retains a positive IRR.

A reduction in LZC capacity has a positive impact on the IRR, given the associated reduction in CapEx, OpEx and RepEx costs, however this has a considerable impact on the carbon intensity of the network, which increases from 49gCO_2e/kWh at no reduction, to 60gCO_2e/kWh and 88gCO_2e/kWh at 25% and 50% reduction respectfully.

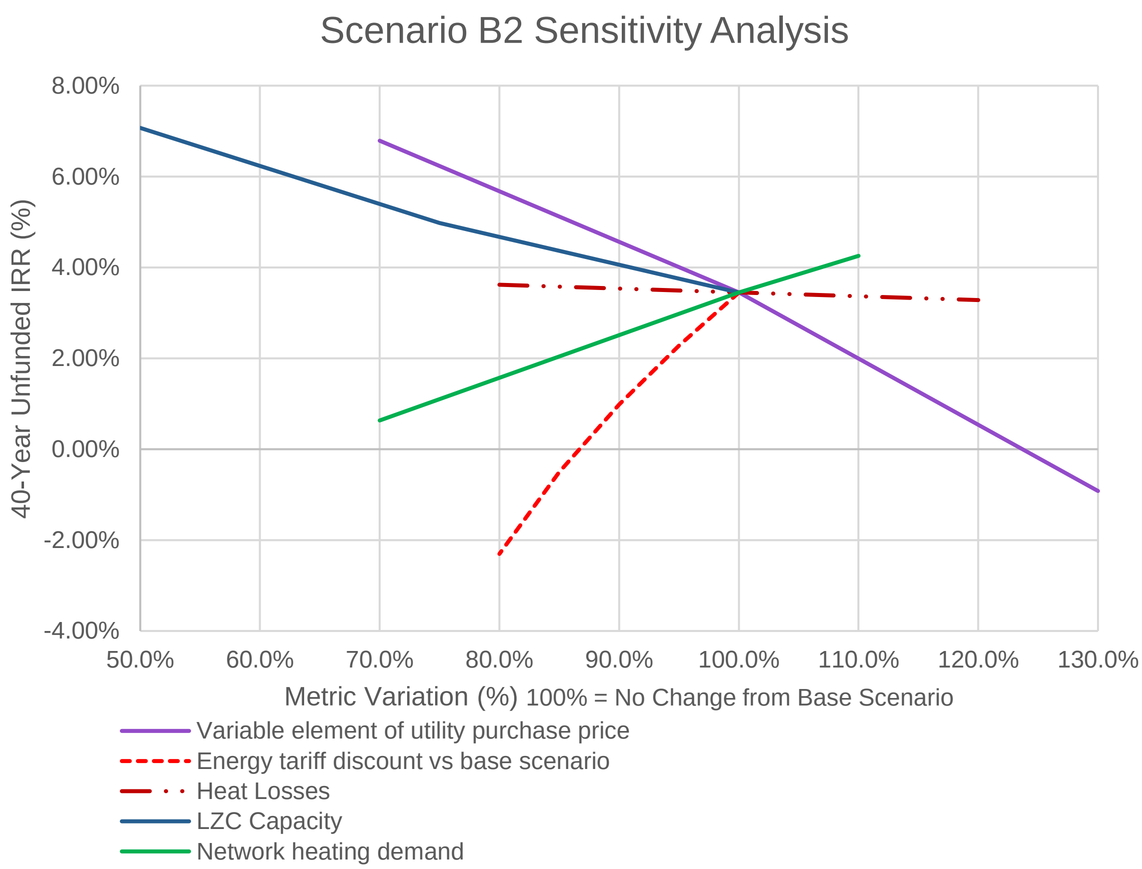


Figure 9-12 - Scenario B2 Economic Impact of Remaining Metric Sensitivity Analysis

9.2. Scenario B9

Scenario B9 is a fully electric, heat pump led solution. It uses a river source heat pump as the lead LZC source, air source heat pumps as a secondary LZC source and electrode boilers as peaking and resilient plant.

9.2.1. Concept System Design

The concept energy generation system for Scenario B9 is demonstrated in Figure 9-13. This includes a potential future addition of open loop ground abstraction system to enhance carbon savings if it is found to be a feasible and desirable option during future design stages.

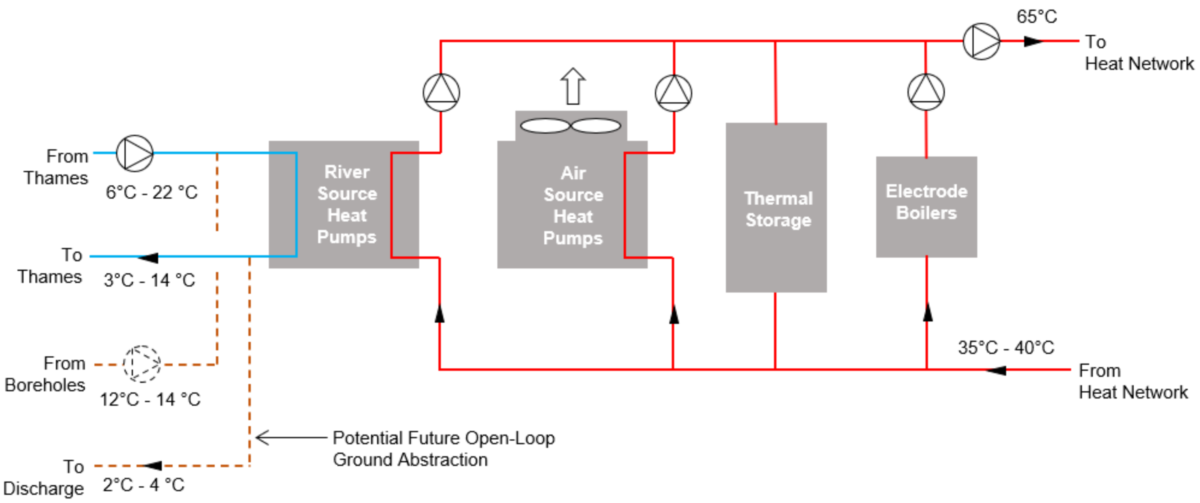


Figure 9-13 - Scenario B9 Concept System Design

9.2.2. Futureproofing for Environmental Improvement

The futureproofing strategies outlined for scenario B2 in 9.1.2 are also applicable to scenario B9.

9.2.3. Plant Sizing & Energy

An outline plant and equipment schedule for Scenario B9 is included in Appendix O. All selections are subject to validation during detailed design stage.

The diversified peak demand for the Scenario B9 network extent has been determined to be 9,213kW. A combination of ASHP and electric boilers as peaking and resilient plant has been used to meet this requirement, with ASHP acting as a secondary LZC source and primary resilient plant. Boilers have been specified as approximately n+1 resilience, which equates to 22% spare capacity.

The resultant annual energy generation split by technology is demonstrated in Figure 9-14.

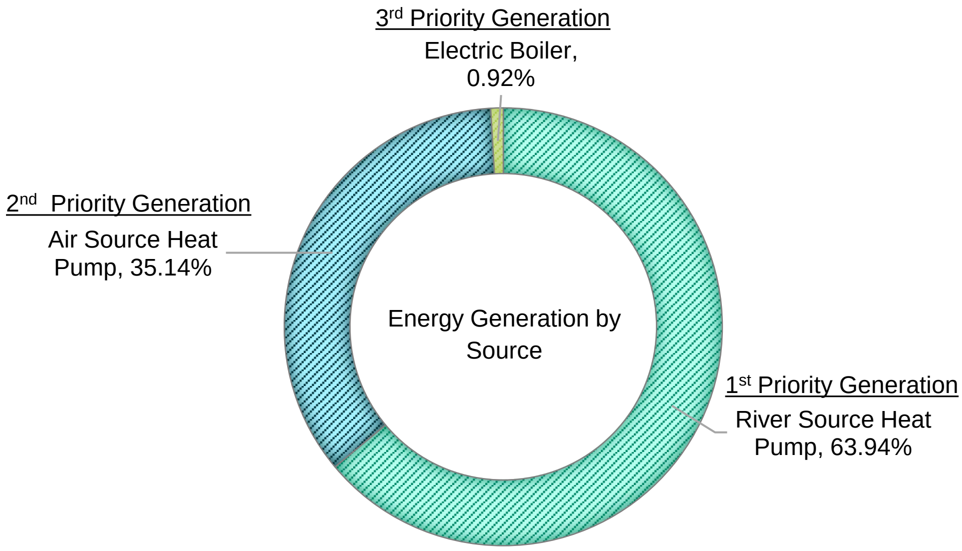


Figure 9-14 – Annual Energy Generation by Source Technology for Scenario B9

The heat losses outlined for Scenario B2 in Figure 9-3 are the same for Scenario B9, and it is therefore also compliant with CIBSE CP1 (2020) BP3.5a.

9.2.4. Energy Centre Layout

The proposed scenario B9 Energy Centre Ground and Roof level layouts are included below.

This design follows the same principles as outlined for scenario B2 in Section 9.1.4 and has the same overall spatial requirements.

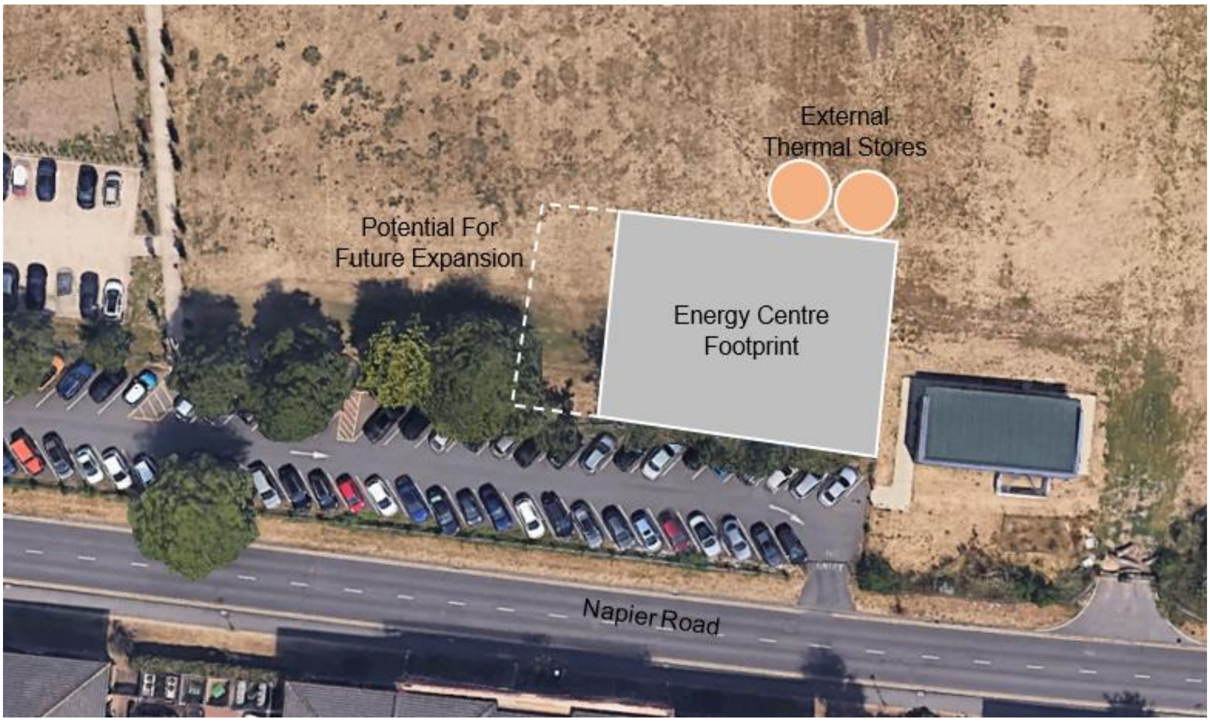
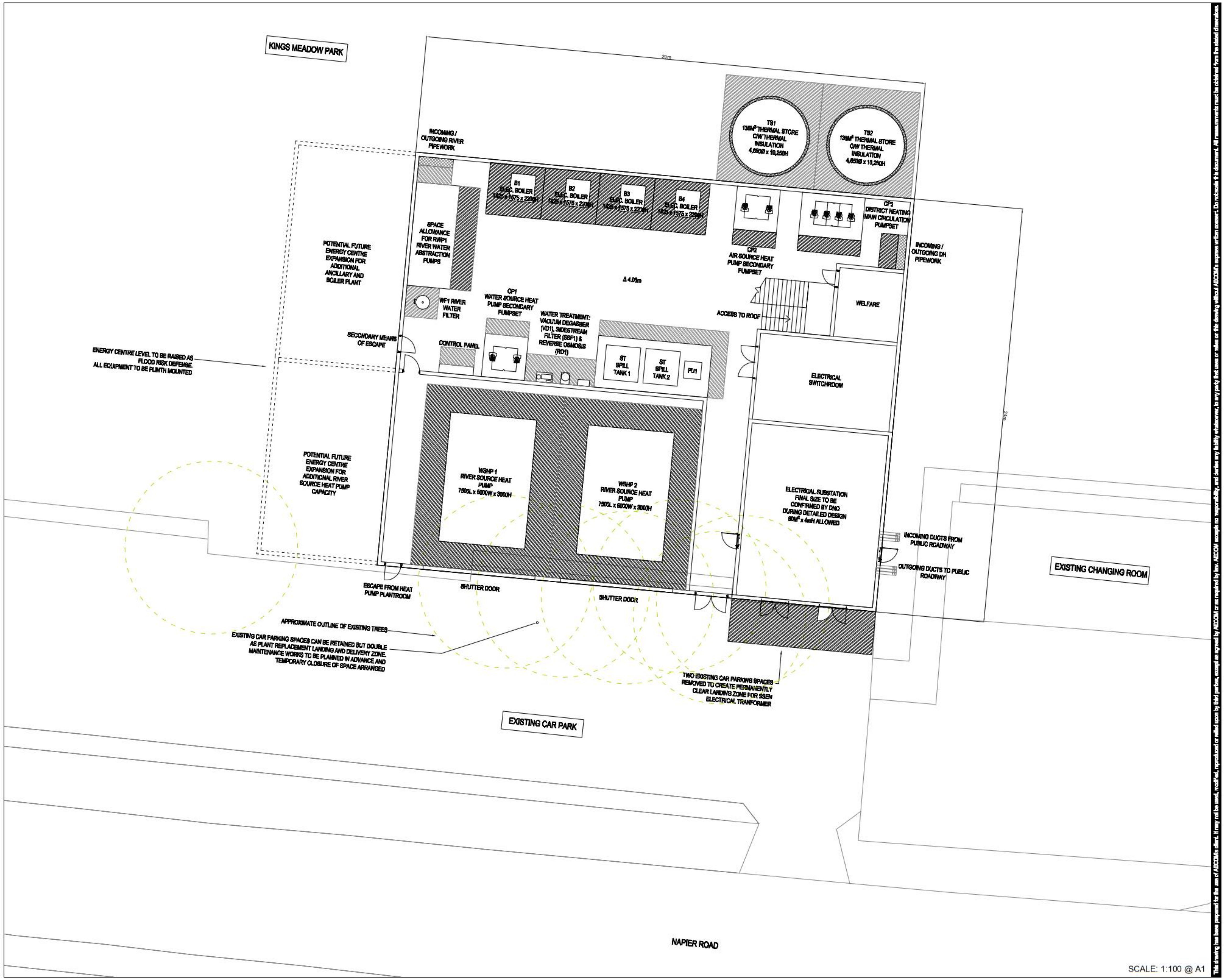


Figure 9-15 - Proposed B9 Energy Centre Arrangement

Drawings are also included as an appendix to this report.



AECOM

PROJECT

READING DISTRICT ENERGY NETWORK

CLIENT

READING BOROUGH COUNCIL

CONSULTANT

AECOM
Aldgate Tower
2 Leman Street
London E1 8FA
www.aecom.com

KEY PLAN

EXISTING TREES

GENERAL NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DOCUMENTATION.
2. DO NOT SCALE FROM THIS DRAWING, USE ONLY STATED DIMENSIONS.
3. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DESIGN, SIZING & SPECIFICATION OF ALL PLANT AND SERVICES IN ACCORDANCE WITH THE EMPLOYERS REQUIREMENTS AND INDUSTRY STANDARD GUIDANCE.
4. INTUMESCENT SEALS SHALL BE PROVIDED WHERE SERVICES PASS THROUGH FIRE COMPARTMENTS TO MAINTAIN THE INTEGRITY OF THE STRUCTURE.
5. ALL PLANT & EQUIPMENT SHALL BE INSTALLED IN ACCORDANCE WITH THE MANUFACTURERS RECOMMENDATIONS
6. ALL SERVICES SHALL BE PROVIDED WITH IDENTIFICATION BANDS & DIRECTIONAL FLOW INDICATION IN ACCORDANCE WITH BS1710
7. ALL PIPEWORK SHALL BE THERMALLY INSULATED AND CLAD FOLLOWING COMPLETION OF PRESSURE TESTING
8. ALL HOT WATER PIPEWORK PASSING THROUGH WALLS SHALL BE SLEEVED AND MADE GOOD TO ACCOMMODATE THERMAL EXPANSION AND CONTRACTION
9. ENERGY CENTRE TO BE NATURALLY VENTILATED FOR BOILER COMBUSTION IN ACCORDANCE WITH BS6644:2011 AND FOR THE DISSIPATION OF HEAT
10. INSTALLATION TO COMPLY WITH THE REQUIREMENTS OF AN ACOUSTIC REPORT AND FIRE STRATEGY

ISSUE/REVISION

I/R	DATE	DESCRIPTION
01	20/05/22	Feasibility Stage

PROJECT NUMBER

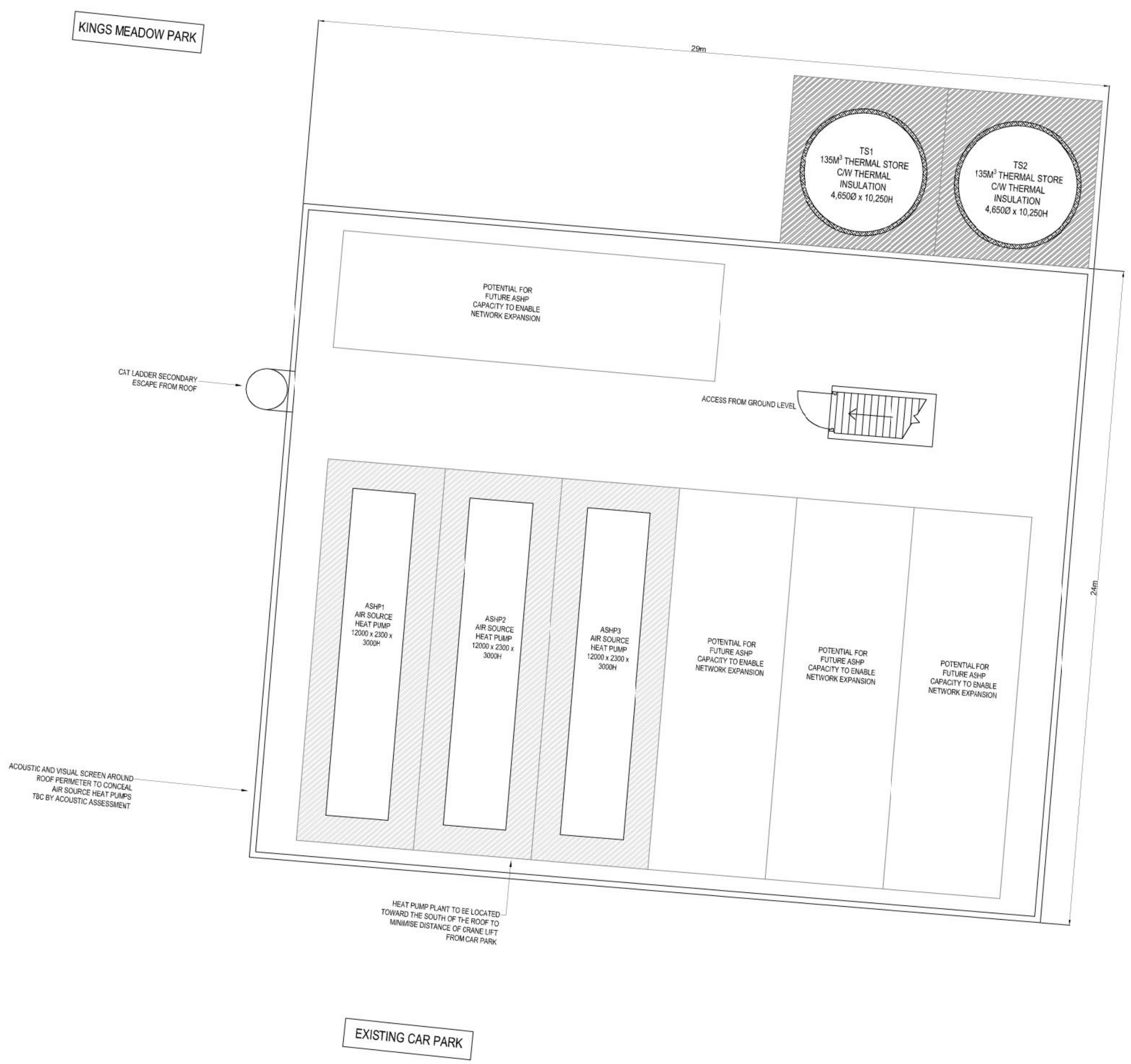
60670504

SHEET TITLE

Reading District Energy Network
Scenario B9
Energy Centre Ground Floor Layout

SHEET NUMBER

60670504-ACM-EC-00-DR-ME-110002



SCALE: 1:100 @ A1

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London E1 8FA
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KEY PLAN

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ISSUE/REVISION

01	29/05/22	Feasibility Stage
I/R	DATE	DESCRIPTION

PROJECT NUMBER

60670504

SHEET TITLE

Reading District Energy Network
Scenario B9
Energy Centre Roof Layout

SHEET NUMBER

60670504-ACM-EC-RF-DR-ME-110002

9.2.5. Economic Performance

The same parameters as outlined in Section 9.1.5 for Scenario B2 have also been applied for the Scenario B9 Base Case.

The resultant IRR for Scenario B9 with no grant funding and maximum grant funding (£9.8million) is demonstrated in Figure 9-16.

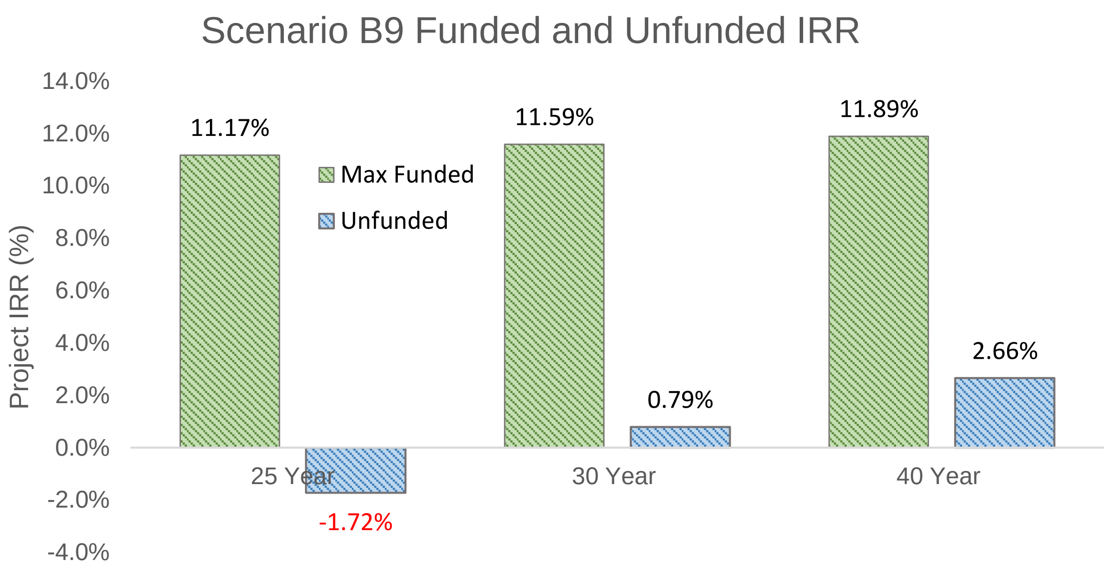


Figure 9-16 - Unfunded and Max Funded Project IRR for Scenario B9

The capital cost of the Scenario B9 network has been estimated using cost data from cost plans and tender returns for recent, real-life projects and estimates from manufacturers. A breakdown of this cost estimate is detailed in Figure 9-17. An unlocked Technoeconomic model (TEM), which details the cost breakdown in further granularity is included as an appendix to this report.

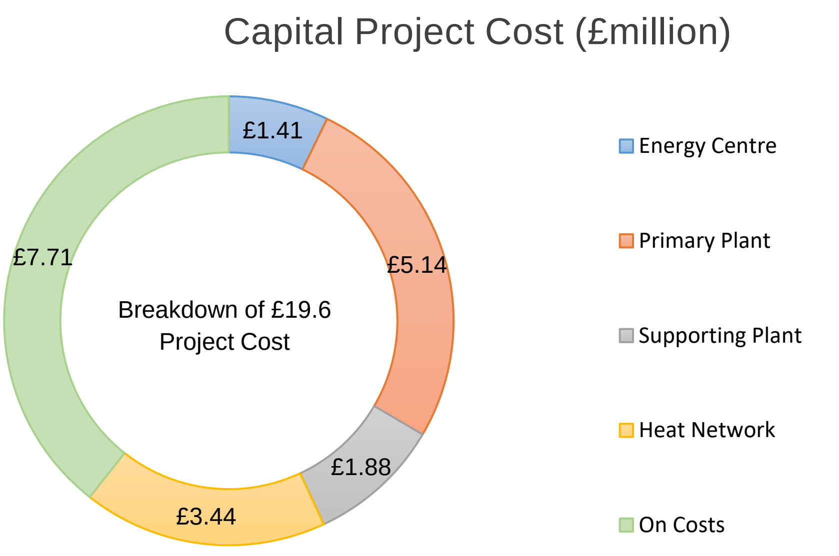


Figure 9-17 - Breakdown of Project Cost Estimate for Scenario B9

The balance of the main annual costs and revenues for Scenario B9 are detailed in Figure 9-18 below.

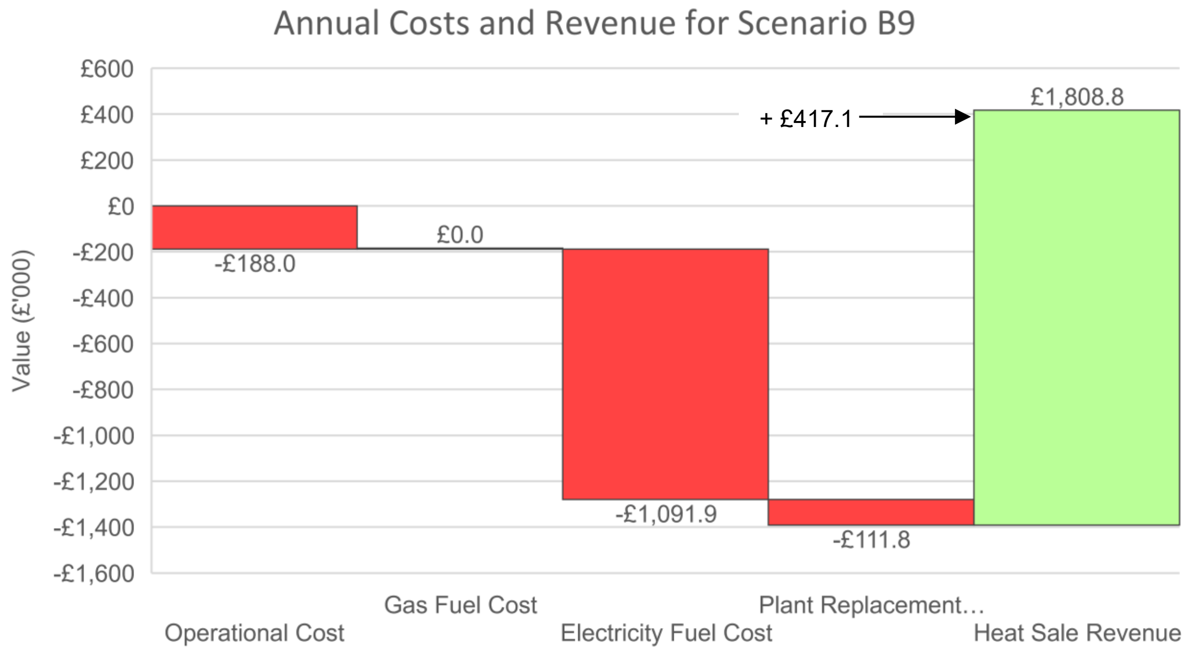


Figure 9-18 - Annual Costs and Revenue for Scenario B9

The cumulative cash flow for the Scenario B9 Base Case is demonstrated in Figure 9-19. The network is predicted to turn and stay positive in 2051, following the first major plant replacement in 2045.

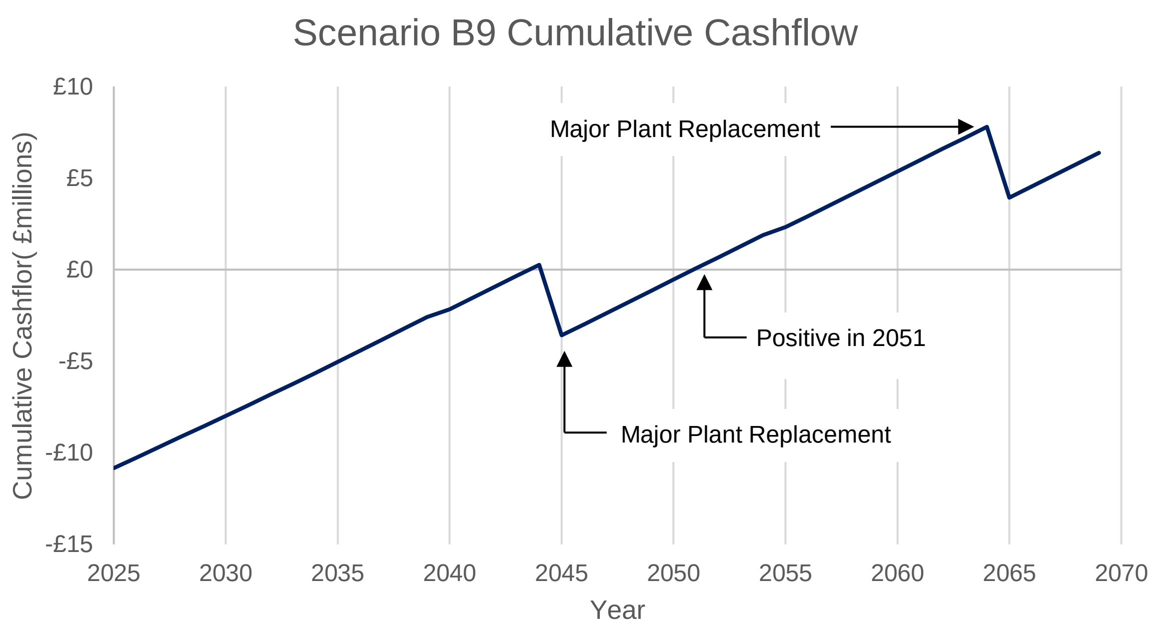


Figure 9-19 - Scenario B9 Base Case Cumulative Non-Discounted Cashflow

9.2.6. Levelised Cost of Heat (LCoH)

The indicative[42] LCoH for Scenario B9 network against the counterfactual systems is demonstrated in Figure 9-20. District heating offers a lower cost solution for decarbonisation for the proposed customer buildings.

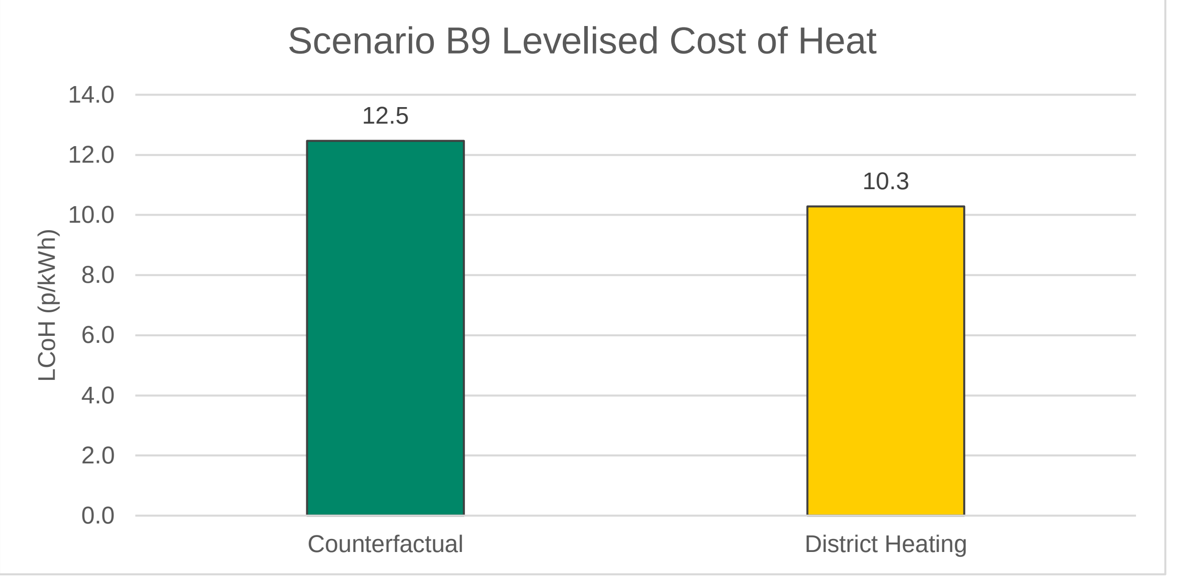


Figure 9-20 - Scenario B9 Levelised Cost of Heat

9.2.7. Environmental Performance

The carbon savings provided by the network over the counterfactual heat generation system[43] have been calculated using predictions of future electricity and gas fuel intensity from BEIS Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal[44].

As stated in Section 8, Scenario B9 improves upon the of 50gCO_2e/kWh carbon intensity of heat target due to its fully electrified generation plant.

The network achieves an average carbon intensity of heat of **12.4gCO_2e/kWh** over a 40-year lifespan The annual carbon savings vs the counterfactual for Scenario B9 is demonstrated in Figure 9-21 at year 25, 30 and 40. The carbon savings increase in time due to the reduction in electricity grid carbon intensity vs the natural gas grid which is relatively constant over the same time period.

[42] By AECOMs technoeconomic assessment only. To be determined by a financial consultant

[43] Refer to Section 8.1 for details

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

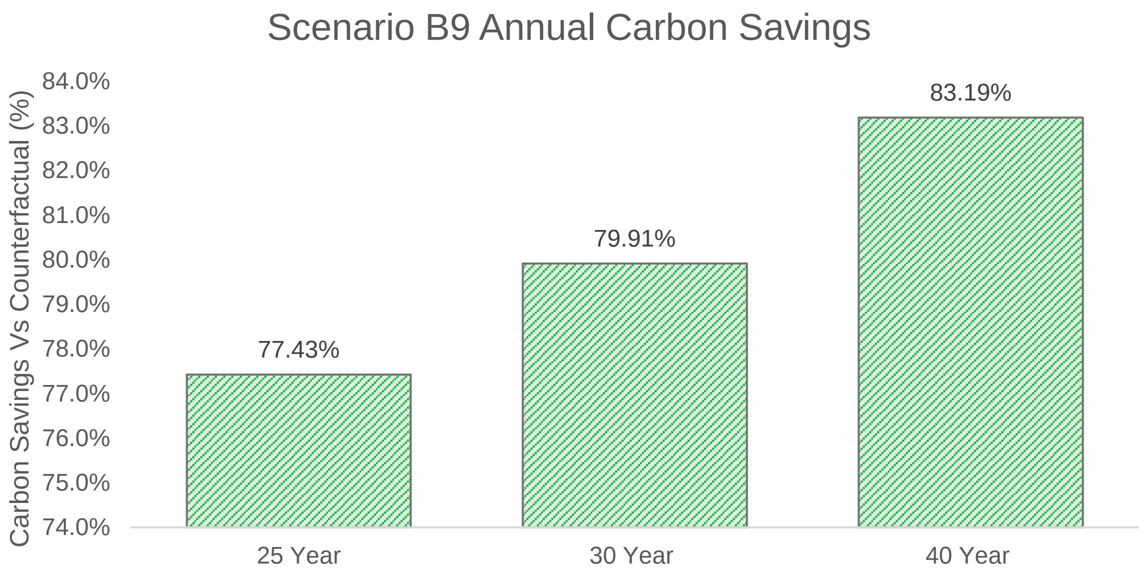


Figure 9-21 - Scenario B9 Annual Carbon Savings vs Counterfactual

The accumulative carbon savings over 40 years for Scenario B2 is **33,803** tonnesCO_2e. Equating this saving to the estimated initial project capital cost gives a value of £580/tonneCO_2e. As described for Scenario B2, this network should also be considered as an initial core heat network that aspires to expand to the high number of existing buildings in the Town Centre.

9.2.8. Sensitivities

9.2.8.1. Discounted Heat Supply

These sensitives are in line with those conducted for Scenario B2 in Section 9.1.8.1. In the first sensitivity, discounts were applied evenly to existing buildings and new developments. In the second, discounts to existing buildings was prioritised. Table 9-3 demonstrates what discounts could be offered whilst retaining the target IRR for Scenario B9.

Metric	Sensitivity 1	Sensitivity 2
Connection Charge – Existing Buildings	12.5% Discount	75% Discount
Connection Charge – New Developments	12.5% Discount	0% Discount
Heat Tariff – Existing Buildings	5% Discount	5% Discount
Heat Tariff – New Developments	5% Discount	5% Discount
40-Year IRR	10%	
State Aid (% of CapEx)	45%	

Table 9-3 - Discounted Heat Supply Sensitivities for Scenario B9

9.2.8.2. HNDU Sensitivities

The following sensitivities include those recommended by the HNDU scope of works in addition to project specific sensitivities.

Figure 9-22 demonstrates the impact of decrease and increase in the estimated project CapEx on the 40-year unfunded project IRR. The IRR remains positive at a 30% increase in the estimated total CapEx. At a 30% decrease in the estimated total CapEx, the IRR approaches levels which would be attractive to private sector investors without grant funding.

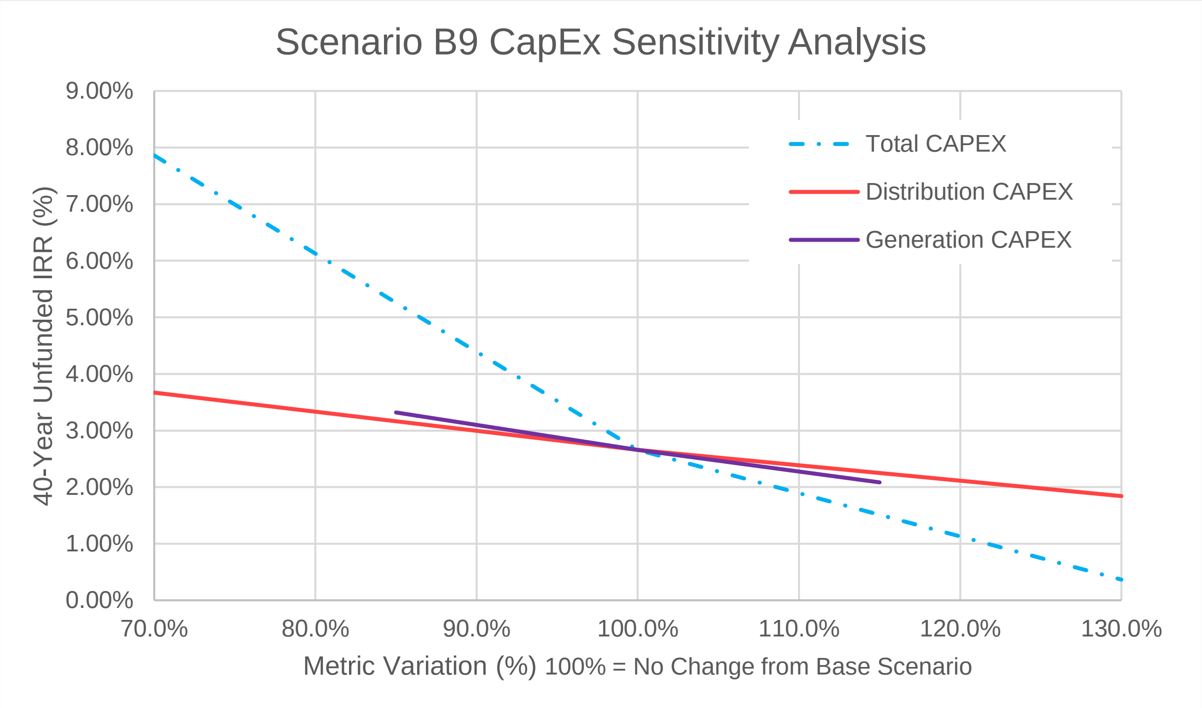


Figure 9-22 - Scenario B9 CapEx Sensitivity Analysis

Figure 9-23 demonstrates the impact of the remaining parameters on the 40-year unfunded project IRR. The project is most sensitive to discount to energy tariffs and cost of fuel purchase prices, which cause the IRR to turn negative at a 10% discount and 15% increase respectfully.

Increase in the network heat loss has only a marginal impact on the IRR, with a 50% increase (80% to 130%) resulting in a 0.36% drop in IRR.

A 30% reduction in estimated heat demand from the network retains a positive IRR, albeit this closely approaches 0%.

A reduction in LZC capacity up to 25% has a positive impact on the IRR, given the associated reduction in CapEx, OpEx and RepEx costs, however this begins to turn negative after this point and at 50% reduction is lower than at 0% reduction. This is caused by the increase in the amount of heat that is then generated by direct electric boilers in this scenario to offset the loss in LZC generation, and the resultant significant increase in electricity fuel cost.

A reduction in LZC also has an impact on the carbon intensity of the network, which increases from 47gCO_2e/kWh at no reduction, to 50gCO_2e/kWh and 63gCO_2e/kWh at 25% and 50% reduction respectfully.

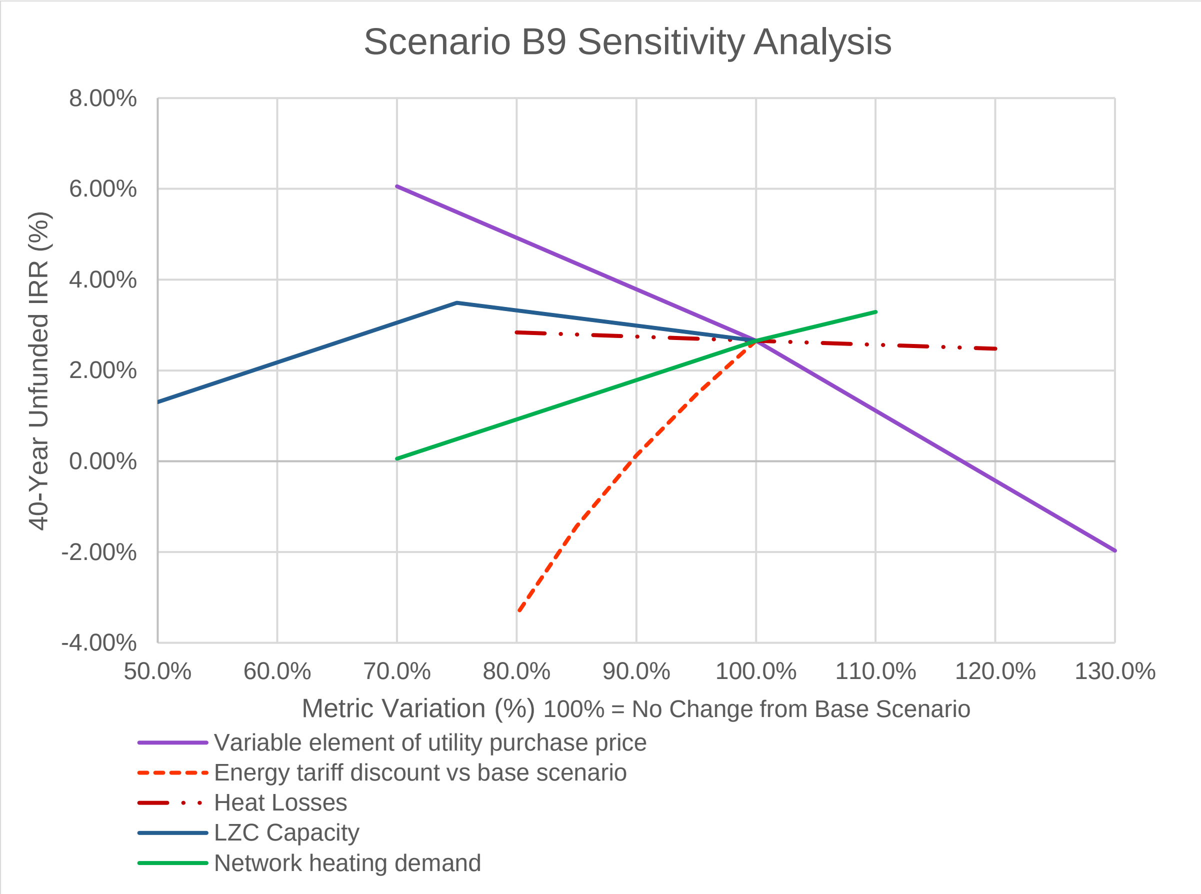


Figure 9-23- Scenario B9 Economic Impact of Remaining Metric Sensitivity Analysis

9.2.9. Risks

Please refer to *Risk Register and Assumptions Log_Rev01_HMMP*, included as an appendix to this report, for information.

10. **Soft market testing and ownership options**

Soft market testing was undertaken and ownership options are examined.

10.1. Soft market testing

As part of a heat network feasibility study for Reading Borough Council (RBC) some limited Soft Market testing was undertaken. The aim of which was to understand the heat network market opinion of the proposed heat network following the feasibility study.

10.1.1. Approach

AECOM working with HermeticaBlack, an expert in commercial matters and procurement for the development of heat networks, undertook the soft market testing using the following approach:

- Initial discussion with RBC procurement department to discuss the approach and agreement from the procurement team to proceed.
- Develop list of stakeholders
- Preparation of soft market testing information pack
- Contact of stakeholder and arrange virtual calls
- Hold Soft market testing calls
- Review written submissions
- Prepare report

10.1.2. Stakeholders

A range of stakeholders were identified for the soft market testing process. They represented a broad spectrum of the district energy sector from contractors through to companies that can fund, own, build and operate heat networks. These stakeholders were:

- Vital Energi
- EON
- EQUANS
- SSE
- Pinnacle Power
- Switch2

In addition, some alternative delivery options were included in the process to give RBC a wider view of the market and possible delivery options. These were:

- BHIVE: BHIVE will allow public sector heat network owners/developers in England and Wales to procure funding and funding-related services for their heat network projects from a range of potential funders. This has been set up by The Department for Energy Security and Net Zero.
- Clear Futures: Clear Futures works with public sector organisations who need a flexible, collaborative partnership to overcome built environment challenges and drive change in their communities faster, smarter and sustainably.

10.1.3. Soft market testing information pack

Each stakeholder was sent an information pack which set out a description of the proposed network including background to the study, local planning context, network description, maps and a technical description. The information pack is included in Appendix Q to this report.

The information pack also include a list of questions which were highlighted as key areas for discussion and feedback. These were:

- What is your organisation's interest in the scheme?
- Are there any elements of the scheme as presented which would reduce/limit your interest in the scheme?
- Are there any elements of the scheme as presented which would impact your ability to deliver the scheme (including funding, technical and commercial delivery)?
- What role would you like to see RBC play in the future development of this network opportunity?
- What changes or actions you would like to see to increase interest in the scheme?
- What characteristics of your organisation/approach would support the successful delivery of this scheme as a driver of decarbonisation in Reading?

10.1.4. Findings of soft Market testing

For the purpose of this report, the feedback and findings of the soft market testing will be reported in two categories: technical and commercial.

- Technical: This category covers feedback related to the technical characteristics of the network e.g. heat source.
- Commercial: This category covers feedback related commercials such as the councils role, funding, procurement and operation of the network.

10.1.5. Technical

Respondent feedback on technical elements of the scheme can be summarised as follows:

- A larger scheme that incorporated public sector buildings would be welcome.
- No clear issues with network route.
- Utilities information and network routing at pinch points should be carried out to de-risk the network.
- Land ownership of network route would require consideration.
- Railway crossing was seen as a major barrier and it was suggested that engagement with Network Rail is undertaken.
- Local electrical grid capacity for an all electric solution highlighted as a potential issue.
- Design, location and planning permission for energy centre would be important.
- Access to the River Thames and the quantity of heat available for extraction was seen as a priority for the scheme as well as EA licence requirements.
- Some stakeholders queried the use of RSHP and if alternative low carbon heat sources could be utilised e.g. ASHP.
- Some stakeholders queried if technical performance such as the use of RSHP or carbon intensity of heat would be included as a tender requirement.

10.1.6. Commercial

Respondent feedback on commercial elements of the scheme can be summarised as follows:

- **No "anchor" loads**. The scheme currently relies on the scheme developer at the next stage to secure heat offtake agreements with customers. Responders view the lack of guaranteed anchor load (e.g. council portfolio) to be a significant development risk.
- **Future expansion**. There was a concern noted from some participants that the potential future scale of network (and therefore their willingness to invest development funding at risk) was unclear, with several obstacles:
  - Rail crossings
  - Uncertainty around value of new connections
- Programme risk (and in particular procurement) was a raised a major concern. Most responders highlighted long procurement times and complex terms as barriers to developing a network. There are a number of options to increase the speed to market, including use of joint developmental agreements or alternate procurement routes. However, these are highly project specific, and must be approached with care to ensure project outcomes are delivered.
- Programme will also impact ability to access grant funding such as the Green Heat Network Fund (GHNF), which have tight boundaries around draw down of funds. The challenge of these timelines is exacerbated if a full procurement exercise is required.

These concerns are typical of projects in this stage of development, where parties seek to secure or reduce the risk involved in development finance. Measures proposed by respondents to manage this risk include the following, which can be explored as the project progresses:

- Inclusion of a commitment by the Council to connect its owned buildings;
- Stronger planning policy levers to mandate connection
- Explore alternative procurement routes; and
- Shared risk allocation to deal with heat connection take up

10.1.7. Summary of soft market testing

The proposed network was well received with no major technical issues raised. Common technical issues associated with network routing, heat technology, river access and energy centre were raised but these would normally be mitigated through the detailed project development (DPD) and commercialisation stages.

The role of the council as a customer was seen as a key barrier and some responders would like to see the council as an early anchor load to de-risk the early stages of the scheme.

Commercial matters such as procurement type, timeline and the role of the council were the main focus of discussion. Responders were interested in the use of joint development agreements, or other alternatives, to speed up the procurement process.

10.2. Commercial and ownership

The commercial context for a heat network is complex and varied. Please refer to Appendix R for further details where commercial concepts are set out. This section of the report hights the commercial agreements required and the ownership options available to RBC.

10.2.1. Commercial Agreements

A district heat network (DHN) needs a range of commercial agreements to govern funding, design, build, operation and maintenance of physical assets, and meet obligations of customer supply agreements for low carbon energy. A map of the various agreements required for a heat network are shown below. Please refer to Appendix R for further details.

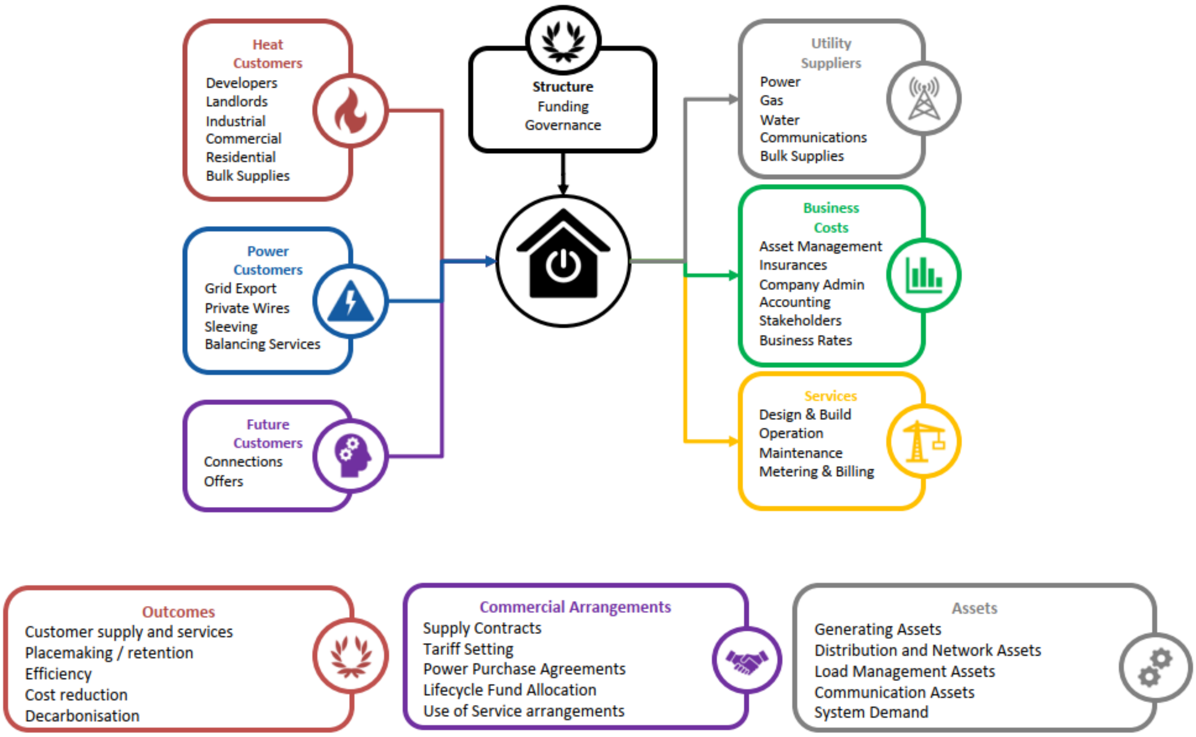


Figure 10-1 Commercial agreements map

The requirement of these agreements is developed further in the Detailed Project Development (DPD) stage and developed in detail in the Commercialisation stage. The exact detail and role of the agreements are linked to the ownership structure of the network.

10.2.2. Ownership and delivery structure options

There are a wide range of commercial structures available, all of which are capable of producing a technically functioning system. The different structures allow different degrees of commercial control and risk. Each of the options show in figure are further examined in Appendix R. Figure xx below, shows the various model and the level of control and commercial control of a heat network. For example, an in house delivery model would give maximum control to RBC, with the 3rd party ESCO giving RBC the lowest levels of influence with a range of options in between. The selection of an ownership and delivery structure is something which will require careful consideration and should align with the operating values and goals of RBC.

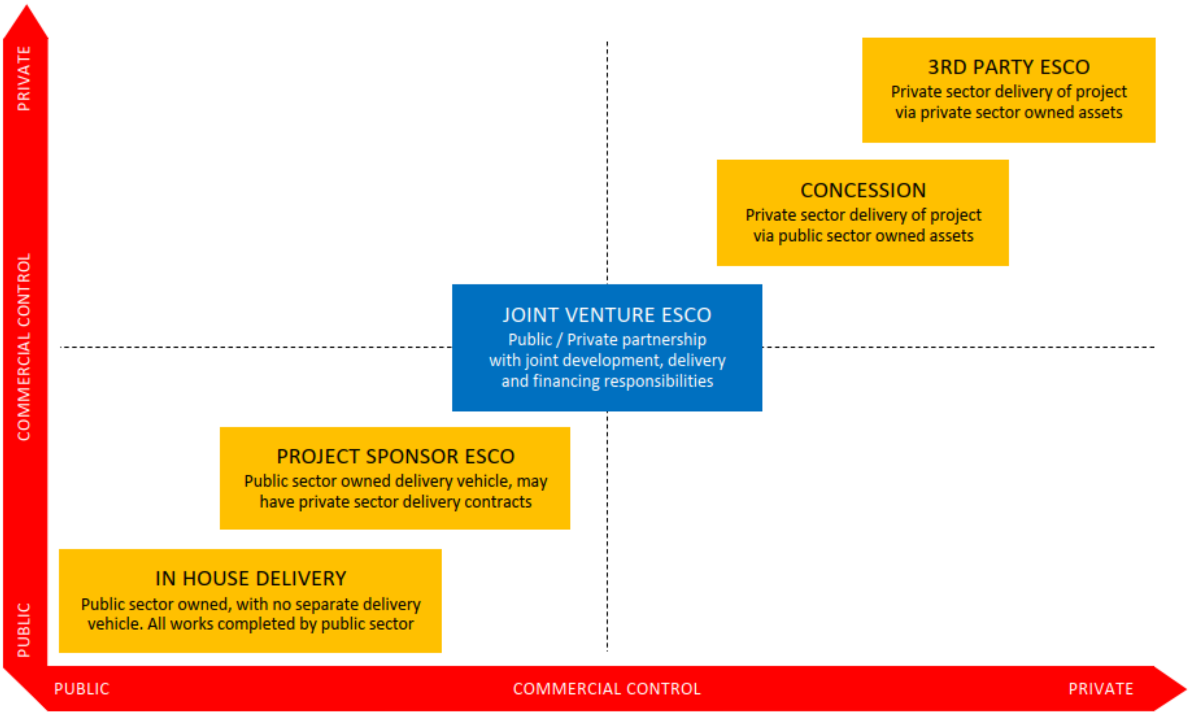


Figure 10-2 ownership structure options

11. Conclusions

From the analysis undertaken during this feasibility study, the following conclusions can be drawn:

11.1. Technical

- There is the potential for a technically feasible district heating network in the “North of the Station” cluster in Reading that offers carbon savings for the proposed network extent, comprising 7 existing buildings and 7 proposed developments.
- The River Thames is a natural available source of low grade heat with sufficient capacity to generate low carbon heat for not only the identified network, but also a large number of buildings within Reading town centre, beyond the study boundary. It has been estimated that there is sufficient heat within the Thames at Reading to replace approximately 50% of the natural gas that is currently burned for heating within Reading.
- The inclusion of a secondary low carbon heat source, in air source heat pumps, at the energy centre provides an economical means to overcome periods when the River Thames is too cold for a river source heat pump to operate.
- There is availability of space within the proposed the proposed energy centre to add additional plant capacity to serve an expanded network. Additionally, there is space available on the proposed energy centre location to expand the footprint of the energy centre if required.
- There is potential for future expansion of the network into the “Forbury Road / Kenavon Drive” and “Station Hill and Around” clusters with the crossing below the railway lines being enabled economically as part of this scheme by including the Kodak and Forbury Road new developments.
- Significant hazards have been identified on the propose network route, including rail crossings and major roundabouts as well as major utilities, such as high voltage electrical cables and intermediate pressure natural gas.

11.2. Stakeholder

- The heat on date requirements from many of the new developments will require the network design and construction to be undertaken without significant delays. If this cannot be achieved, there is a risk that they pursue their own on-site generation and are lost as a potential customer. This could have a detrimental impact on the economic viability of the scheme.
- The Forbury Road and Kodak developments are considered to be key enablers of the network expansion south of the railway line to gain access to Reading Town Centre. If these sites are not secured as customers, it may be more difficult to obtain a financially viable means of making this railway crossing in future, and the ability of the network to offer further carbon savings to buildings in the town centre, limited.
- Carbon savings realised by connecting to new developments are significantly less than those achieved by connecting to existing buildings, however new developments are an attractive customer for a prospective heat network operator and economically enable this initial core network.
- Engagement with all customers was not undertaken as part of this study, and so there is a risk that some of those identified will not wish to connect, which could negatively affect both the carbon savings and IRR.
- There is an opportunity for Leg 2a to offer improvement carbon and economic performance however the proposed customers on this section carry significant risk, due to their lack of response during engagement and/or own decarbonisation plans.

11.3. Commercial

- The networks offers decarbonised heat at a lower Levelised Cost of Heat (LCoH) than the alternative low carbon solutions.

- Subject to the receipt of suitable level of grant funding, it is possible to offer heat at a discounted price to all customers, or only existing buildings and retain an IRR that would be attractive to the private sector.
- A network which includes natural gas for peaking and resilient plant outperforms a full electric solution economically and can offer larger discounts to encourage connection, however, does not achieve the same level of carbon savings.
- Without grant funding, the network is not likely to be attractive to private sector investors. It is anticipated that grant funding of 40+% of the project CapEx would be required to do so, subject to the results of negotiations with offtakers regarding connection charges and heat tariffs.

12. Recommendations and Next Steps

AECOMs recommendations for next steps are:

- RBC consider which of the developed network options outlined in this report is their preferred solution, however it is AECOMs recommendation that scenario B9, which includes electric boilers as resilient plant is pursued. This solution achieves the highest carbon savings of the two developed options, does not incorporate any natural gas generation, which aligns with Readings environmental policy and has an IRR which, with grant funding, would likely be considered as an attractive investment opportunity.
- RBC consider which of the commercial structures is their preferred option.
- RBC make an application for funding to HNDU to assist with Detailed Project Development stage of design costs. The next funding round, round 12, is due to open for applications on 23/05/22, with the first funding wave ending on 01/07/22. Given the importance of new developments to the scheme’s viability, and the proximity of their “heat on” date requirements, it is recommended that an application is submitted at the earliest possible convenience to reduce the risk is any project delays.
- The chosen preferred solution is advanced to Detailed Project Development stage of design in accordance with the HNDU stage of works.
- Engagement with the buildings proposed for connection is continued (and initiated where this was not done as part of feasibility) to maintain interest in the scheme and to understand development plans.
- A feasibility study for expansion of the network into the adjoining clusters is undertaken in parallel to the DPD package of works to advise any futureproofing of the core network that is required to be undertaken.
- Engagement is held with prospective ESCos to introduce the scheme and gauge interest, as well as gaining an understanding of the current market.
- Key Performance Indicators for the network are considered and targeted within the DPD stage of design, and included with any future contracts with an ESCo.
- Early engagement is held with the Environment Agency to understand:
    - Impact of construction of the energy centre in the flood risk zone
    - Potential for abstraction of river water for heat recovery
    - Potential for discharge of open loop ground water if required, for a non-consumptive ground source solution.
- Reading Borough Council planning department are consulted on the proposed energy centre design to obtain feedback for incorporation during DPD.
- A meeting is held with the Rivermead redevelopment design team to understand potential opportunities for integration of the development with the proposed network.

Appendix A – Stakeholder Engagement

A.1 During Study Period and Recommended Engagement

Building / Development	Stakeholder Tier	Latest Engagement	Recommended Ongoing Engagement
Proposed New Developments			
Former Royal Mail Development	Tier 1	No engagement held as agreed with RBC Planning Department	Initiate contact with the developer once agreed with RBC. Obtain latest details of the proposed plans and introduce the scheme and its benefits.
Napier Court Development	Tier 1	Scheme introduced to the developer, Sladen Estates. Details of the proposed development not received.	Continue to liaise with Sladen Estates. Obtain details of the proposed plans and introduce the scheme and its benefits.
Former SSE Development	Tier 1	No engagement held as agreed with RBC Planning Department	Initiate contact with the developer once agreed with RBC. Obtain latest details of the proposed plans and introduce the scheme and its benefits.
Aviva Development	Tier 1	No engagement held as agreed with RBC Planning Department	Initiate contact with the developer once agreed with RBC. Obtain latest details of the proposed plans and introduce the scheme and its benefits.
Kodak & Ventello Development	Tier 1	Engagement held with the site planning agent, Savills and obtained point of contact. No engagement held with the developer, Viridis Real Estate.	Initiate contact with the developer once arranged via Savills. Obtain latest details of the proposed plans and introduce the scheme and its benefits.
Forbury Retail Park Development	Tier 1	Engagement held with the developer technical designer, Method Consulting. Scheme introduced and high-level understanding of development plans obtained. Awaiting receipt of detailed development plans from the client team. No engagement with the developer held.	Continue engagement with Method Consulting to obtain detailed development plans and understand timelines and requirements from the network. Initiate contact with the developer once arranged.
Great Brigham Mead Development	Tier 1	Engagement held with McKay Securities Plc, the current owners. The sale of the site to the developer, Kings Oak, is being completed in April ’22. No approach has been made to King’s Oak.	Initiate contact with the developer once sale has been completed. Obtain latest details of the proposed plans and introduce the scheme and its benefits.
Existing Buildings			
Crowne Plaza Hotel	Tier 1	Multiple engagement attempts undertaken to both Crowne Plaza and Meridian Hotels. No response received.	Continue to attempt engagement with the hotel to understand the potential for connection and obtain information on existing consumption and systems.

Reading Bridge House	Tier 1	Complete RFI received from Topland.	Continue to engage with Topland to understand the potential for connection and develop the strategy.
Clearwater Court	Tier 1	Initial engagement undertaken with Thames Water and scheme introduced. Awaiting an introduction with an appropriate contact within the company to obtain details for the building.	Continue to engage with Thames Water and obtain a suitable contact. Obtain information on the existing consumption and systems as well as potential for connection.
Rivermead Leisure Complex	Tier 1	Initial engagement undertaken with Greenwich Leisure Limited regarding both the existing and future demands following completion of the planned redevelopment, however no formal information was received.	Continue to engage and understand details of the redevelopment works. Explore opportunities to integrate these works with the district energy network scheme.
Thames Quarter	Tier 1	Initial contact made through general enquiries which was forwarded to the building landlord. No contact with the landlord was held.	Continue to engage with the building landlord, and understand the existing on-site energy systems and predicted economic lifespan, which may be considerable due to the recent completion of the building.
Thames Lido	Tier 1	Engagement held with the sites architectural consultants, Marshall and Kendon, and initial introduction made with the owner, Glassboat. Not details of the sites consumption or existing systems obtained.	Continue to engage with Glassboat to understand the existing consumption and systems as well as potential for connection and develop the strategy.
2 Norman Place	Tier 1	Introduction via email made to Vail Williams, the site planning agent, however no response was received.	Continue to engage and obtain a suitable contact. Obtain information on the existing consumption and systems as well as potential for connection.
Premier Inn, Caversham Bridge	Tier 1	Multiple engagement attempts undertaken. No response received.	Continue to attempt to engage and obtain a suitable contact. Obtain information on the existing consumption and systems as well as potential for connection.
Caversham Bridge House	Tier 1	Complete RFI received from Stantec.	Continue to engage with Stantec to understand the potential for connection and develop the strategy.
Kings Meadow House	Tier 1	Initial engagement undertaken with the Environmental Agency however no formal information was received.	Continue to engage with the Environmental Agency. Obtain information on the existing consumption and systems as well as potential for connection.
Sovereign House	Tier 1	Introduction via email made to Jones Lang LaSelle (JLL), however no response was received.	Continue to seek a suitable contact. Obtain information on the existing consumption and systems as well as potential for connection.
Puregym Caversham Road	Tier 2	Complete RFI received from PureGym.	If assessed to be a suitable connection, continue to engage, understand the potential for

			connection and develop the strategy.
EP Collier Primary School	Tier 2	Gas consumption data received from RBC.	Continue to engage to obtain improved consumption data and understand the existing on site heat generation equipment. Develop the connection strategy.
Napier Court Office Buildings (Penant House, Emerald House and Unit 5-6)	Tier 2	Engagement held with Savills and understanding that the site has been sold to a developer. See Napier Court Development	Engagement to continue as detailed for Napier Court Development
Shurgard Self Storage	Tier 2	Engagement attempted. No response received.	If assessed to be a suitable connection, continue to engage, understand the potential for connection and develop the strategy.
Reading Fire Station	Tier 2	No engagement undertaken.	Obtain a suitable contact. Obtain information on the existing consumption and systems as well as potential for connection.
Toby Carvery Caversham Bridge	Tier 2	Multiple engagement attempts undertaken. No response received.	Continue to attempt to engage and obtain a suitable contact. Obtain information on the existing consumption and systems as well as potential for connection.

Appendix B – Feasibility Study Methodology

The methodology developed to undertake this study is summarised below.

1. **Stakeholder Engagement:** A list of the sites/buildings with the potential to connect to the network was created, and through a desktop exercise, arranged into Tier 1 and Tier 2 according to their significance to the network. Meetings were held with the RBC Planning Department to understand the status of the new developments in the area and an approach to engagement with these developments agreed with the Client team. Contact details for existing buildings were obtained and project Briefing Packs submitted with a Request For Information (RFI) questionnaire, asking stakeholders to provide information on their sites including, existing energy demand and existing energy generation plant. For more information on stakeholder engagement, please refer to Appendix A.
2. **Data Collection & Energy Demand:** Completed RFIs which included metered consumption data from stakeholders were used to generate energy demand profiles for those buildings. Values from Display Energy Certificates (DEC) for existing buildings was used as a secondary priority source, using the most recent year that was unaffected by the impact of the pandemic. Where neither of these data sources were available for existing buildings, and for new developments, benchmarked energy consumption data was used. The value of these benchmarked figures was, where possible, based on real consumption data from similar buildings and the use of CIBSE TM46 Good Practise and CIBSE Guide F data avoided. These benchmark figures were agreed with the Client team.
3. **Energy Demand Mapping:** Using the energy demand analysis, energy maps were produced which illustrate the size and location of heating and cooling clusters in the boundary.
4. **Low Carbon Heat Opportunities:** A desktop study was undertaken to identify opportunities to supply low carbon heat with a focus on quantifying sources close to areas of high demand. A review of the available technologies was carried out by assessing their suitability against deliverability, environmental, financial and technical criteria.
5. **Techno-economic Modelling of Preferred Solutions:** A network masterplan was developed for the cluster, with multiple scenarios and sensitivities tested to ascertain the level of environmental and economic performance of each of the network solutions identified.
6. **Recommendations** as to which network solution represents the most promising opportunity were made.

Appendix C – Determination of Peak Demand

In addition to degradation to the primary network performance, at a building level, oversized thermal substation plate heat exchangers have historically reduced effectiveness at flow rates below the design, due to flow being more laminar in nature. Overestimation of peak demands mean that the actual flow rate through the plate never reaches the design. It is important therefore that accurate estimates of peak demand requirements are obtained through futher engagement with potenitial customers during future design stages.

Peak demand for each customer site is detailed in Table 12-1. For new developments, this has also been broken down into space heating and hot water service (HWS), assuming instantaneous HWS generation. This has not been included for existing buildings due to the lack of understanding of the current HWS generation systems and consequential difficulty in accurately estimating this.

Building / Development	Peak Heat Demand (kW)	Peak Cooling Demand (kW)
Aviva Development	2,676 kW (2,141 kW SH + 535 kW HWS)	401 kW
Former Royal Mail Development	2,020 kW (1,488 kW SH + 532 kW HWS)	277 kW
Forbury Retail Park Development	1,822 kW (1,132 kW SH + 690 kW HWS)	185 kW
Napier Court Development	655 kW (354 kW SH + 301 kW HWS)	0 kW
Kodak & Ventello Development	862 kW (561 kW SH + 301 kW HWS)	0 kW
Former SSE Development	564 kW (296 kW SH + 268 kW HWS)	0 kW
Great Brigham Mead Development	339 kW (156 kW SH + 182 kW HWS)	0 kW
Rivermead Leisure Complex	450 kW	251 kW
Thames Quarter	768 kW	4 kW
Crowne Plaza Hotel	844 kW	118 kW
Reading Bridge House	341 kW	294 kW
Thames Lido	177 kW	0 kW
Clearwater Court	295 kW	257 kW
Premier Inn, Caversham Bridge	200 kW	53 kW
2 Norman Place	140 kW	124 kW
Kings Meadow House	112 kW	52 kW
Sovereign House	75 kW	72 kW
EP Collier Primary School	96 kW	0 kW
Reading Fire Station	72 kW	0 kW
Caversham Bridge House	57 kW	53 kW
Toby Carvery Caversham Bridge	37 kW	0 kW
Puregym Caversham Road	12 kW[45]	17 kW
Total Undiversified Peak	**12,614 kW**	**2,158 kW**

Table 12-1 – Undiversified Peak Heating and Cooling Demands

For new developments, the peak demand has been calculated using the methodology outlined in CIBSE CP1 (2020) and using information regarding accommodation composition, obtained during stakeholder engagement and from information submitted as part of the planning applications. The parameters applied to the peak demand calculation methodology are detailed in Table 12-2. These values have been derived from experience of thermal modelling of similar new buildings, CP1 (2020) and NHBC standards for residential hot water demand and using estimates for non-residential areas.

[45] Energy demand for Puregym is extremely low based on the metered data provided. It is recommended that a survey of building is undertaken in future stages, if deemed to be a viable connection

Parameter	Estimated Value
Peak Space Heating Load from Residential Unit	38 W/m^2 of floor area
Peak Space Heating Load from Non-Residential Area	50 W/m^2 of floor area
Peak Space Cooling Load from Residential Unit	0 W/m^2 of floor area
Peak Space Cooling Load from Office[46]	11 W/m^2 of floor area
Peak Space Cooling Load from Commercial / Retail[46]	46 W/m^2 of floor area
Average Residential Unit Floor Area (where not detailed)	60 m^2
Peak HWS Demand – 1 Bed & Studio Apartment	18.8 kW
Peak HWS Demand – 2+ Bed Apartment	25.1 kW
Peak HWS Demand – Residents Gym	60.0 kW
Peak HWS Demand – Community Centre	15.0 kW
Peak HWS Demand – Retail Unit	15.0 kW
Peak HWS Demand – Office Unit	10.0 kW

Table 12-2 - Parameters Used to Estimate Peak Demand in New Developments

Through future engagement, more information on the existing systems shall be obtained to improve the estimate of peak demand. Potential network off-takers shall be encouraged to consider their split of Space Heating and Domestic Hot Water at peak demand when requesting a connection. Connection sizes shall be requested based on the kg/s of LTHW required from the network rather than the kW of heat. Connection charges aligned to this to encourage off-takers to consider the higher ΔT associated with HWS generation rather than assuming a blanket ΔT, in order to avail of the financial savings from a reduced connection charge. This will benefit the network by reducing pipework and pump sizing to meet peak demands, improving the efficiency of the network.

Diversified peak demands have been calculated using annual hourly demand profiles for each of the proposed connected buildings, based on their specific use type. These individual profiles are combined into a consolidated network demand profile, the peak of which is used to determine the upper limit of generational capacity by resilient plant.

A range of network extents are tested in Section 8.2, to determine the optimum scenario. Each of these will have a unique diversified peak demand. However, for a network comprising all of the loads outlined in Table 12-1 above, the diversified peak demand has been determined to be 10,116kW, giving a diversity factor of 0.807. CIBSE Guide A, Table 5.13, states that district heating schemes can have a diversity factor of 0.7, however given that the majority of the demand (~57%) is from Residential use, 0.807 is considered to be reasonable at this stage.

Space or buildings served by plant	Diversity factor
Single space	1.0
Single building or zone:	
— central control	0.9
— individual room control	0.8
Group of buildings:	
— similar type and use	0.8
— dissimilar uses*	0.7

* Applies to group and district heating schemes where there is substantial heat storage in the distribution mains, whether heating is continuous or intermittent.

Figure 12-1 - Table 5.13 from CIBSE Guide A (2015

[46] Determined using database of metered coolth consumption profiles

Appendix D – BaU Counterfactual

When determining the counterfactual, consideration has been given to the GHNF guidance[47], which states that:

"For customers at risk in **new build developments[48]**, a low carbon counterfactual will be used for establishing a benchmark cost for low carbon heat. This assessment will include the cost of asset purchase, maintenance and fuel costs" and "For customers at risk in **existing buildings**, a gas counterfactual will be used in urban settings and a heating oil counterfactual in rural or off-gas grid settings".

For new build developments, due to Building Regulations energy targets and local planning policy, the BaU scenario will be a low carbon solution, taken to be on-site Air Source Heat Pumps (ASHP). Newer buildings are constructed with modern, highly efficient fabrics and include heating systems which work with lower operating temperatures than have been traditionally used, such as underfloor heating. A proposed change to Building Regulations Part L would restrict heating systems flow temperatures to 55°C. Lowering operating temperatures allow ASHP to operate more efficiently, reducing fuel consumption and, in addition, are typically cheaper than high temperature heat pumps.

It is anticipated that the majority of existing buildings will have gas-fired heating plant, with gas boilers being most common, potentially with gas CHP in larger buildings. For these, there are generally three counterfactual positions:

1. **Do Nothing Scenario;** Continue with the present-day energy generation and delivery strategy;
2. **Pay to be Dirty Scenario;** Continue with the present-day energy generation and delivery strategy with additional consideration to the cost to society in terms of the non-traded cost of carbon and air quality; or
3. **Retrofitted On-Site Low Carbon Heat Generation;** The present-day energy generation system is replaced with a low carbon alternative, taken to be ASHP.

Scenarios 1 and 2 are not conducive with the low carbon heat generation that is offered by connection to a district heat network are so are not considered.

In Scenario 3, it is assumed that building fabric, existing delivery and heat emitter systems are designed to be used with traditional heating temperatures for gas fired systems, which generally range from 70°C - 82°C. The BaU in this case is taken to be a high temperature ASHP, operating with a flow temperature of 75°C.

The cost rates of counterfactual plant CapEx and OpEx varies with the scale of the demand. Generally, the lower the peak demand (kW) the higher cost rate (£/kW). This is demonstrated in Figure 12-2 and Figure 12-3 for the counterfactual systems used in the study.

[47] Green Heat Network Fund Round 1: guidance for applicants

[48] Developments which have not been built at the time the GHNF application is made

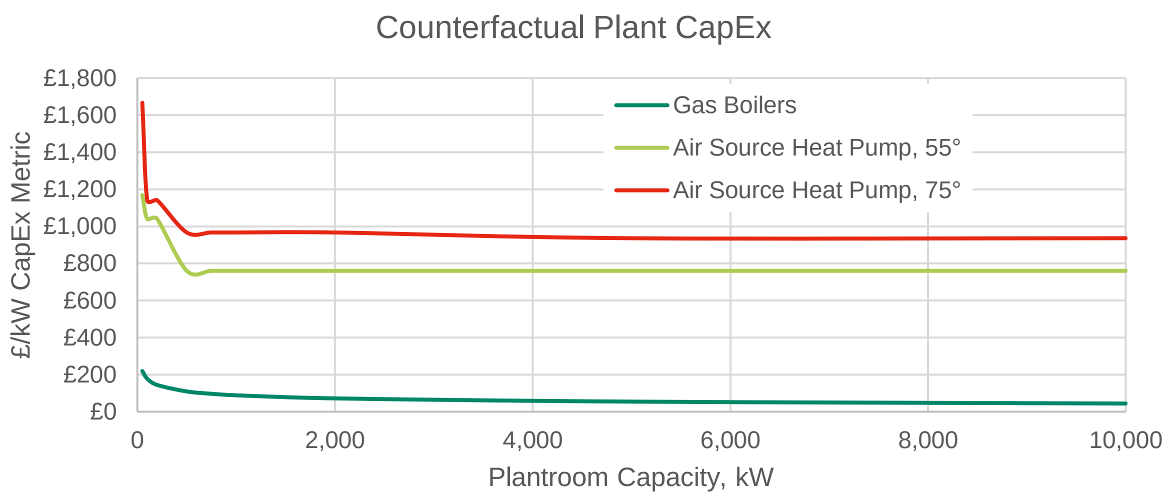


Figure 12-2 - Counterfactual Plant CapEx Cost Rate

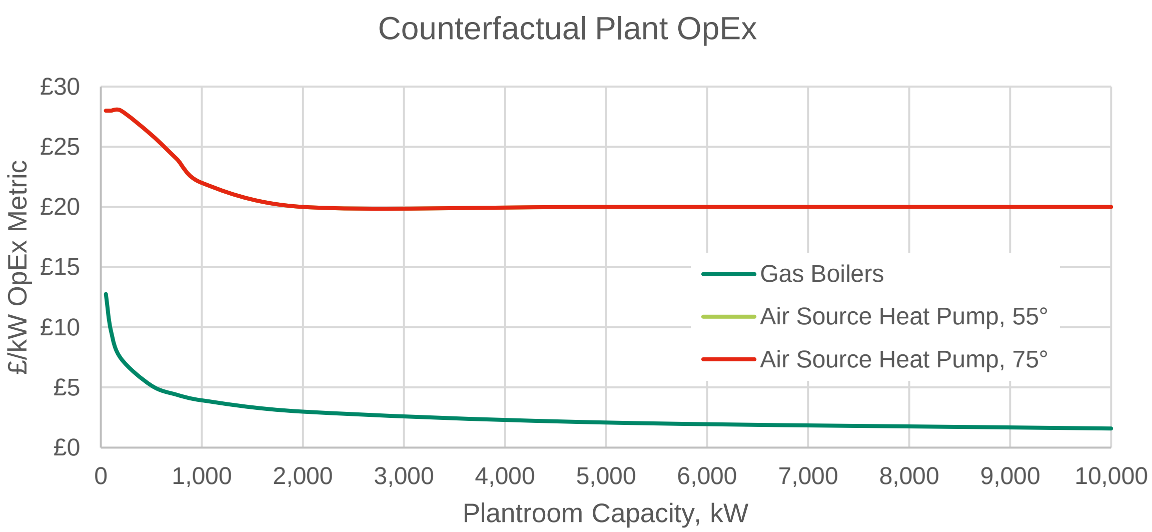


Figure 12-3 - Counterfactual Plant OpEx Cost Rate[49]

Under all these counterfactual positions, the energy heating technologies differ on a building by building basis based upon their energy requirements. To estimate the comparative running costs of these different heating generation systems, a Whole Cycle Cost of Heat (WLCoH) analysis was conducted for each site under all scenarios, giving a pence per kilo watt hour value for each system. This value represents the time adjusted cost of energy generation and delivery over the whole life span of the project and can be used as a comparative metric when assessing different technologies.

The Whole Lifecycle Cost of Heat includes both capital costs (initial investment and periodic replacement) and operations costs (maintenance and fuel). The results of the WLCoH analysis for new developments is demonstrated in Figure 12-4[50].

[49] OpEx for both ASHP solution is the same

[50] Costs stated are over the first 20 years of operation, prior to the first replacement of the on-site heat generation plan

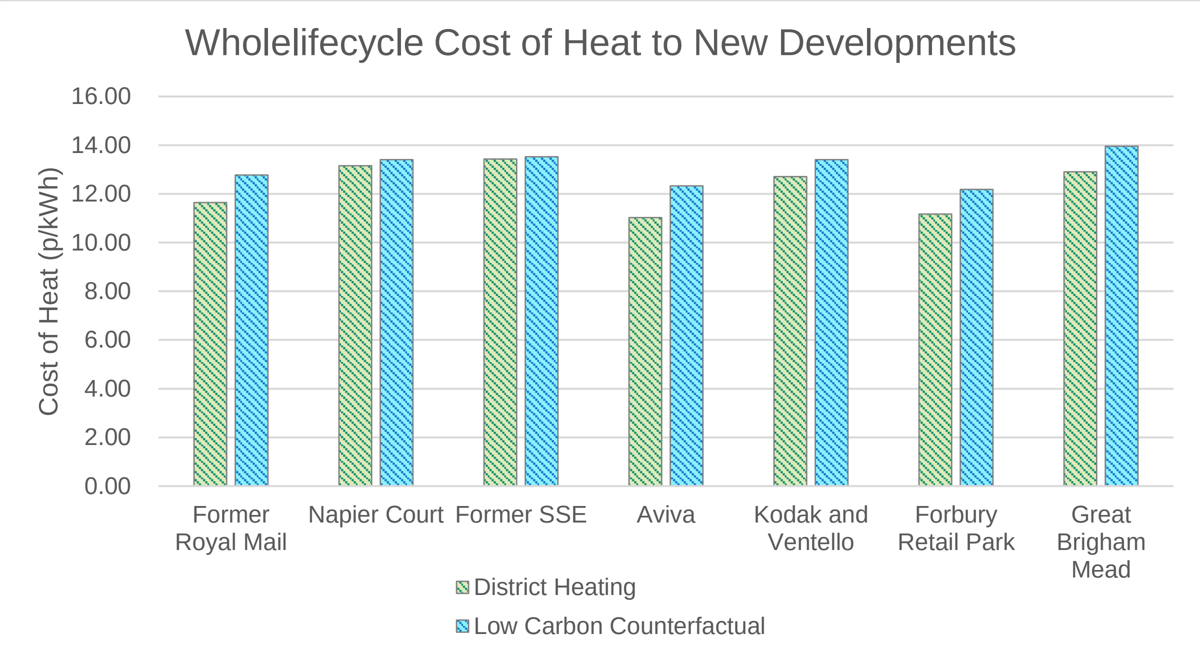


Figure 12-4 - Whole Lifecycle Cost of Heat for New Developments for DH and the BaU

As demonstrated, for all new developments, the WLCoH is cheaper for a connection to district heating compared to the low carbon counterfactual. There is variation between developments, with Former SSE being lowest at 0.7% cheaper and Aviva being highest at 10.5%. Averaged across all new developments, district heating is 8.8% cheaper than an on-site low carbon generation solution.

The levelised cost of heat (LCoH) for the counterfactual systems was determined for the five different network extent scenarios (A1 = A) assessed in Section 8.2. The combination of different customer buildings results in a variation of the LCoH, as demonstrated in Figure 12-5

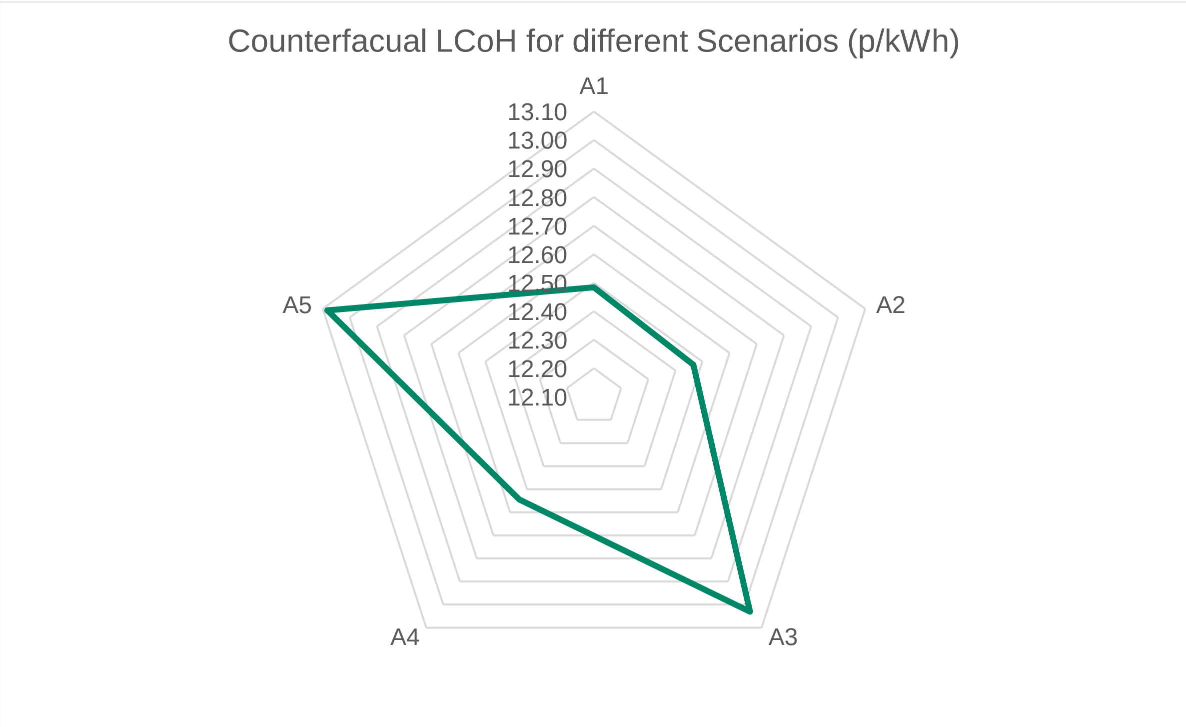


Figure 12-5 - WLCoH for Network Extent Scenarios

Appendix E – Heat Source Feasibility and Appraisal

E.1 River Source Heat Pump Feasibility

Flow data for the river Thames has been obtained from the National River Flow Archive. The measurement point is Ref: 39130 – Thames at Reading, located at Reading Bridge. The daily mean water flow rate from 1993 – 2020 were obtained and averaged for each month over that period.

The Environmental Agency (EA) are the regulatory authority for the section of the River Thames through Reading. In Chapter 4, The Environmental Permitting Regulations 2016 SR2010No2, the EA set out their rules for abstraction or discharging heat into surface water, which limit the amount of heat which can be transferred from the river.

Standard practise for open loop river source heat pump (RSHP) systems in the UK has been to abstract and discharge no greater than 10% of the total volumetric flow rate of the river. EA rules state that no greater than 25% of the 95% exceedance of the total volumetric flow rate of the river can be abstracted and discharged. The resultant abstractable flow rates for each of these parameters is demonstrated in Figure 12-6 below. The minimum abstractable volume using both of these sets of parameters is 1.1m^3/s. Assuming a ΔT of 3°C, this equates to 13.9MW of heat.

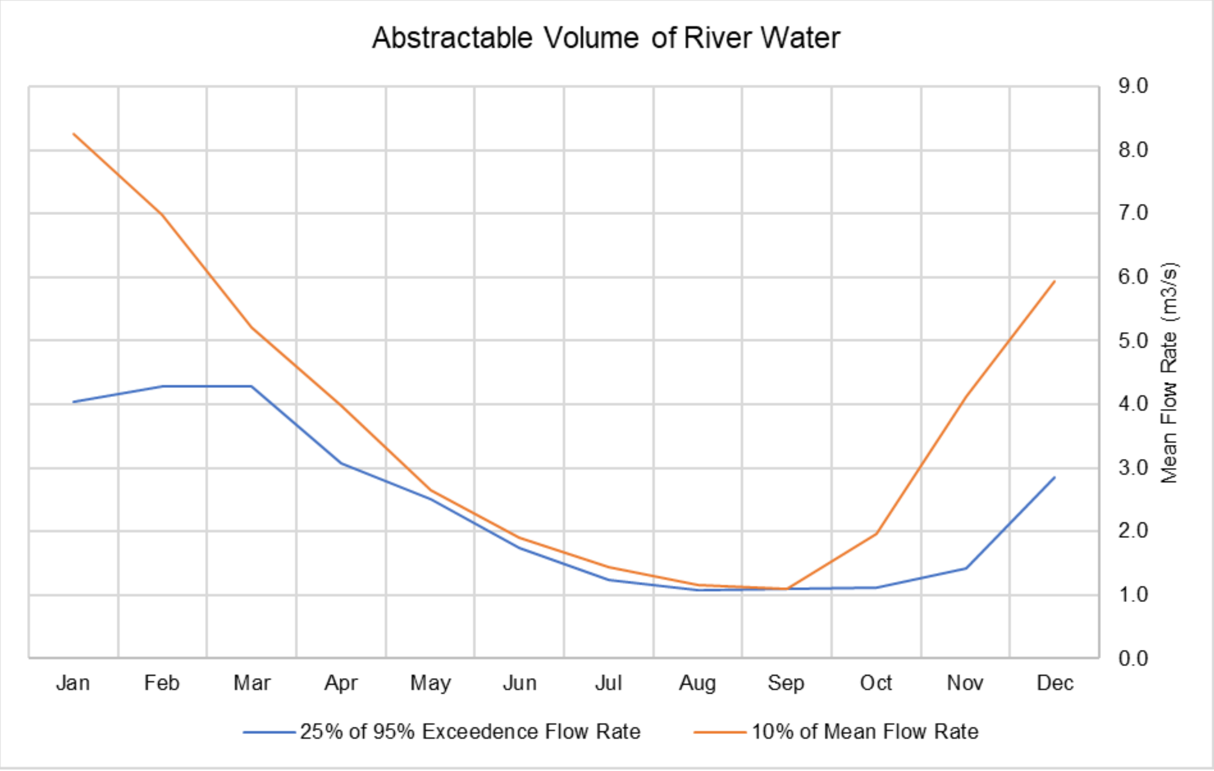


Figure 12-6 - Maximum Abstractable River Water Volume for Average Monthly Flow Rates 1993-2020 at Reading Bridge

River water temperatures for the river Thames has been obtained from https://dl1.findlays.net. The measurement point is at Shiplake Lock, located approximately 7km east of the proposed abstraction point. The dataset from 2020 was used in this assessment, as the most recent complete set. The minimum, mean and maximum monthly water temperatures are demonstrated in Figure 12-7.

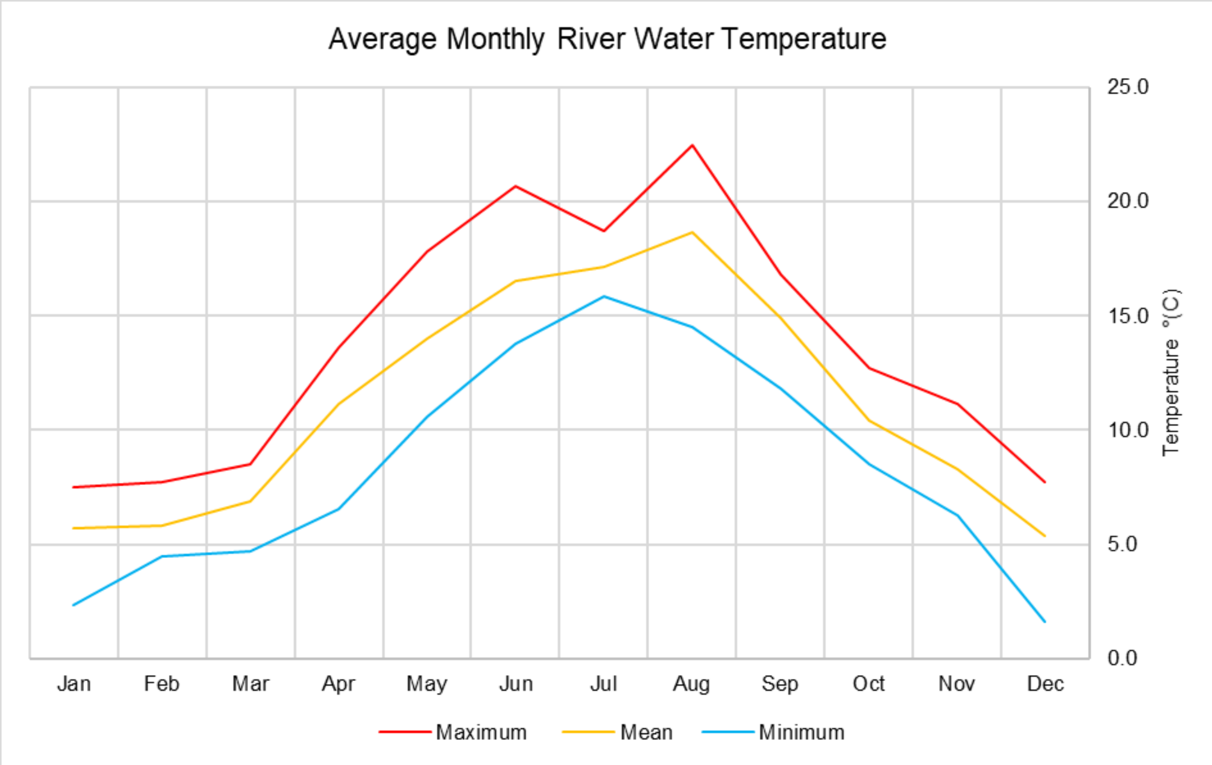


Figure 12-7 - Average Monthly Water Temperatures 2020 at Shiplake Lock

Standard practise for open loop river source heat pump (RSHP) systems in the UK has been to discharge water back to the river 3°C lower than it was abstracted. EA rules state that there should be no greater than 8°C difference between the abstracted and discharged water. In summer this presents an opportunity to increase the ΔT and reduce pumping electrical consumption by reducing the flow rate and therefore speed accordingly. This is more difficult to achieve during winter when the risk of freezing is more prominent. The cooling effect this would provide in summer would be to the benefit of river ecology.

Demonstrated in Figure 12-8 is the maximum ΔT that can be taken from the river water at each month of the year using EA rules. From December – February, this is limited to 3°C due to the risk of freezing, however increases to 8°C in May and remains at this level until September, after which it begins to reduce in October and November. This larger ΔT increases the energy availability during the warmer months, as is indicated by the green line, peaking in April. To reduce downtime due to the risk of freezing, it is proposed to include a pre-heat function with the river abstraction system. This larger ΔT compensates for the reduced summer flow rates, and so increases the minimum heat capacity within the river to 31.4MW.

Pre-heating the river water using an alternative heat source, such as the district heating network or gas boilers, will reduce the times at which the water is at risk of freezing. By doing so, it is estimated that the annual heat that could be abstracted would be 386GWh/annum. With the addition of a 1.5°C pre-heat, the RSHP system is estimated to be available for 96.3% of the year.

During summer months, where there is no risk of freezing, this does not affect the heat available, however in winter can provide a significant benefit, as is demonstrated by the red line in Figure 12-8.

Parameters	Minimum Heat (MW)	Annual Energy (GWh) w/o pre-heat	Annual Energy (GWh) with pre-heat
Standard Practise	13.9	295	386
EA Rules	31.4	382	438

Table 12-3 - Summary of Heat and Energy Availability within the River Thames

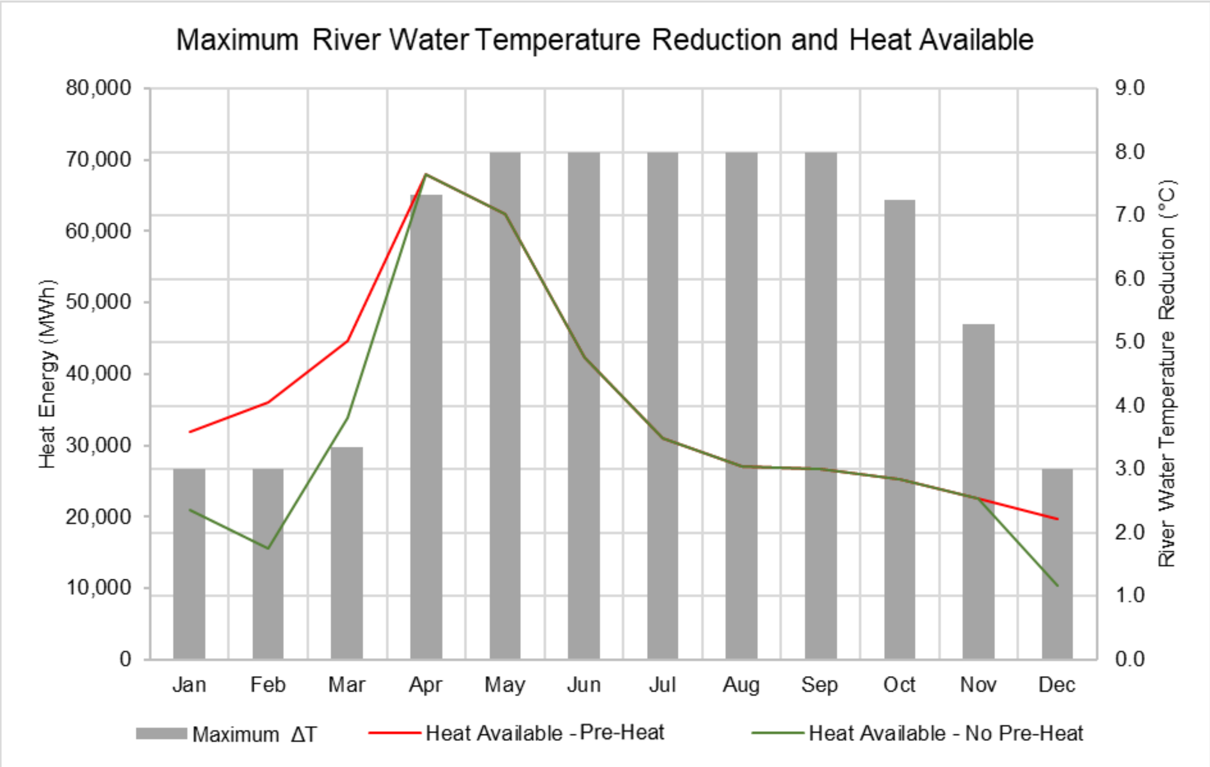


Figure 12-8 - Maximum Temperature Reduction and Heat Available using EA Parameters

Pre-heating has not been incorporated into this assessment.

E.2 Ground Source Heat Pump Feasibility

A high level Ground Source Heating Cooling feasibility report has been carried out by AECOMs Hydrogeology team. Please refer to *Reading GSHC_High Level Feasibillity Study* , included as an appendix to this report, for information.

E.3 Waste Heat Recovery – SSEN Electrical Transformer

The transformer at Reading Town is understood to have a capacity of 60MVA.In a study by Bowman Et Al, the availability of waste heat that could be recovered from electrical transformers is estimated by:

$$Recovered\ Waste\ Heat\ (kW) = Tranformer\ Capacity\ (MVA) \times Electrical\ Loading\ (\%) \times Heat\ Recoverable\ (\%) \times Total\ Loss\ (\frac{kW}{kVA})$$

Electrical Loading is the demand as a percentage of peak that is being imposed on the transformer by the downstream electrical network. This will vary significantly daily and seasonally, with peak demand being considered a rare and brief occurrence, however it would be reasonable to assume that will increase with time due to the electrification of heat and growth of electrical vehicles. For this assessment, an average of 40% has been assumed.

Heat Recoverable is the amount of heat losses which can be recovered by heat recover system, which is all cases will be less than 100%. For this assessment, an average of 80% has been assumed.

Total Loss is the combination of no-load and load losses, which varies with transformer model. For this assessment a mean of 0.00676kW/KVA has been taken for this, derived from a review of manufacturers name plate data.

Based on the above, Reading Town substation can provide 150kW of recovered heat.

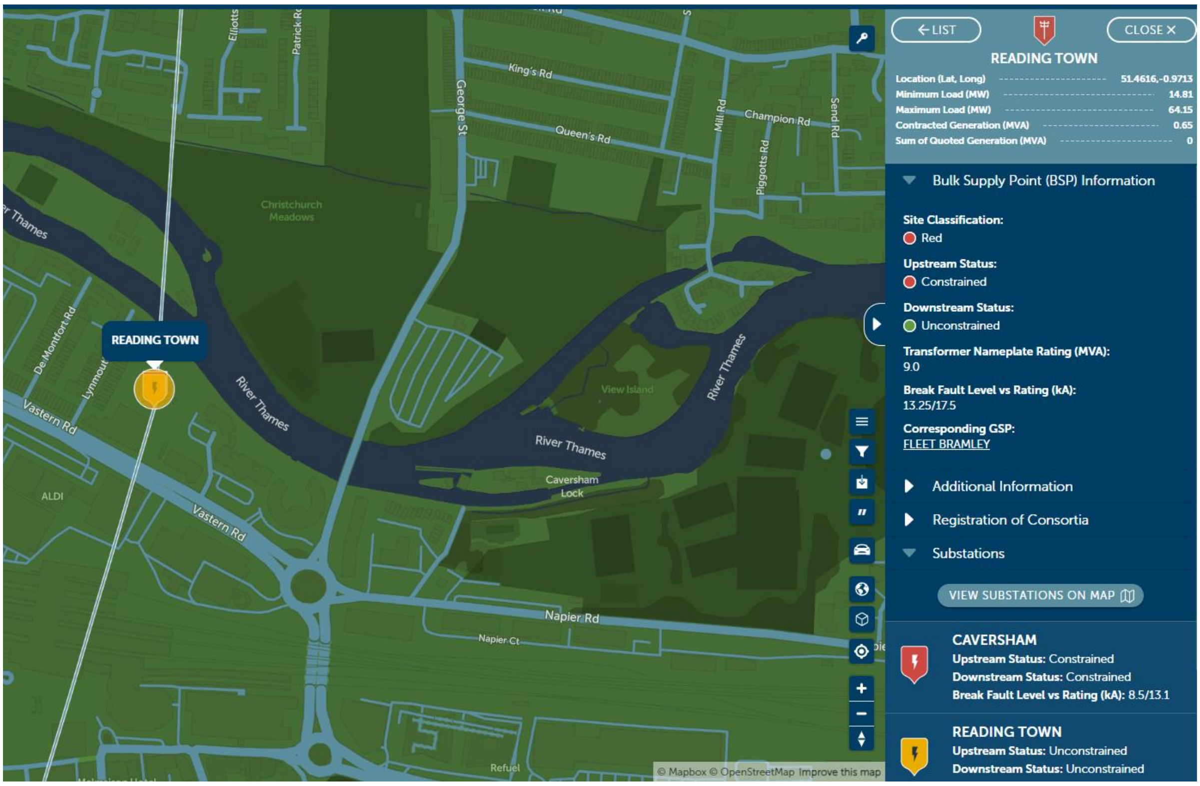


Figure 12-9 - Scottish and Southern Electricity Networks Map showing Reading Town Substation

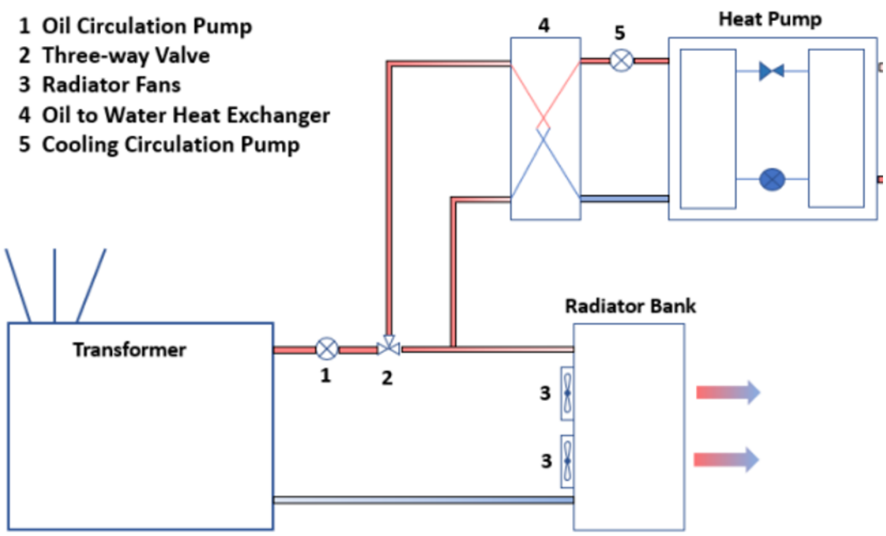


Figure 12-10 - Transformer Heat Recovery Concept Schematic

E.4 Heat Source Appraisal Criteria and Results

Each of the fifteen criteria used to appraise the heat source technologies are included in Figure 12-11 below. Included are the relative impact they are deemed to have to the scheme viability, weighted from 1-5, with 1 having a low impact on the scheme and 5 having a high impact. The resultant weighting correlates the relative importance to a value amounting to 100%.

Each of the potential opportunities is then scored from 1-5 on each of the criteria in accordance with its viability or performance in that specific criteria, with 1 being poor performing and 5 being high performing. As an example, gas boilers would score well in Technology Cost due to their low price but would score poorly in Level of Carbon Savings due to the emissions from combustion of gas.

The result of this methodology is each potential opportunity being assigned an overall score out of 100, with highest representing the best opportunity, allowing each of the potential technologies to be ranked.

Category	Criterion	Relative Importance 1 - 5	Weighting %
Technical	Technology maturity and availability	5	9
	Suitability for scale and profile of heat demand	5	9
	Security of supply	3	6
	Suitability for required supply temperatures	4	8
	Proximity to heat demands	2	4
Environmental	Level of CO_2 emission savings	5	9
	Air quality implications	5	9
	Wider environmental impacts	2	4
Financial	Technology cost	3	6
	Impact on scheme financial viability	5	9
	Long term financial risks	3	6
Deliverability	Suitability to Reading	4	8
	Implications for energy centre size/design	3	6
	Implications for additional space requirements	2	4
	Reliance on third parties	2	4
			100

Figure 12-11 – Heat Source Appraisal Criteria Weighting

		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
Category	Name Ref	Gas Boiler	Gas CHP	River Source Heat Pump	Ground Source Heat Pump	Air Source Heat Pump	Electrical Transformer	Chilled Water Waste Heat Recovery	Biomass Boiler	Hydrogen Fuel Cell
Technical	Technology maturity and availability	5	5	4	5	5	3	5	4	1
	Suitability for scale and profile of heat demand	5	5	5	3	4	2	2	5	4
	Security of supply	5	5	4	4	5	3	3	3	2
	Suitability for required supply temperatures	5	5	5	5	4	4	4	5	5
	Proximity to heat demands	5	5	5	5	5	4	5	5	3
Environmental	Level of CO2 emission savings	1	1	5	5	3	5	5	4	5
	Air quality implications	1	1	5	5	5	5	5	1	5
	Wider environmental impacts	3	2	4	3	4	5	5	3	1
Financial	Technology cost	5	5	3	3	4	3	4	4	1
	Impact on scheme financial viability	4	5	4	4	4	2	2	4	5
	Long term financial risks	2	2	4	4	5	3	4	2	2
Deliverability	Planning Implications	1	2	5	5	5	4	5	2	5
	Implications for energy centre size/design	5	4	3	3	2	4	3	3	3
	Implications for additional space requirements	5	5	3	3	3	2	3	2	3
	Reliance on third parties	4	4	4	4	5	2	5	2	1
	Total score (%)	71.32	72.83	86.42	83.77	84.15	68.68	78.87	67.17	67.92
	Rank	6	5	1	3	2	7	4	9	8

Figure 12-12 - Technology Appraisal Results Year 1-15

Category	Name Ref	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9
		Gas Boiler	Gas CHP	River Source Heat Pump	Ground Source Heat Pump	Air Source Heat Pump	Electrical Transformer	Chilled Water Waste Heat Recovery	Biomass Boiler	Hydrogen Fuel Cell
Technical	Technology maturity and availability	5	5	5	5	5	3	5	4	2
	Suitability for scale and profile of heat demand	5	5	5	3	4	2	2	5	4
	Security of supply	5	5	4	4	5	3	4	3	3
	Suitability for required supply temperatures	5	5	5	5	4	4	4	5	5
	Proximity to heat demands	5	5	5	5	5	4	5	5	3
Environmental	Level of CO2 emission savings	1	1	5	5	4	5	5	4	5
	Air quality implications	1	1	5	5	5	5	5	1	5
	Wider environmental impacts	3	2	4	3	4	5	5	3	2
Financial	Technology cost	5	5	4	4	4	3	4	4	2
	Impact on scheme financial viability	4	4	4	4	4	2	2	4	5
	Long term financial risks	2	2	4	4	5	3	4	2	2
Deliverability	Planning Implications	1	1	5	5	5	4	5	2	5
	Implications for energy centre size/design	5	4	3	3	2	4	3	3	3
	Implications for additional space requirements	5	5	3	3	3	2	3	2	3
	Reliance on third parties	4	4	4	4	5	2	5	2	1
	Total score (%)	71.32	69.43	89.43	84.91	86.04	68.68	80.00	67.17	72.83
	Rank	6	7	1	3	2	8	4	9	5

Figure 12-13 - Technology Appraisal Results Year 15+

Appendix F – Technical Notes on Lowering Secondary Side Heating Temperatures

The estimated interventions and associated capital cost estimations have been included in this appendix below. Please note that these are outline estimates, based on the stated assumptions and more detailed studies would be required to confirm the measures, costs, viability and benefits in each location to inform a business case for investment.

F.1 Assumptions:

Daywork Rate (£/hour) - Senior Mechanical Craftsman: £22.1/hour – Spons M&E 2020 +20%

Water Sampling Cost: £2,000

Fit-Out of Radiators (£/m^2): £52.50/m^2 – Spons M&E 2020 Affordable Residential Fit-Out

Fit-Out of Fan Coil Units (£/m^2): £24.00/m^2 – Spons M&E 2020 Cat A Office Fit-Out

Fit-Out Rate Reduction for Installation of 30% Additional Capacity: 50%

Time for Rebalancing of Systems (hours/m^2): 0.1 hour/m^2

For Option 2, considered to be a worst case scenario where existing system operated at 82°C/71°C, therefore requiring replacing of heat emitters, it is taken that the distribution systems will not require replacing as the ΔT will increase from 11°C to at least 20°C, lowering flow rates and making existing pipework sizes suitable.

Option 1 – No upgrades to existing systems. Rebalancing for different operating temperature undertaken.

Option 2 – Emitter upgrade and rebalancing different operating temperature undertaken.

F.2 Rivermead Leisure Complex

Estimated Gross Internal Area: 7,890m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £17,460
- Water Sampling - £2,000

Total: £19,460

Option 2 – 30% Increase in Emitters Output (FCU)

- Option 1 Costs - £19,460
- Emitter Upgrade - £94,680

Total: £114,140

F.3 Thames Quarter

Estimated Gross Internal Area: 19,731m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £43,660
- Water Sampling - £2,000

Total: £45,660

Option 2

Upgrade to existing emitters not anticipated as building has been recently completed and is finished to a high specification which is likely to included underfloor heating.

F.4 Crowne Plaza Hotel

Estimated Gross Internal Area: 6,583m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £14,560
- Water Sampling - £2,000

Total: £16,560

Option 2 – 30% Increase in Emitters Output (FCU)

- Option 1 Costs - £16,560
- Emitter Upgrade - £79,000

Total: £95,560

F.5 Reading Bridge House

Estimated Gross Internal Area: 13,057m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £28,890
- Water Sampling - £2,000

Total: £30,890

Option 2 – 30% Increase in Emitters Output (FCU)

- Option 1 Costs - £30,890
- Emitter Upgrade - £156,690

Total: £187,580

F.6 Thames Lido

Estimated Gross Internal Area: 1,100m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £2,430
- Water Sampling - £2,000

Total: £4,430

Option 2 – 30% Increase in Emitters Output (FCU)

- Option 1 Costs - £4,430
- Emitter Upgrade - £13,200

Total: £17,630

F.7 Clearwater Court

Estimated Gross Internal Area: 11,317m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £25,040
- Water Sampling - £2,000

Total: £27,040

Option 2 – 30% Increase in Emitters Output (FCU)

- Option 1 Costs - £27,040
- Emitter Upgrade - £135,810

Total: £162,850

F.8 Premier Inn, Caversham Bridge

Estimated Gross Internal Area: 2,100 m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £4,650
- Water Sampling - £2,000

Total: £6,650

Option 2 – 30% Increase in Emitters Output (Radiators)

- Option 1 Costs - £6,650
- Emitter Upgrade - £55,120

Total: £61,770

F.9 2 Norman Place

Estimated Gross Internal Area: 5,384 m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £11,910
- Water Sampling - £2,000

Total: £13,910

Option 2 – 30% Increase in Emitters Output (FCU)

- Option 1 Costs - £13,910
- Emitter Upgrade - £64,640

Total: £78,550

F.10 Kings Meadow House

Estimated Gross Internal Area: 4,294 m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £9,500
- Water Sampling - £2,000

Total: £11,500

Option 2 – 30% Increase in Emitters Output (FCU)

- Option 1 Costs - £11,500
- Emitter Upgrade - £51,530

Total: £63,030

F.11 Sovereign House

Estimated Gross Internal Area: 3,018 m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £10,670
- Water Sampling - £2,000

Total: £8,670

Option 2 – 30% Increase in Emitters Output (FCU)

- Option 1 Costs - £8,670
- Emitter Upgrade - £36,220

Total: £44,890

F.12 EP Collier Primary School

Estimated Gross Internal Area: 2,857 m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £6,322
- Water Sampling - £2,000

Total: £8,322

Option 2 – 30% Increase in Emitters Output (Radiators)

- Option 1 Costs - £8,322
- Emitter Upgrade - £74,998

Total: £83,320

F.13 Reading Fire Station

Estimated Gross Internal Area: 1,100 m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £2,430
- Water Sampling - £2,000

Total: £4,430

Option 2 – 30% Increase in Emitters Output (Radiators)

- Option 1 Costs - £4,430
- Emitter Upgrade - £28,870

Total: £33,300

F.14 Caversham Bridge House

Estimated Gross Internal Area: 4,791 m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £10,600
- Water Sampling - £2,000

Total: £12,600

Option 2 – 30% Increase in Emitters Output (FCU)

- Option 1 Costs - £12,600
- Emitter Upgrade - £57,500

Total: £70,100

F.15 Toby Carvery Caversham Bridge

Estimated Gross Internal Area: 650 m^2

Option 1 - No upgrades to existing systems

- Re-Balancing of system for lower operating temperatures - £1,340
- Water Sampling - £2,000

Total: £3,340

Option 2 – 30% Increase in Emitters Output (Radiators)

- Option 1 Costs - £3,340
- Emitter Upgrade - £17,160

Total: £20,500

F.16 Puregym Caversham Road

Estimated Gross Internal Area: 1,342 m^2

Option 1

Existing heat emitters are believed to be majority VRF so are unsuitable for recommissioning.

Total: £N/A

Option 2 – Replacement of Existing Emitters (FCU)

- Commissioning and Balancing - £2,970
- Emitter Upgrade - £34,230

Total: £37,200

F.17 Next Steps

The next steps for each potentially connected existing building are outlined as:

1. Arrange and undertake a survey of the existing building heating systems.
2. Obtain or develop a schematic of the building heating circuit such that the required extent and scope of works can be determined.
3. Obtain or develop a heat loss model for the building including refurbishments to determine the required heating.
4. Reduce operating temperatures to that which would be achieved with connection to district heating and monitor internal temperatures throughout a winter period to assess whether the existing system capacity is sufficient.
5. Produce a scoping document to set out the works required and tender to contractors, including water sampling, pump modification, boiler and control adjustments, and the rebalancing of heating circuits.
6. Undertake system rebalancing. This can be carried out prior to connection to district heating network if the current primary plant (i.e. boilers) has the ability to do so. Alternatively, this will be carried out when the district heating network is ready for connection.

Appendix G – Flood Risk

The following high level technical assessment was carried out by AECOMs flood risk specialists for the proposed Energy Centre locations.

River Thames Flood Levels

There are two models of the River Thames in this location;

- Upstream of the Reading Bridge (B3345) is covered by the Thames (Sandford to Mapledurham) model (2018).
- Downstream of the Reading Bridge (B3345) is covered by the Thames (Mapledurham to Sonning) model (2011).

The Environment Agency review and update their flood maps periodically. This is the available data for the study area at the time of writing.

Water levels for the available annual exceedance probability (AEP) events have been extracted from the models for 6 locations (shown in Figure 1 and Table 1).

Table 1 - Water levels (mAOD) at 6 locations across the 3 potential sites (see Figure 12-14)

Model	Location	100yr	100yr Gate Closed	100yr 20%CC	100yr 25%CC	100yr 35%CC	100yr 70%CC	1000yr
2018 Model (Sandford to Mapledurham)	1	38.01	n/a	n/a	38.25	38.31	38.48	38.43
	2	-	n/a	n/a	38.21	38.25	38.42	38.37
	3	-	n/a	n/a	-	-	38.50	38.45
	4	-	n/a	n/a	38.21	38.25	38.42	38.47
2011 Model (Mapledurham to Sonning)	5	-	37.68	37.56	n/a	n/a	n/a	37.82
	6	-	37.95	-	n/a	n/a	n/a	38.05

Values in this table have been rounded to two decimal places.

n/a – scenario not run for the model.

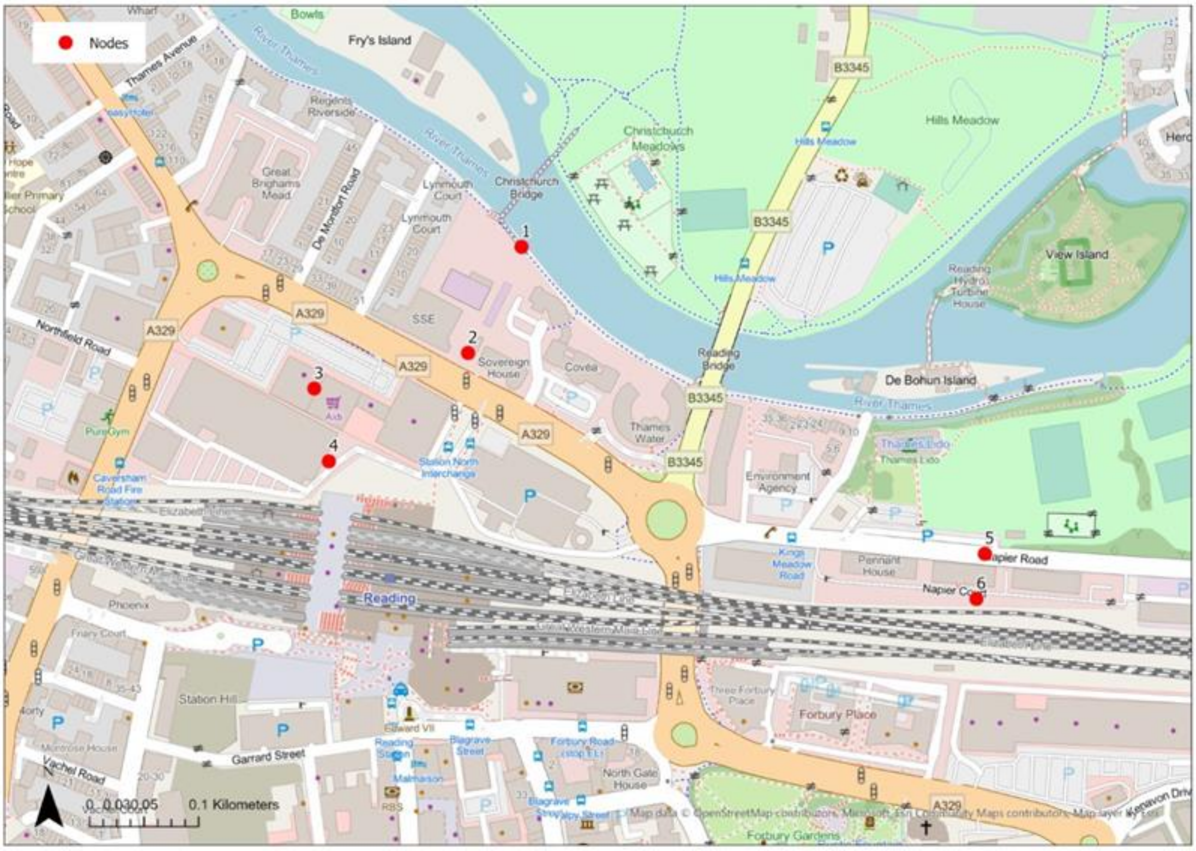


Figure 12-14 - Locations of Interest

Which water levels to use?

We understand the lifetime of the development is a minimum of 40 years, and likely longer (50-60 years).

The latest climate change guidance (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances) shows that the site is within the Thames and South Chilterns Management Catchment. In this management catchment, peak river flow allowances for the 2050s are 14% (central), 22% (higher central) and 42% (upper end). For the 2080s peak river flow allowances are 31% (central), 43% (higher central) and 76% (upper end). The guidance states that for *essential infrastructure* (see definition further below), the higher central allowance should be used (for the 2080s this is 43%).

Within the available modelling studies, an allowance of 70% has been applied to the 100-year event for the 2018 modelling study (points 1-4). The 1000 year is also available for both studies (2011 and 2018). These water levels provide a useful starting point to inform design and indicate a flood level of ~38.5m AOD. Raising sensitive equipment above this level (plus an additional freeboard) will provide protection during the design flood event.

However it is important to note that you will also need to ensure that raising of the equipment results in no loss of floodplain storage or conveyance, which may increase flood risk elsewhere. As a result, raising the *entire* development footprint is unlikely to be a feasible response if the site does not currently have similar building structures present, as this will reduce the volume of storage available in the floodplain and is likely to alter flowpaths.

Other considerations

Here are some other initial thoughts on the development / next steps in terms of flood risk considerations.

Sequential Test

When locating development, the National Planning Policy Framework and Planning Practice Guidance advocate a sequential approach, with sites at lower risk of flooding considered before those at greater risk. Figure 12-15 shows the flood risk from rivers in the area. The Flood Map for Planning presented in Figure 2 shows that the area is within Flood Zone 1, 2 and 3 associated with the River Thames.

- Flood Zone 1 Low Probability: Land having a less than 1 in 1,000 annual probability of river flooding.
- Flood Zone 2 Medium Probability: Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding.
- Flood Zone 3a High Probability: Land having a 1 in 100 or greater annual probability of river flooding.

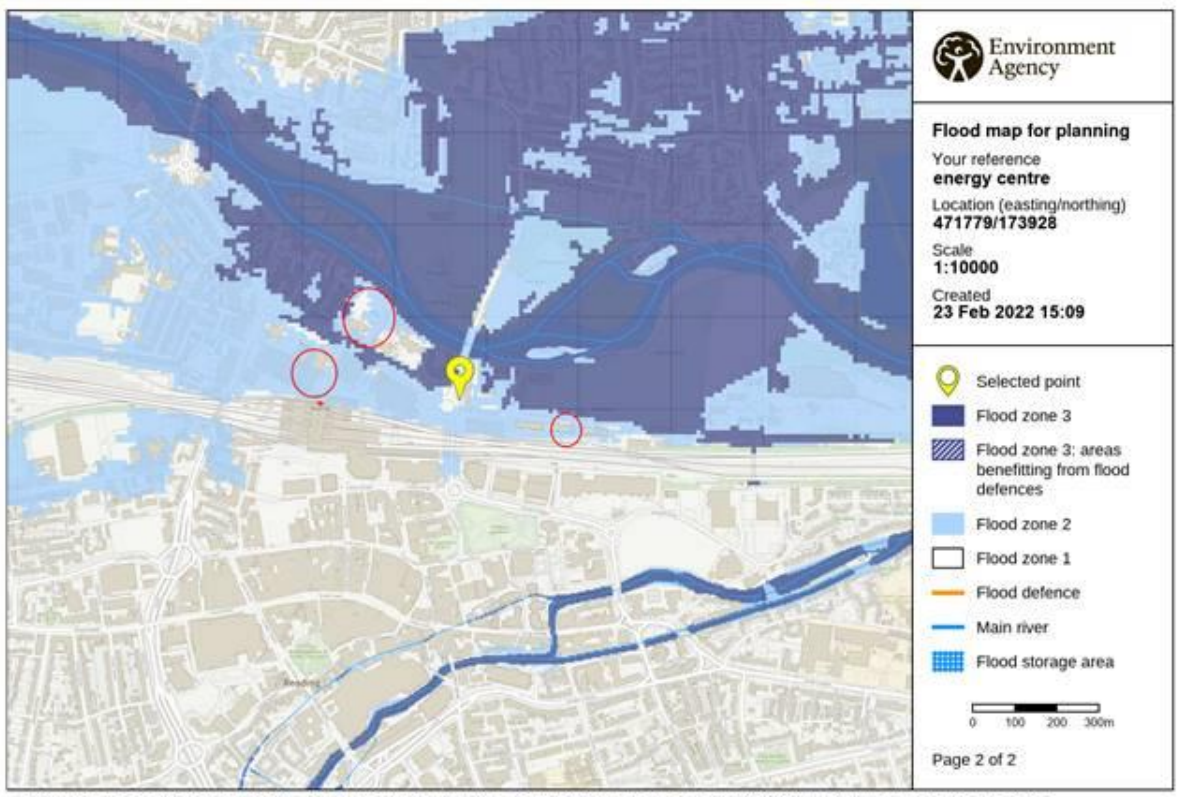


Figure 12-15 - Flood Map for Planning (rivers and sea)

Vulnerability classification

From the initial description we would classify the Energy Centre as “Essential Infrastructure” in PPG Table 2. It is recommended that this classification is confirmed with the LPA and Environment Agency through pre-application enquiry process.

Within the PPG (Flood Risk and Coastal Change) Table 2 the definition for “Essential Infrastructure” includes:

Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood.

Essential Infrastructure is permitted in Flood Zone 2. It is also permitted in Flood Zone 3a subject to the satisfaction of the Exception Test.

Exception Test

To pass the exception test it must be demonstrated that:

(a) the development would provide wider sustainability benefits to the community that outweigh the flood risk; and

(b) the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

Both elements of the exception test should be satisfied for development to be permitted.

Surface water management

New development should ensure that surface water runoff is effectively managed and the rates and volumes of runoff from the site are not increased, and where possible are reduced. SUDS should be implemented on the site as part of the surface water drainage strategy. Figure 12-16 provides an extract from the 'risk of flooding from surface water' mapping available online and shows that the area is susceptible to surface water ponding.

Figure 12-16 - Risk of flooding from surface water (https://www.gov.uk/check-long-term-flood-risk)

Pre-planning application enquiries

It is recommended that the LPA and Environment Agency are consulted early in the planning process to agree vulnerability classification, appropriate mitigation measures and suitable consideration of the impact of the development on the risk of flooding to the surrounding area.

Appendix H – Electrical Grid Demand

H.1 Building Level Demand

Assumptions

Ratio of Starting Power to Output for Air Source Heat Pump: 1 : 2.0

Electrical Power Factor: 0.85

Safety Factor: 10%

Circulation Pump Efficiency: 65%

Primary Pump Circuit Head (m): 0.25

Building / Development	Peak Heat Demand (kW)	ASHP Elec Demand (kW)	Pump Elec Demand (kW)	Total Electrical Demand (kVA)
Aviva Development	2,676	1,338	12	1,589
Former Royal Mail Development	2,020	1,010	9	1,199
Forbury Retail Park Development	1,822	911	8	1,082
Napier Court Development	655	328	3	389
Kodak & Ventello Development	862	431	4	512
Former SSE Development	564	282	3	335
Great Brigham Mead Development	339	170	2	201
Rivermead Leisure Complex	450	225	2	267
Thames Quarter	768	384	3.5	456
Crowne Plaza Hotel	844	422	4	501
Reading Bridge House	341	171	2	202
Thames Lido	177	89	1	105
Clearwater Court	295	148	2	175
Premier Inn, Caversham Bridge	200	100	1	118
2 Norman Place	140	70	1	83
Kings Meadow House	112	56	1	67

Sovereign House	75	38	1	45
EP Collier Primary School	96	48	1	57
Reading Fire Station	72	36	1	43
Caversham Bridge House	57	29	1	34
Toby Carvery Caversham Bridge	37	18	1	22
Puregym Caversham Road	12	6	1	7
			Total	**7,488 kVA**
			Total + Margin	**8,240 kVA**

Table 12-4 - Estimates of Electrical Demand for Individual Sites to Deploy an ASHP Solution

H.2 Assumptions for Energy Centre Demand

Assumptions

Ratio of Starting Power to Output for Water Source Heat Pump: 1 : 2.5

Ratio of Starting Power to Output for Air Source Heat Pump: 1 : 2.0

Electrical Power Factor: 0.85

Safety Factor: 10%

Circulation Pump Efficiency: 65%

Primary Network Pump Circuit Head (m): 0.60

River Abstraction Pump Circuit Head (m): 0.60

Heat Pump Primary Pump Circuit Head (m): 0.15

Ancillary Electrical Loads (W/m^2): 20

Plant Item	Electrical Demand (kW)	Total Electrical Demand (kVA)
Water Source Heat Pump	1,600	1,822
Air Source Heat Pump	0	0
Gas Boiler	6	7
Network Circulation Pump	110	129
River Abstraction Pump	220	259
WSHP Primary Pump	11	13
ASHP Primary Pump	0	0

Ancillary Loads	24	28
	Total	**2,321 kVA**
	Total + Margin	**2,550 kVA**

Table 12-5 - Estimate of Electrical Demand for Gas Boiler Peaking Energy Centre

Plant Item	Electrical Demand (kW)	Total Electrical Demand (kVA)
Water Source Heat Pump	1,600	1,822
Air Source Heat Pump	3,000	3,529
Gas Boiler	0	0
Network Circulation Pump	110	129
River Abstraction Pump	220	259
WSHP Primary Pump	11	13
ASHP Primary Pump	16	19
Ancillary Loads	24	28
	Total	**5,862 kVA**
	Total + Margin	**6,450 kVA**

Table 12-6 - Estimate of Electrical Demand for ASHP Peaking Energy Centre

Appendix I – Valuation of Space Saving

With a connection to district heating, any space that was allocated for use for air source heat pumps can be reallocated for another use. There are many potential alternative uses for this space, such as resident amenity space / roof gardens which could provide value to the development, however in this assessment, it assumed that this space is utilised for locating photovoltaic (PV) panels.

PV panels generate electricity by harnessing light energy and have typically been reported to have a return of investment period of 7-8 years based on historical electricity fuel prices that are offset by this generation.

Section 7.7 provides an assessment of the area of roof space that can be saved through connection to district heating at a range of capacities of air source heat pump. This can be determined across any range, however some specific examples are included below for demonstration.

Peak ASHP Capacity (kW)	Approximate Roof Area Saving (m^2)
200	32
500	48
1000	63
2000	108
3000	140

Table 12-7 - Approximate Roof Area Saving through Connection to District Heating

The estimated cost savings demonstrated in Section 7.7 are based on the assumptions below. These parameters may vary on a case by base basis.

Assumptions

Annual Electrical Generation per m^2 of Roof[51]: 80kWh/year/m^2

Annual Electrical Generation per kWpeak: 890kWh/kWp

Annual Degradation in PV Output: 0.8%

Capital Cost of PV Panels: £900/kWp

Annual Maintenance Cost for PV Panels: 1% of Capital Cost

Replacement Cycle of PV Panels: 25 Years

Safety Factor: 10%

Electricity Fuel Tariff: Real 2020 Electricity Commercial Central Tariff (p/kWh)[52]

Annual Inflation: 3%

S106 Carbon Offset Rate (£/tonneCO_2/year): 60[53]

S106 Offset Payment Terms: 30 Years

S106 Electricity Emission Factor (gCO_2/kWh): 233[54]

[51] https://www.spiritenergy.co.uk/kb-flat-roof-solar-mounting

[52] BEIS Green Book Supplementary Guidance Data Table 4

[53] Reading Sustainable Design and Construction Supplementary Planning Document

[54] SAP 10 Carbon Factors

The results of this analysis are included in Table 12-8.

Peak Demand of Development (kW)	Potential Saving over 40-year Network Lifespan (£)
200	£17,746
500	£26,620
1000	£34,938
2000	£59,894
3000	£77,640

Table 12-8 - Potential Valuation of Roof Space Saving with Connection to District Network

Retail space within a recent development within the study boundary has an anticipated rental value of £157/m^2/annum[55]. The results of this analysis are included in Table 12-9.

Peak Demand of Development (kW)	Potential Annual Rental Value (£)[56]	Value over 40-year Network Lifespan (£)[57]
200	£8,000	£320,000
500	£9,400	£376,000
1000	£15,700	£628,000
2000	£27,500	£1,100,000
3000	£37,500	£1,500,000

Table 12-9 - Potential Valuation of Plantroom Space Saving with Connection to District Network

[55] 1,370 Sq Ft ground floor retail space in Thames Quarter, RG1 8DQ

[56] Assumes the example rate is obtained and no resilient boilers retained on site

[57] Assumes no gap in tenancy

Appendix J – Utility Connections

The following is a budget estimate from Scottish and Southern Electricity Networks (SSEN) at the proposed Energy Centre location. Quotations for two electrical demands were requested, 6.68MW and 9.85MW and a single budget estimate cost was returned for £2.15m.

It is recommended that the futureproofing strategy for the heat network is considered and a formal application obtained to advise the Technoeconomic analysis in the next stage.

Damien McCaul
AECOM
ALDGATE TOWER
2 LEMAN STREET
LONDON
E1 8FA

Connections Design
Scottish and Southern Electricity Networks
Walton Park
Walton Rd
Portsmouth
PO6 1UJ

		Date:	04/01/2022
Our Reference:	*EVQ180 or EVQ181 or EVQ188 or EVQ190*	If telephoning or calling please ask for:	
Your Reference:			*Emmanuel Kima*
		Tel No:	+44 (0) 1206 233193

PROPOSED ELECTRICITY CONNECTION TO: 9.85MW OR 6.68MW LOAD, LOCATION OPTION 3 OR 4, NEW DEVELOPMENT, NAPIER ROAD, READING, RG1 8BW

Dear Damien,

Thank you for your enquiry regarding a budget estimate for a connection with an import/export of 9.86/0MW or 6.68/0MW for a Load scheme into our electricity network. We have carried out a preliminary assessment of the works required to make connection to the distribution network in the area and we are pleased to provide you with our findings along with an estimate of the costs for the option identified. Please note that we have not carried out any detailed design work or network impact analysis. This budget estimate is provided as a result of a preliminary assessment only and possibly without any site-specific considerations being taken into account. You should note that the estimate we provide at this stage may vary considerably from any further budget estimate or the price in any formal connection offer. A budget estimate is not a formal offer for connection and cannot be accepted by you.

Import/Export 9.86/0MW or 6.68/0MW capacity connected at 33kV

The provisional works identified are as follows –

- 33kV Circuit Breaker (CB) connection into READING TOWN;
- 1 km of 33kV single circuit cable route from the Point of Connection (PoC) to the Point of Supply (PoS) at the customer's site;
- 33kV metering circuit breaker (CB) with Glass-Reinforced Plastic (GRP) housing and base;
- Harmonic check required;
- Active Network Management (ANM) Costs for the implementation of the SWAN (South West Active Network) scheme as required by National Grid;
- Tele control and metering;

Please note that this indicative price is based on the information provided, our interpretation of your requirements and current costs. This budget estimate allows for the construction of a suitable DNO substation compound. The proposed substation site will need to be of suitable size on level ground with adequate access for incoming and outgoing circuits and for larger vehicles. This estimate does not include any assessment for diversion requirements. We have not carried out detailed design work or network studies to confirm that the network can accommodate the requested capacity. There is therefore no guarantee that this level of capacity will be available without reinforcement works, which may be substantial. As we have only carried out preliminary off-site investigations, physical, technical and wayleave difficulties may mean that the proposals are not practical. We therefore reserve the right to amend the designs/prices accordingly and as a result they should only be used for budgetary purposes.

Distribution Constraints

Formal assessment required to confirm load capacity at Reading Town and whether connection is compliant with P2/7 security of supply standards.

Budget estimate assumes the cable route from PoC to PoS is readily available. Costs/timescales associated with securing cable route are excluded from budget estimate.

Connection is subject to formal assessment to determine any prohibitive issues concerning voltage, reverse power flow and 33kV and 132kV thermal rating.

Any network assessment carried out as part of a formal connection offer, will take into account these works and you may be required to pay an apportioned part of network investment, which may be a significant cost. Further information can be found on our generation availability heat map: *https://www.ssen.co.uk/GenerationAvailabilityMap/?mapareaid=2*

Transmission Constraints

Any planned transmission works may be subject to change.

There may be a requirement for SSEN to initiate a transmission assessment study or alternatively SSEN may be required to submit to NGET a request for a Statement of Works (should your project be 1 MW or above) for the purposes of identifying any necessary transmission reinforcements if you decide to progress with a formal connection offer. In the event that this is required there may also be a requirement for you to underwrite any required Transmission upgrades.

If determined as part of a formal assessment that a statement of works is needed, the application fee to NGET will be charged to the customer. NGET has 90 days to provide detailed information, including timescales, on the required transmission works. Further information on the Statement of Works process is set out in the CUSC Section 6, Clause 6.5.5. Further information can be found at:
www.nationalgrid.com/uk/Electricity/Codes/systemcode/contracts

Please also be aware that any formal connection offer will be made under our current Connection Charging Methodology Statement. If you do progress with a connection then there may also be charges applied for the use of the distribution network, as set out in our Use of System Charging Statements. Copies of our charging statements can be found on our website at:

Walton Park, Walton Road, Portsmouth, PO6 1UJ ssen.co.uk

Scottish and Southern Electricity Networks is a trading name of: Scottish and Southern Energy Power Distribution Limited Registered in Scotland No. SC213459; Scottish Hydro Electric Transmission plc Registered in Scotland No. SC213461; Scottish Hydro Electric Power Distribution plc Registered in Scotland No. SC213460; (all having their Registered Offices at Inveralmond House 200 Dunkeld Road Perth PH1 3AQ); and Southern Electric Power Distribution plc Registered in England & Wales No. 04094290 having their Registered Office at No. 1 Forbury Place 43 Forbury Road Reading RG1 3JH which are members of the SSE Group
www.ssen.co.uk

The estimated cost for us to provide the Point of Connection to the existing distribution network is likely to be in the order of **£440,000 plus VAT**.

The estimated cost for us to provide the Point of Supply (all works up to DNO metering position) is likely to be in the order of **£1,690,000 plus VAT**.

A minimum of 24 months should be allowed for a PoC and 24 months for a PoS, following acceptance of a formal connection offer, to provide this connection. The completion time from acceptance of a formal offer could be reduced if detailed design work was carried out in advance of issuing the formal offer.

Network studies have not been carried out but it is likely that your generating station will be required to include the capability of operating in voltage control mode with a power factor operating range of **0.95 lead to 0.95 lag** in order to ensure the voltage levels on our network remain within statutory limits.

This connection may be subject to second comer charges.
This connection may trigger network reinforcements once formal detailed studies are carried out. Reinforcements could be due to thermal limitations, fault level issues with inadequate plant ratings or voltage level issues.
All indoor and outdoor connections at substations are subject to there being adequate physical space. Any space limitations may result in extending the building and/or site boundary and/or bus.
Timescales are indicative and subject to change.

https://www.ssen.co.uk/Library/ChargingStatements

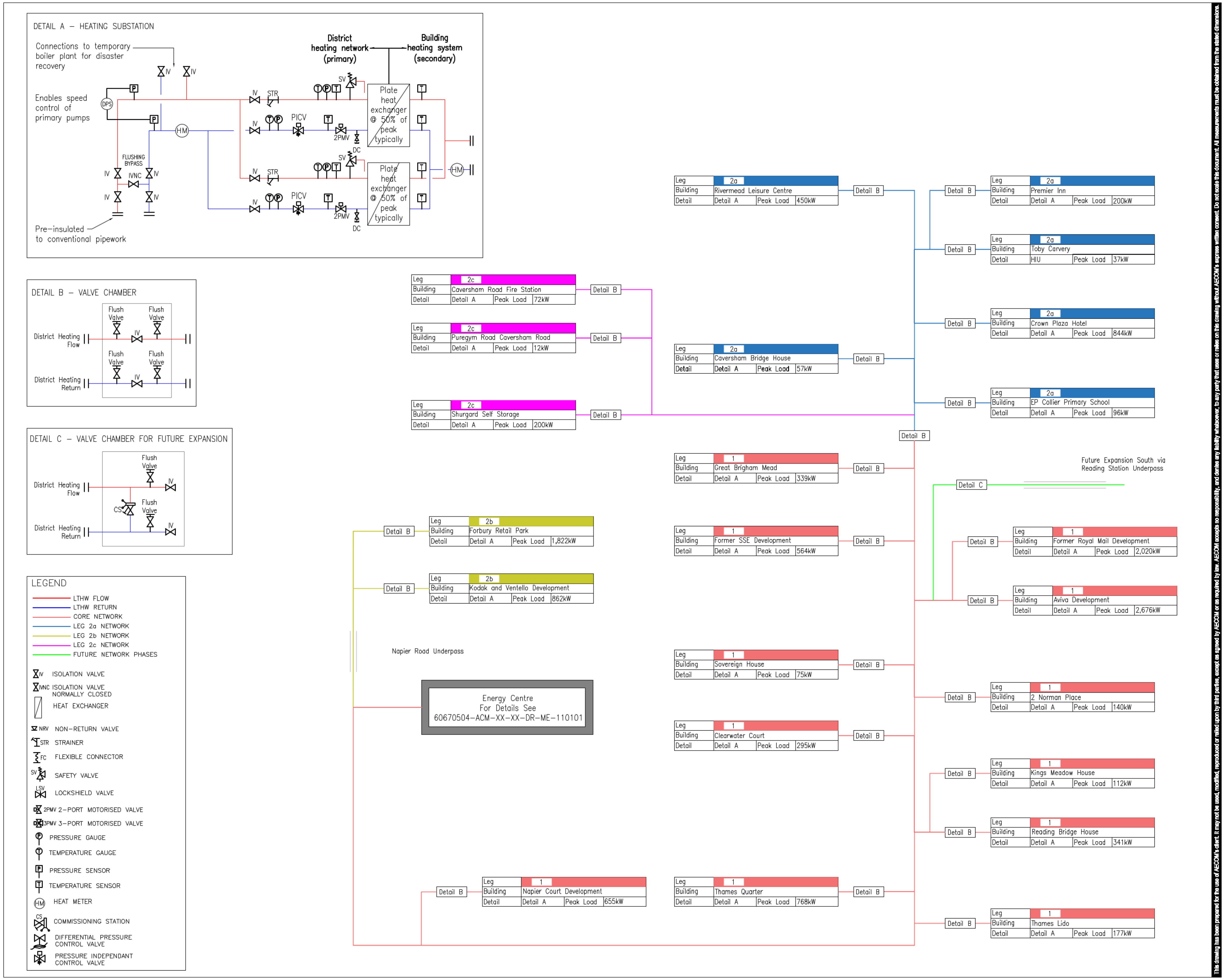
If you would like to progress towards a formal connection offer, please contact Major Connections Contracts (email: MCC@sse.com, Tel: 0345 0724319). We look forward to hearing how you wish to progress with your project.

Yours sincerely,

Emmanuel Kima
Connections Designer

Appendix K – Schematic Drawings

Schematic drawings for the district heating network, and energy centre Scenarios B2 and B9 can be found overleaf.



AECOM

PROJECT

READING DISTRICT ENERGY NETWORK

CLIENT

READING BOROUGH COUNCIL

CONSULTANT

AECOM
Aldgate Tower
2 Leman Street
London E1 8FA
www.aecom.com

GENERAL NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DOCUMENTATION.
2. DO NOT SCALE FROM THIS DRAWING, USE ONLY STATED DIMENSIONS.
3. THIS DRAWING DEMONSTRATES THE PRINCIPLE OF OPERATION FOR THE ENERGY DISTRIBUTION SYSTEMS IN ACCORDANCE WITH CIBSE HEAT NETWORKS: CODE OF PRACTICE FOR THE UK CP1:20 STAGE 2 FEASIBILITY.

ISSUE/REVISION

I/R	DATE	DESCRIPTION
-	-	-
01	27/05/22	Feasibility Stage

PROJECT NUMBER

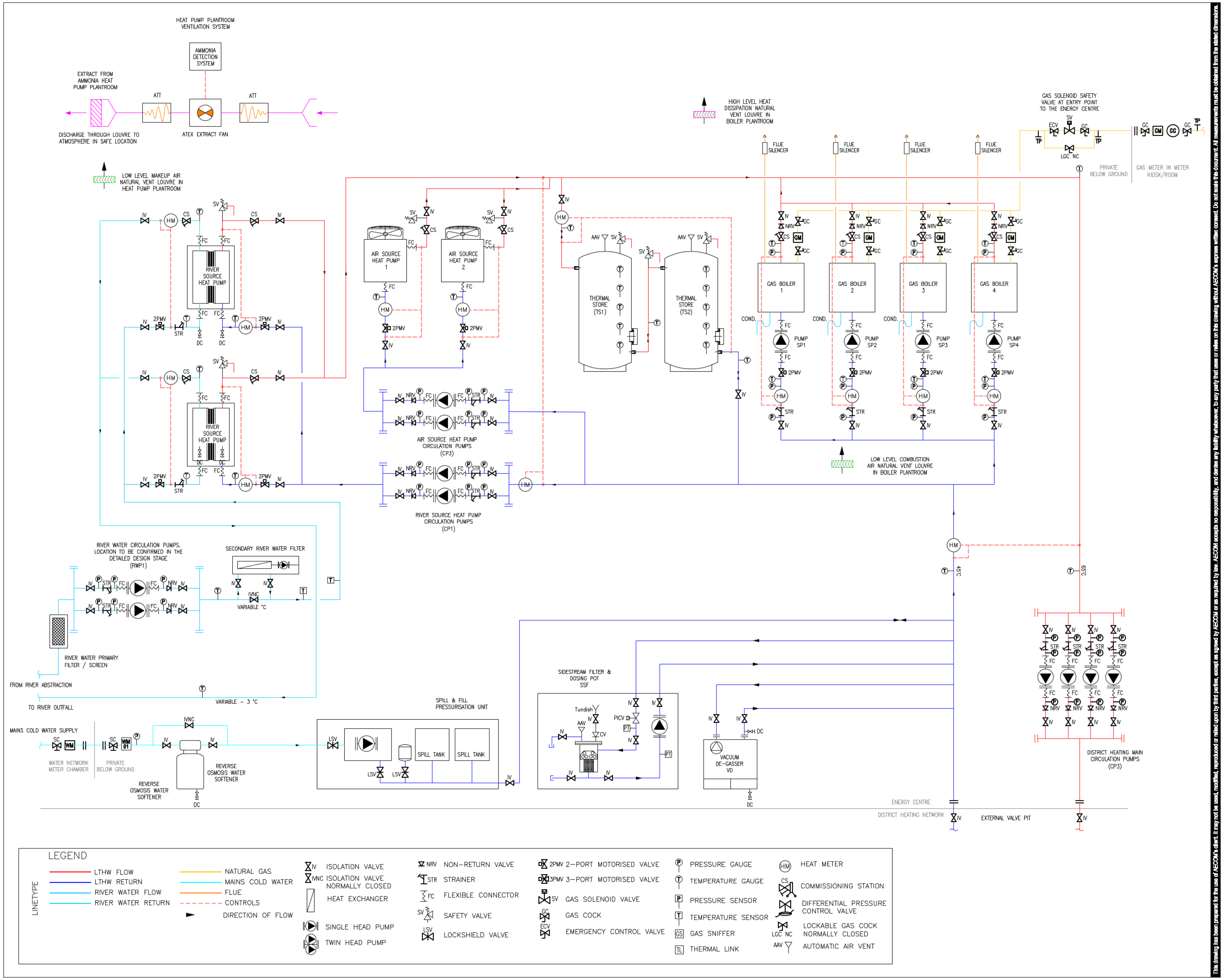
60670504

SHEET TITLE

Reading District Energy Network
District Heating Network Schematic

SHEET NUMBER

60670504-ACM-00-00-DR-ME-110101



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ISSUE/REVISION

I/R	DATE	DESCRIPTION
-	-	-
01	27/05/22	Feasibility Stage

PROJECT NUMBER

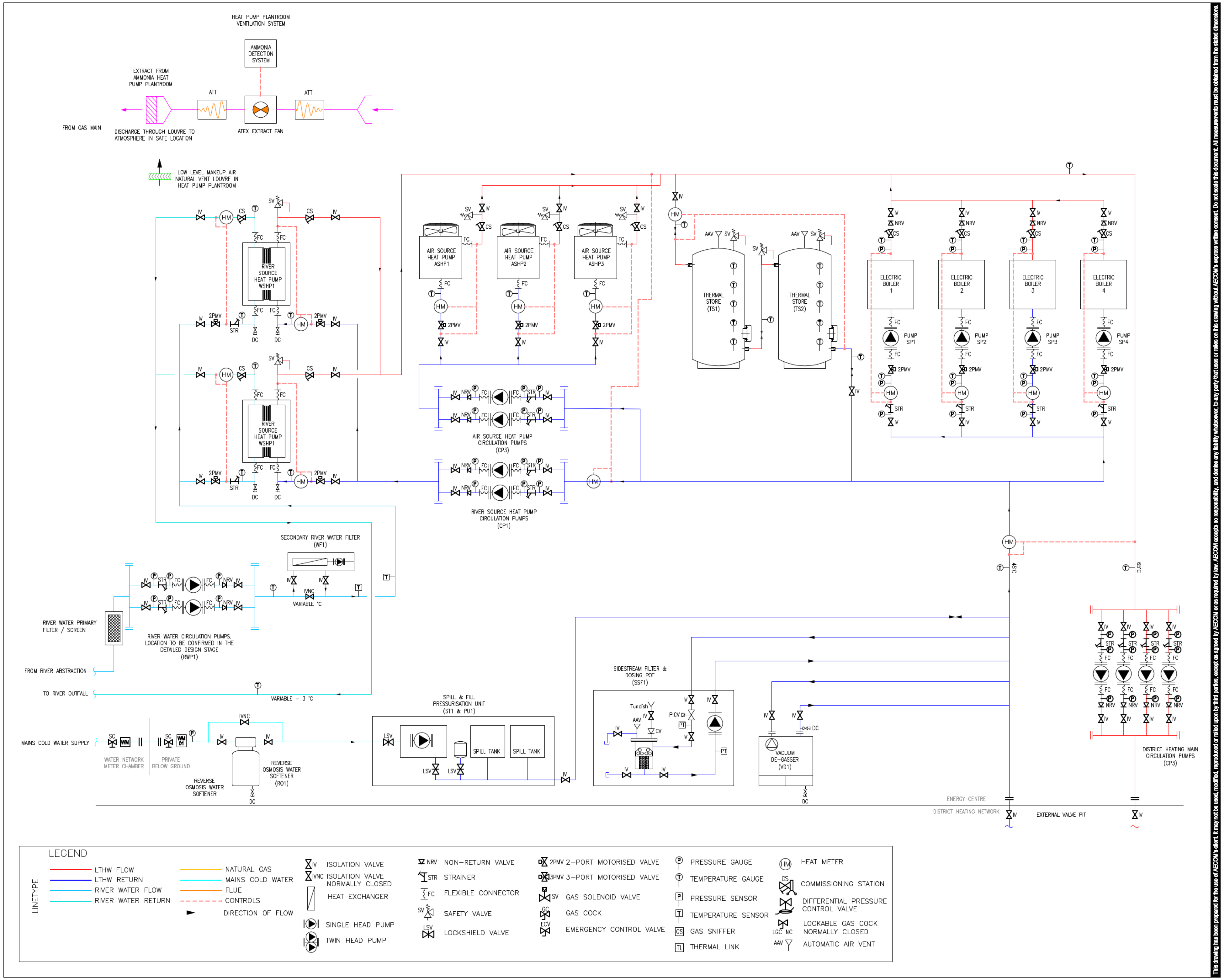
60670504

SHEET TITLE

Reading District Energy Network
Scenario B2
Energy Centre Schematic

SHEET NUMBER

60670504-ACM-XX-XX-DR-ME-110101



AECOM

PROJECT

READING DISTRICT ENERGY NETWORK

CLIENT

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GENERAL NOTES

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ISSUE/REVISION

-	-	-
01	27/05/22	Feasibility Stage
I/R	DATE	DESCRIPTION

PROJECT NUMBER

60670504

SHEET TITLE

Reading District Energy Network
Scenario B9
Energy Centre Schematic

SHEET NUMBER

60670504-ACM-XX-XX-DR-ME-110102

Appendix L – CIBSE CP1 (2020) Compliance

This report contains evidence of compliance with the applicable objectives of the CIBSE CP1: Heat Networks: Code of Practice for the UK (2020), as demonstrated in Table 12-10 below. A complete CP1 checklist is also provided as an appendix to this report, and should be read with the RBC CP1 Statement of Applicability (SoA).

Objective	Within SoA?	Location of Evidence
2.1a	Yes	Section 2 of this report
2.1b	Yes	Section 2 of this report
2.1c	Yes	Section 2 of this report and Heat Mapping report
2.1d	Yes	Appendix A of this report
2.2a	Yes	Section 4 of this report
2.2b	Yes	AECOM Technoeconomic Model
2.2c	Yes	Section 4 of this report
2.2d	Yes	Section 5 of this report
2.3a	Yes	Section 4.2 of this report
2.3b	No	Not required but principles are demonstrated on schematic drawings
2.4a	Yes	Section 6.2 of this report
2.4b	No	Not required
2.5a	Yes	Section 6 of this report
2.5b	Yes	AECOM Technoeconomic Model
2.5c	Yes	Section 9 of this report and AECOM Technoeconomic Model
2.6a	Yes	Section 6 of this report
2.6b	Yes	Section 6 of this report
2.7a	Indicative	Section 8.2 of this report
2.7b	Yes	Section 9 of this report
2.8a	Yes	AECOM Technoeconomic Model
2.8b	Yes	Demonstrated on general arrangement drawings
2.9a	Yes	Section 9 of this report and AECOM Technoeconomic Model
2.9b	Yes	Section 9 of this report and AECOM Technoeconomic Model
2.9c	Yes	Section 9 of this report and AECOM Technoeconomic Model

2.10a	Yes	Risk Register_Rev02_Feas
2.10b	Yes	Section 9 of this report
2.11a	Yes	Section 9 of this report
2.11b	Yes	Section 9 of this report
2.11c	Yes	Calculations and dispersion model not completed however flue discharge included in energy centre general arrangement
2.12a	Yes	This report
2.12b	No	Not required
2.12c	No	Not required
2.12d	Yes	Risk Register_Rev02_Feas
2.13a	Yes	Hermetica Black report
2.13b	Yes	Engagement with RBC Procurement Department

Table 12-10 - CIBSE CP1 Objectives and Compliance

Appendix M – Direct and Indirect Connections

With a direct connection, there is no hydraulic separation between the district heating network pipework and pipework on site that is owned and operated by the customer or landlord. With an indirect connection, separation is provided through a plate heat exchanger, in a thermal substation or heat interface unit (HIU).

The advantages of direct connections include:

- No approach temperature loss across the heat exchanger, meaning the network could potentially operate at a lower temperature;
- Omits the cost and space requirements of HIU heat exchangers and thermal substations;
- Requires fewer components, such as secondary circulation pumps, secondary pressurisation and water treatment systems and the associated controls and power; and
- Reduced maintenance cost given the reduction in components.

The advantages of indirect connections include:

- HIUs and thermal substations provide a clear ownership and responsibility demarcation point;
- There is no mixing of system water, reducing the potential for disputes over water quality contamination;
- The potential damage caused by a leak within a building is reduced, given the volume of water in the system is limited.
- Avoids the requirement for components within a building, such as radiators, to be suitably rated for the pressures of a district network; and
- Avoids the network needed to operate at a static pressure required to serve the worst case / tallest connected building.
- Allows for the network ownership to be distinct from secondary and tertiary operation. This allows for more commercial flexibility in the management of the network.

When connecting to existing buildings, it is typical that the existing heating system will (at least in part) be retained. These systems can often be of a considerable age, contain some corrosion and potentially poor water quality control. Permitting mixing of water between such a system and a new district network could result in significant damage to plant and network, significantly reducing the lifespan and incurring capital costs. A network operator may be unwilling to accept this risk. For this reason, it is assumed that all connections to existing buildings will be indirect.

For new developments, provided the network operator is engaged with the design of the on-site network, the issues over water and network quality may be of less concern and so a single thermal substation may not be required. The hydraulic separation between a network and the systems within individual residential and commercial units that is provided by a HIU retains benefits over a direct connection to these systems. The decision as to whether the network provides a point of separation at a thermal substation, or at HIUs within each individual unit is subject to engagement between the network operator and the council. For this assessment, it is assumed that all connection to new developments will be indirect at a single point in a thermal substation.

Appendix N – Impact on Electrical Grid Demand

In the counterfactual decarbonisation scenario, where existing buildings and new developments employ on-site low carbon heat generation plant, assumed to be air source heat pumps (ASHP), the electrical supply to these sites would need to be sized to power these heat pumps. For existing buildings where these heat pumps would replace gas fuelled plant, it is highly likely that the existing electrical supply would need to be upgraded to handle this increase in demand. However, even if the existing supply had sufficient spare capacity to avoid this, the increase in demand would still be placed on the electrical grid.

Heat pumps serving an individual site or building need to be sized to provide 100% of the peak demand for that site, whereas heat pumps in a district heating network can avail of the natural diversity that occurs when serving multiple buildings.

It is estimated that the total additional grid demand for counterfactual ASHP solution would be approximately 8,240kVA. For a district heating network which matches[58] the carbon intensity of the counterfactual ASHP solution, this demand would be approximately 2,550kVA.

For a fully electrified heating network, which uses ASHP as peaking plant in lieu of gas boilers, the electrical demand would be approximately 6,450kVA. In this scenario, the electrical demand at the energy centre is significantly increases, however remains circa. 20% lower than counterfactual ASHP solution with higher carbon savings.

An additional benefit that is not quantifiable with the above figures is that the reinforcement works required to provide the electrical supply to the energy centre is required to a single point only, whereas there could be an area wide requirement to provide upgraded supplies to each individual site, potentially causing more widespread, significant and costly disruptions.

[58] 50gCO_2e/kWh in 2025 was the agreed target to match the ASHP counterfactual

Appendix O – Outline Plant Schedules

Table 12-11 contains an outline major mechanical plant schedule for Scenario B2.

Ref.	Equipment Type	Equipment Selection	Duty / Capacity
B1 – 4	Condensing Gas Boilers	4 x Hoval UltraGas 2300D	2,200kW @ 65°CF 40°CR
WSHP1 - 2	River Source Heat Pumps	2 x GEA Bespoke Ammonia Heat Pump	1,050kW @ Prim: 6°CF 3°CR Sec: 65°CF 40°CR
ASHP1 - 2	Air Source Heat Pumps	2 x Solid Energy R290 AW252SP	1,300kW @ -3°OA Sec: 65°CF 40°CR
SP1 - 4	Boiler Shunt Pumps	4 x Grundfos TP 80-240/2 A-F-A-BQQE-LX1	21l/s @ 150kPa
CP1	Water Source Heat Pump Secondary Pumpset	2 x Grundfos TPE 65-210/2 S-A-F-A-BQQE-JDB	20l/s @ 200kPa
CP2	Air Source Heat Pump Secondary Pumpset	2 x Grundfos TPE 65-250/2 S-A-F-A-BQQE-KDB	25l/s @ 200kPa
CP3	District Heating Main Circulation Pumpset	4 x Grundfos CR 95-3 A-F-A-V-HQQV	107l/s @ 600kPa
RWP1	River Water Abstraction Pumpset	2 x Etabloc ETB 125-100-200 Variable Speed	165 l/s @ 400kPa, turndown to 63l/s @ 250kPa
WF1	River Water Abstraction Filter	Amiad Water Systems Omega 18k	165l/s @ 100μ
TS1 - 2	LTHW Thermal Store	2 x Hartwell Stainless Steel Vertical	135m^3
PU1	Spill & Fill Pressurisation Unit	KGN Pillinger FSA-1-60 /2PV312	Initial Pressure 4.7 Bar (gauge). Max Pressure 5.4 Bar (gauge)
ST1	Stainless Steel Pressurisation Spill Tank	KGN Pillinger Bespoke	8m^3 +8m^3 nominal
VD1	Vacuum Degasser	Spirotech HA150F	2.5 - 6.0 Bar @ 200m^3 System Water Content
SSF1	Sidestream Filter, Dosing Pot & Air Vent	Hydro X - HXE side-stream Filter (DN40)	Full System Water Content in 24 Hours
RO1	Reverse Osmosis System	Hydro X - HXE Reverse Osmosis System for Top-Up	5% of system volume per year
WQM1	Water Quality Monitoring System	HXE Hydro-Net monitoring controller	-
GSV1	Emergency Gas Isolation Solenoid Valve	Banico ZEVF150	9000kW 0.23m3/s
BF1	Gas Boiler Flue	4 x Ø500 Boiler Flues	

EF1	Ammonia Plantroom ATEX Extract Fan	Elta Fans Revolution	

Table 12-11- Outline Major Mechanical Plant Schedule for Scenario B2

Table 12-12 contains an outline major mechanical plant schedule for Scenario B9.

Ref.	Equipment Type	Equipment Selection	Duty / Capacity
B1 – 4	Electric Boilers	4 x Lochinvar BWN36-2059F	2,059kW @ 65°CF 40°CR
WSHP1 - 2	River Source Heat Pumps	2 x GEA Bespoke Ammonia Heat Pump	1,050kW @ Prim: 6°CF 3°CR Sec: 65°CF 40°CR
ASHP1 - 3	Air Source Heat Pumps	3 x Solid Energy R290 AW202SP	1,075kW @ -3°OA Sec: 65°CF 40°CR
SP1 - 4	Boiler Shunt Pumps	4 x Grundfos TP 80-240/2 A-F-A-BQQE-LX1	20l/s @ 150kPa
CP1	Water Source Heat Pump Secondary Pumpset	2 x Grundfos TPE 65-210/2 S-A-F-A-BQQE-JDB	20l/s @ 200kPa
CP2	Air Source Heat Pump Secondary Pumpset	2 x Grundfos TPE 65-250/2 S-A-F-A-BQQE-KDB	31l/s @ 200kPa
CP3	District Heating Main Circulation Pumpset	4 x Grundfos CR 95-3 A-F-A-V-HQQV	107l/s @ 600kPa
RWP1	River Water Abstraction Pumpset	2 x Etabloc ETB 125-100-200 Variable Speed	165 l/s @ 400kPa, turndown to 63l/s @ 250kPa
WF1	River Water Abstraction Filter	Amiad Water Systems Omega 18k	165l/s @ 100µ
TS1 - 2	LTHW Thermal Store	2 x Hartwell Stainless Steel Vertical	135m^3
PU1	Spill & Fill Pressurisation Unit	KGN Pillinger FSA-1-60 /2PV312	Initial Pressure 4.7 Bar (gauge). Max Pressure 5.4 Bar (gauge)
ST1	Stainless Steel Pressurisation Spill Tank	KGN Pillinger Bespoke	8m^3 +8m^3 nominal
VD1	Vacuum Degasser	Spirotech HA150F	2.5 - 6.0 Bar @ 200m^3 System Water Content
SSF1	Sidestream Filter, Dosing Pot & Air Vent	Hydro X - HXE side-stream Filter (DN40)	Full System Water Content in 24 Hours
RO1	Reverse Osmosis System	Hydro X - HXE Reverse Osmosis System for Top-Up	5% of system volume per year
WQM1	Water Quality Monitoring System	HXE Hydro-Net monitoring controller	-

EF1	Ammonia Plantroom ATEX Extract Fan	Elta Fans Revolution

Table 12-12 - Outline Major Mechanical Plant Schedule for Scenario B9

Appendix P – Performance Against GHNF Gated Metric

This study has considered compliance with the Green Heat Network Fund (GHNF) in anticipation of an application for funding in later project stages. The GHNF offers financial support for commercialisation and construction costs for heat networks that meet the core gated metrics of the scheme, included in Table 12-13 and Table 12-14 below.

Metric	Minimum Score by GHNF	Scenario B2 Performance
Carbon Gate	100gCO2e/kWh thermal energy delivered to consumers using GHNF fuel carbon intensity	83gCO2e/kWh[59] (note: differs from the 50g target earlier due to carbon factors used in line with GHNF)
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	Compliant. See 8.1.
Social IRR	Projects must demonstrate a Social IRR of 3.5% or greater over a 40-year period	6.20%
Minimum Demand	For urban networks, a minimum end customer demand of 2GWh/year. For rural (off-gas-grid) networks, a minimum number of 100 dwellings connected	19.5GWh/year
Maximum Capex	Grant award requested up to but not including 50% of the combined total commercialisation + construction costs (with an upper limit of £1million for commercialisation)	Up to but not including £9.5million
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 (this figure will remain under review)	Up to £13.16million

Table 12-13 - Scenario B2 Performance against GHNF Core Gated Metrics

[59] Carbon intensity of heat using GHNF carbon factors. Differs from SAP and Green Book factors used to determine the 50g/kWh target earlier

Metric	Minimum Score by GHNF	Scenario B2 Performance
Carbon Gate	100gCO2e/kWh thermal energy delivered to consumers using GHNF fuel carbon intensity	83gCO2e/kWh (note: differs from the 50g target earlier due to carbon factors used in line with GHNF)
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	Compliant. See 8.1.
Social IRR	Projects must demonstrate a Social IRR of 3.5% or greater over a 40-year period	5.68%
Minimum Demand	For urban networks, a minimum end customer demand of 2GWh/year. For rural (off-gas-grid) networks, a minimum number of 100 dwellings connected	19.5GWh/year
Maximum Capex	Grant award requested up to but not including 50% of the combined total commercialisation + construction costs (with an upper limit of £1million for commercialisation)	Up to but not including £9.8million
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 (this figure will remain under review)	Up to £13.16million

Table 12-14 - Scenario B9 Performance against GHNF Core Gated Metrics

Appendix Q Soft market testing information pack

Reading District Heating Feasibility Study: Soft market testing

AECOM and HermeticaBlack

Contents

- Background
- Local planning context
- Network description
- Maps x 2
- Technical description
- Soft market testing

Background

- A HNDU Heat Mapping and Master planning study for Reading was previously carried out. This identifed a number of opportunities.
- A HNDU Feasibility study was carried out by AECOM in 2021/2022 which focused on one area – North of the Station.
- The Feasibility study has identified a technically and financially viable heat network.
- Reading Borough Council (RBC) wish to undertake some initial soft market testing related to the development of a potential heat network.

Local Planning Context

District heating is a key element of Reading Bourgh local plan (Adopted November 2019). Extract of Local Plan Policy CC4 below:

> "Any development of more than 20 dwellings and/ or non-residential development of over 1,000 sq m shall consider the inclusion of decentralised energy provision, within the site, unless it can be demonstrated that the scheme is not suitable, feasible or viable for this form of energy provision.
>
> Where there is existing decentralised energy provision present within the vicinity of an application site, further developments of 10 dwellings or more or non-residential development of 1,000 sq m or more will be expected to link into the existing decentralised energy network or demonstrate why this is not feasible."

Network Description

- Water Source heat pump supplied by River Thames with ASHP for times when the river is too cold to achieve 50gCO2e/kWh carbon intensity.
- Proposed initial Energy Centre location adjacent to carpark in local park owned by RBC. Current design has ability to expand to meet new loads.
- Proposed network of 14 connections (all private sector)
  - 7 new build developments – 79% of demand
  - 7 existing buildings – 21% of demand

Proposed Core Heat Network

HERMETICABLACK

Project Management Initials: Designer: LJM Checked: AK Approved: CK ISO A1 594mm x 841mm

Last saved by: DAMIEN.MCCAUL(2022-07-26) Last Plotted: 2022-09-20
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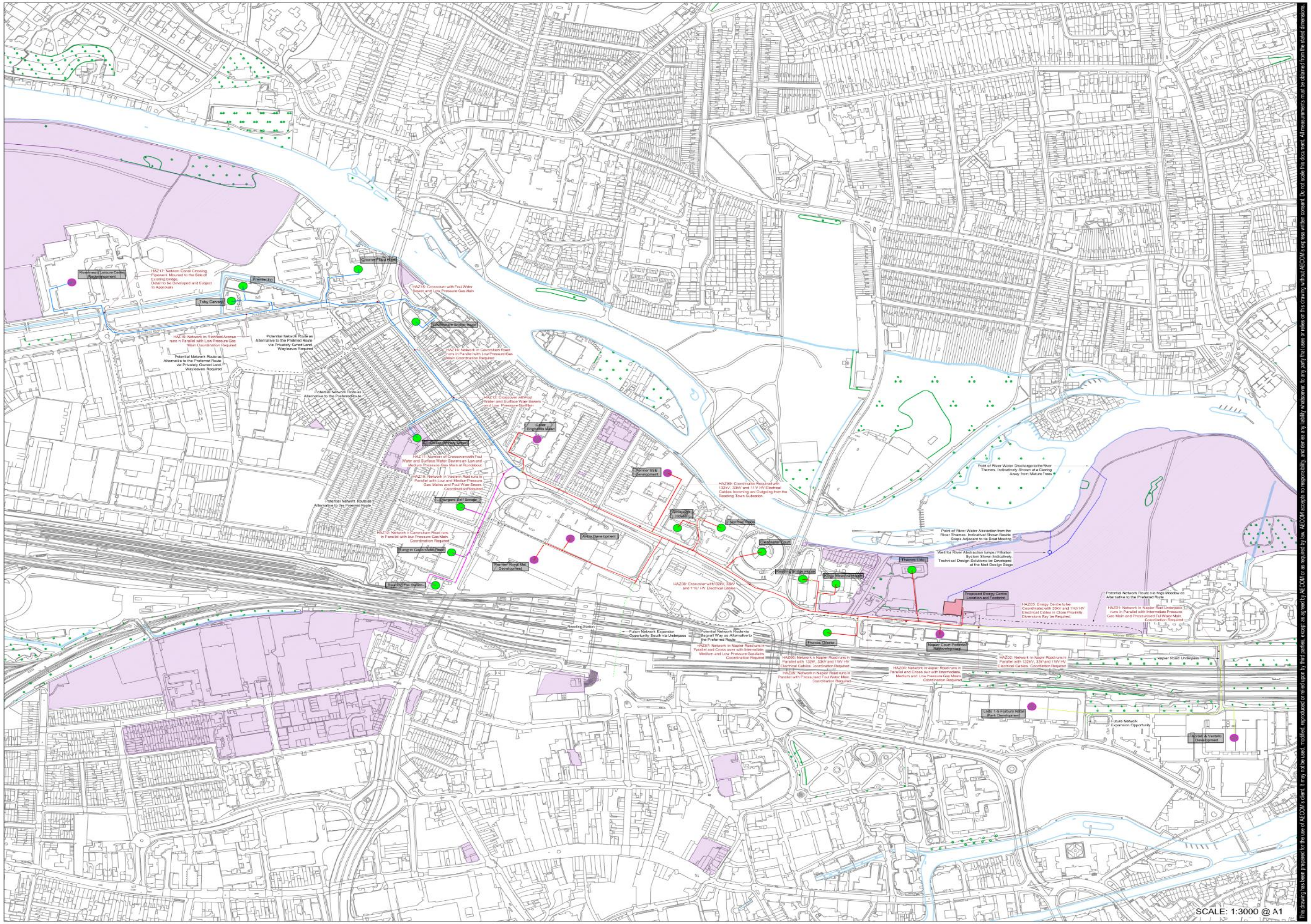

AECOM

PROJECT

READING DISTRICT ENERGY NETWORK

CLIENT

READING BOROUGH COUNCIL

CONSULTANT

AECOM
Aldgate Tower
2 Leman Street
London E1 8FA
www.aecom.com

KEY PLAN

- RIVERWATER ABSTRACTION PIPEWORK
- DHN PIPEWORK CORE NETWORK
- DHN PIPEWORK LEG 2A
- DHN PIPEWORK LEG 2B
- DHN PIPEWORK LEG 2C
- DHN FUTURE EXPANSION OPPORTUNITY
- DHN Pipework Alternative to Preferred Routes
- Heating Substation in Existing Building
- Heating Substation in New Development
- Energy Centre
- Valve Pit
- Council Owned Land
- HAZ** HAZARD IDENTIFIED ON NETWORK ROUTE

GENERAL NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT DOCUMENTATION.
2. DO NOT SCALE FROM THIS DRAWING, USE ONLY STATED DIMENSIONS.
3. BELOW GROUND SERVICES SHALL BE LAID AND COORDINATED IN ACCORDANCE WITH NJUG GUIDELINES ON THE POSITIONING AND COLOUR CODING OF UNDERGROUND UTILITIES.
4. MAJOR POINTS OF COORDINATION WITH UTILITIES HAVE BEEN IDENTIFIED AND SHOULD BE MITIGATED IN FUTURE DESIGN STAGES.

ISSUE/REVISION

I/R	DATE	DESCRIPTION
2	26/07/22	Alternative Route Options Added
1	20/05/22	Feasibility Stage

PROJECT NUMBER

60635692

SHEET TITLE

Reading District Energy Network
Network General Arrangement

SHEET NUMBER

60670504-ACM-00-00-DR-ME-210003

m.com

Technical description

- Diversified peak demand 9.2MW
- Preferred heat supply:
  - River Source Heat Pump – 2.1MW
  - Air Source Heap Pump as secondary LZC technology – 3.2MW
  - Peaking and Resilient technology – Electrode boilers 7.9MW
  - 270m3 thermal storage
- Carbon intensity of 12.4gCO2e/kWh (average over 40-years. Day 1 carbon intensity matches ASHP counterfactual and is compliant with GHNF)
- Annual Heat Sales 19,476MWh at full build out
  - Potential for further expansion of additional 40,500MWH/year
- AECOM estimated project capital cost £19.6m (estimated early 2022)
- AECOM technoeconomic model estimated IRR range of 1-3.5% without grant funding over 40 year period.
- Potential to achieve IRR of up to 13% with grant funding.

Note: IRR is pre-tax, pre-finance.

Soft Market testing

RBC is looking for feedback on the following:

- What is your organisation's interest in the scheme?
- Are there any elements of the scheme as presented which would reduce/limit your interest in the scheme?
- Are there any elements of the scheme as presented which would impact your ability to deliver the scheme (including funding, technical and commercial delivery)?
- What role would you like to see RBC play in the future development of this network opportunity?
- What changes or actions you would like to see to increase interest in the scheme?
- What characteristics of your organisation/approach would support the successful delivery of this scheme as a driver of decarbonisation in Reading?

Appendix R **Heat Network Commercial Introduction**

HEAT NETWORK COMMERCIAL INTRODUCTION

READING COUNCIL

ISSUED AS APPENDIX

MAY 2023

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CONTENTS

COMPONENTS

DISTRICT HEAT NETWORK COMMERCIAL COMPONENTS

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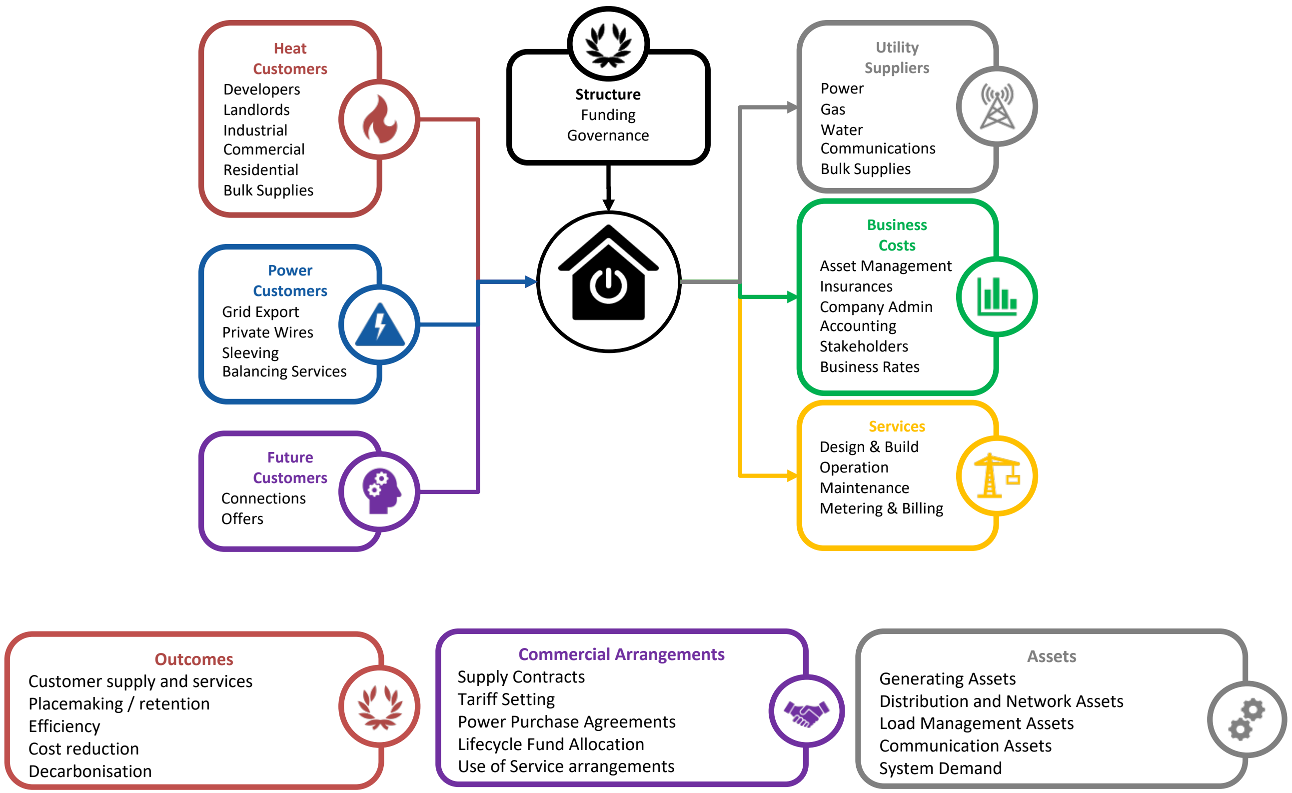
A district heat network (DHN) needs a range of *commercial agreements* to govern funding, design, build, operation and maintenance of *physical assets*, and meet obligations of *customer supply agreements* for low carbon energy.



KEY OPERATIONAL RISKS IN DISTRICT HEAT NETWORKS

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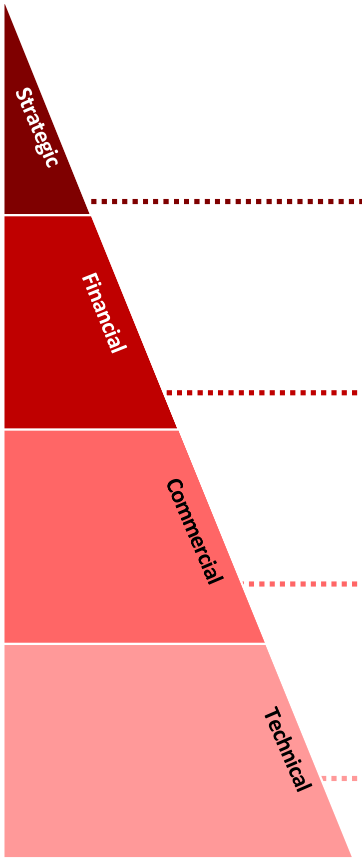
A DHN is effectively a business, with risks of strategic and financial failure. These risks result from failure to manage key commercial and technical delivery risks. Different commercial structures allow for different options to transfer these risks, but there are fundamental mitigations which apply to all.



KEY OPERATION RISKS	KEY MITIGATIONS (ALL STRUCTURES)
• Project fails to deliver strategic goals • Project unable to adapt to changing strategic goals	• Shareholding arrangements • Contractual arrangements support strategic goals, and change of strategy
• Revenue and/or Costs outside of budget	• Robust Asset Management • Control of tariffs, and ability to reflect changes in underlying costs • Robust debt management (including PrePay options) • Appropriate recourse to contractors (KPIs) • Appropriate budgeting (revenues and costs) • Control of Lifecycle Fund
• Failure to deliver heat / power / cooling per the terms of supply agreements • Failure of supply chain	• Supply agreements follow market best practice • Back-to-back KPIs with contractors (e.g. customer response times) • Choice of Tier 1 supply chain, bankable covenant strength / PCGs • Appropriate points of connection (e.g. bulk supply to building vs supply to individual residents)
• Statutory Requirements • Failure of plant or network • Drop in efficiency	• Design to best practice (e.g. CP1 2020) • Redundancy in generation capacity / onsite critical spares • Leak detection systems • Performance monitoring (hardware and process) • Key KPI regimes for Operators and Metering/Billing providers • Rigorous handover/acceptance process

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VALUE REALISATION

KEY POINTS OF VALUE REALISATION

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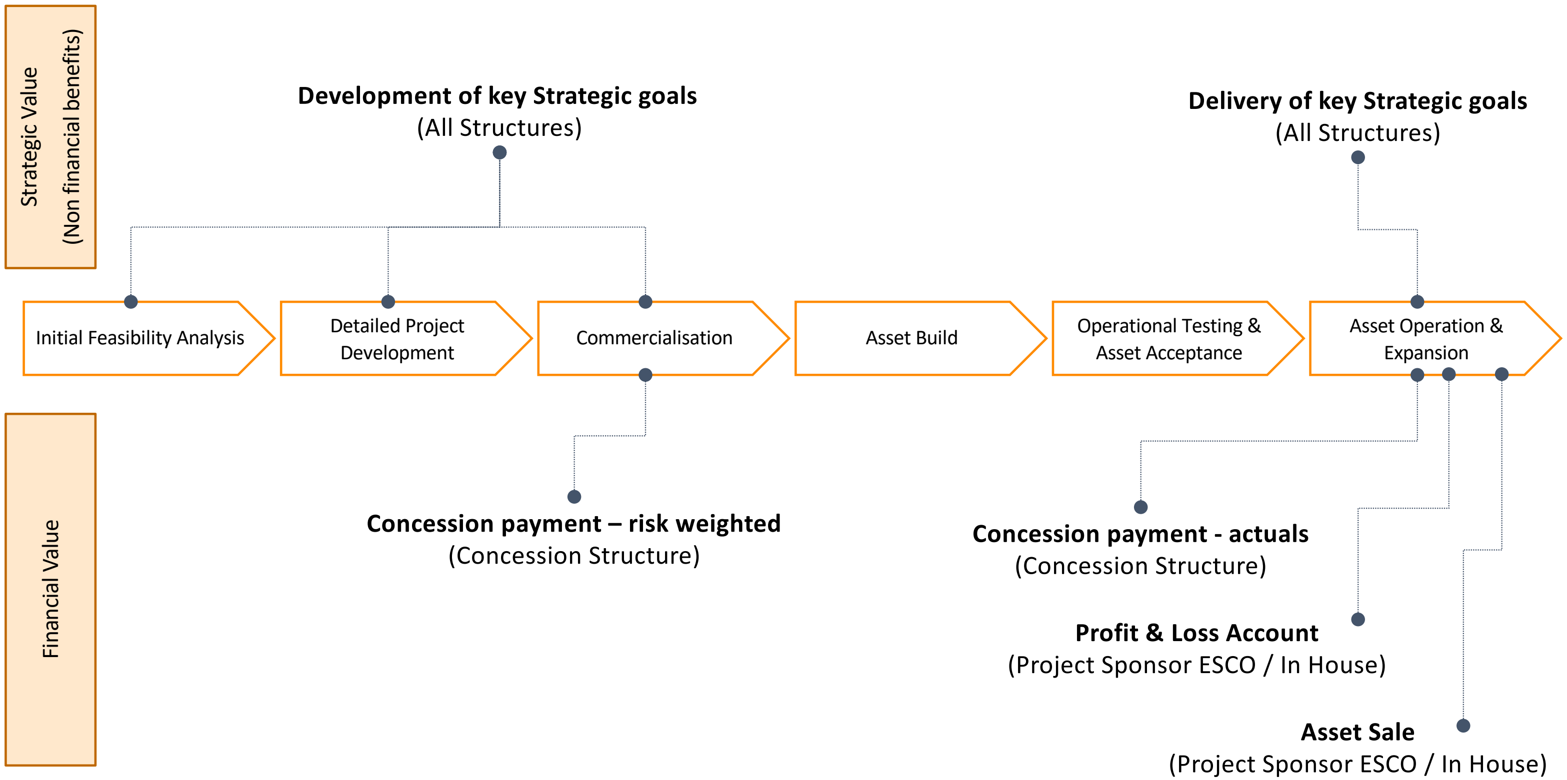
Developing a DHN is a long process, with multiple iterations and potential points of failure. This creates three main outcomes of failure: *abortive costs, failure to deliver project outcomes* and *failure to realise financial value*



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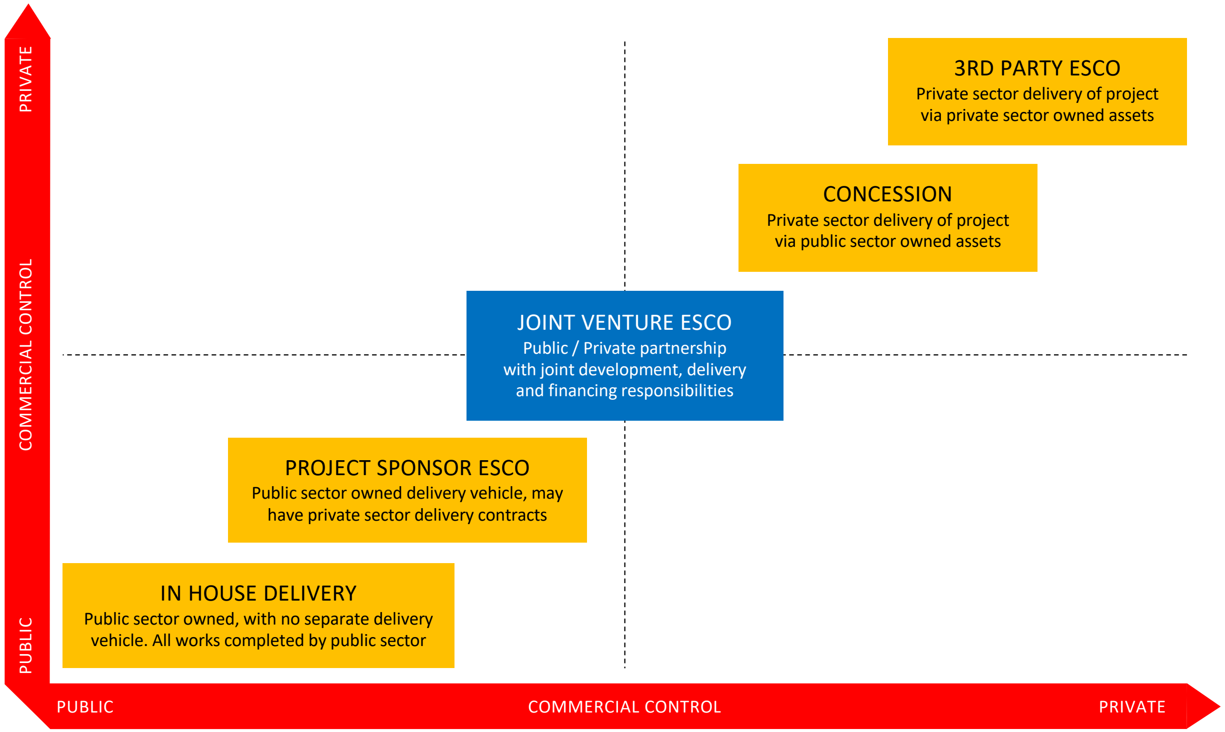
DELIVERY STRUCTURES

DELIVERY STRUCTURE OPTIONS

There are a wide range of commercial structures available, all of which are capable of producing a technically functioning system. The different structures allow different degrees of commercial control and risk.



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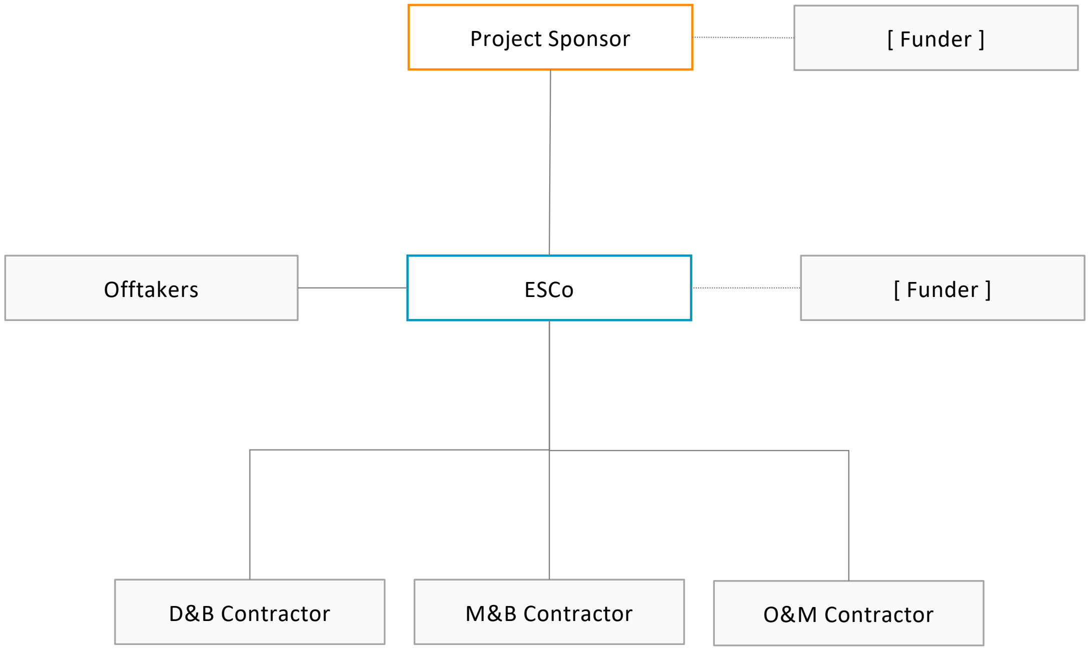
What to consider?

- Multiple commercial, and contractual structures available
- Can be utilised on individual projects or across multiple project typologies
- Different project typologies can mean different solutions fit best
- Utilising input from existing ESCos, ESCo operators and the supply chain
- Timing of input from ESCo or ESCo operators / supply chain is critical
- ESCo operators have the ability to input throughout the development process

GENERAL STRUCTURE OVERVIEW



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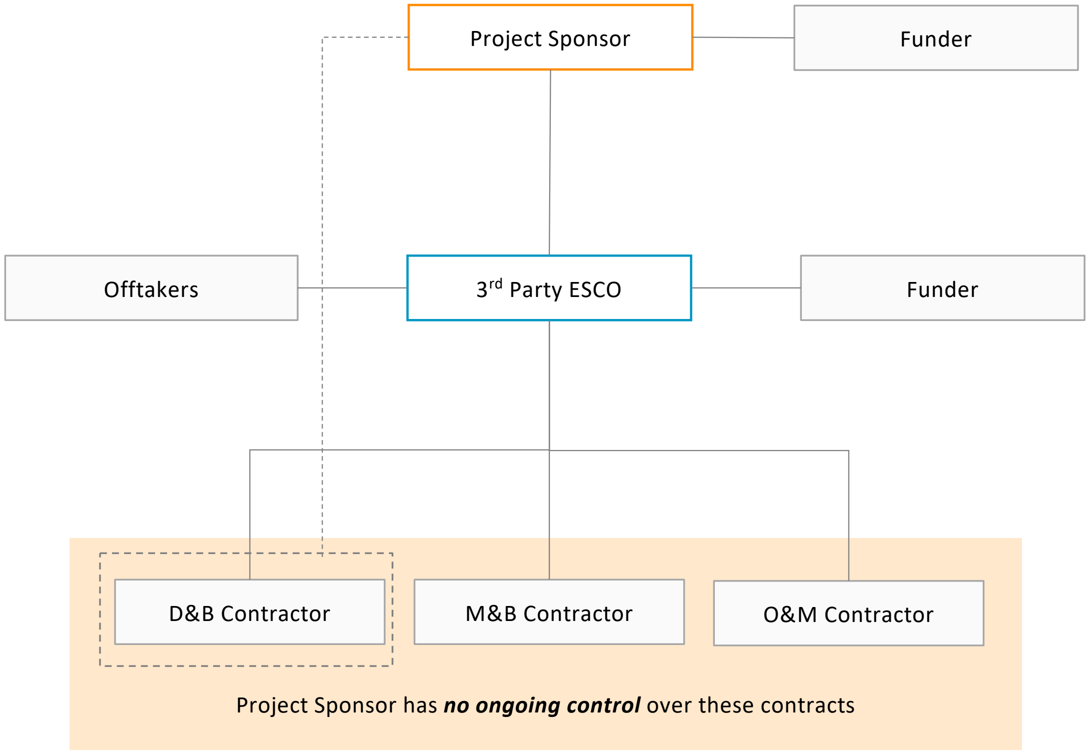
Key Points

- Project Sponsor's role is to establish the **rights and obligations** of the the ESCO, from a service, scope and standards point of view. It may also play a part in **promotion and development** of the project.
- ESCO's role is **Energy Supplier**. In order to achieve this, it has to manage:
  - **Operation and Maintenance**
  - **Metering and Billing**
  - **Customer Services**
  - **Supply of Incoming utilities**
  - **Business Administration**
- **Funding routes** can vary in all scenarios, and between asset elements
- Customers should receive a level of service commensurate with developing market best practice and the direction of incoming legislation

DELIVERY STRUCTURES: **CONCESSION**



Pros

- Project Sponsor *may* own the assets, but does not have to
- Funding can be either from the Project Sponsor (then adopted by ESCO) or the ESCO
- Project Sponsor is sheltered from operating risk
- Can be used to transfer development activities to the concession holder

Cons

- Value returned under Concession is heavily linked to level of development uncertainty and perceived risk.
- Energy to offtakers can be more expensive, as concession holders typically seek a higher level of commercial return.
- Project Sponsor does not see any direct financial benefit
- While the Project Sponsor can steer performance via an output specification, there is limited control over ESCO operation, including Contractors performance, network expansion and energy tariffs
- Exiting / termination a concession before expiry of the term is difficult and expensive.

DELIVERY STRUCTURES: **PROJECT SPONSOR ESCO**

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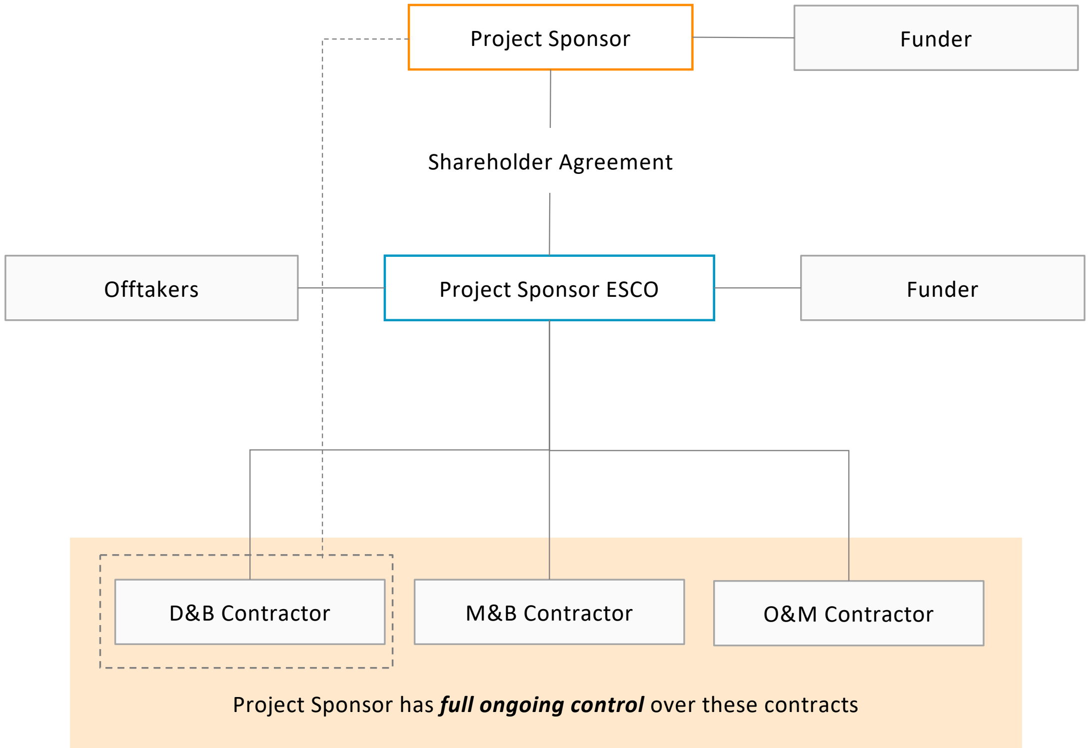


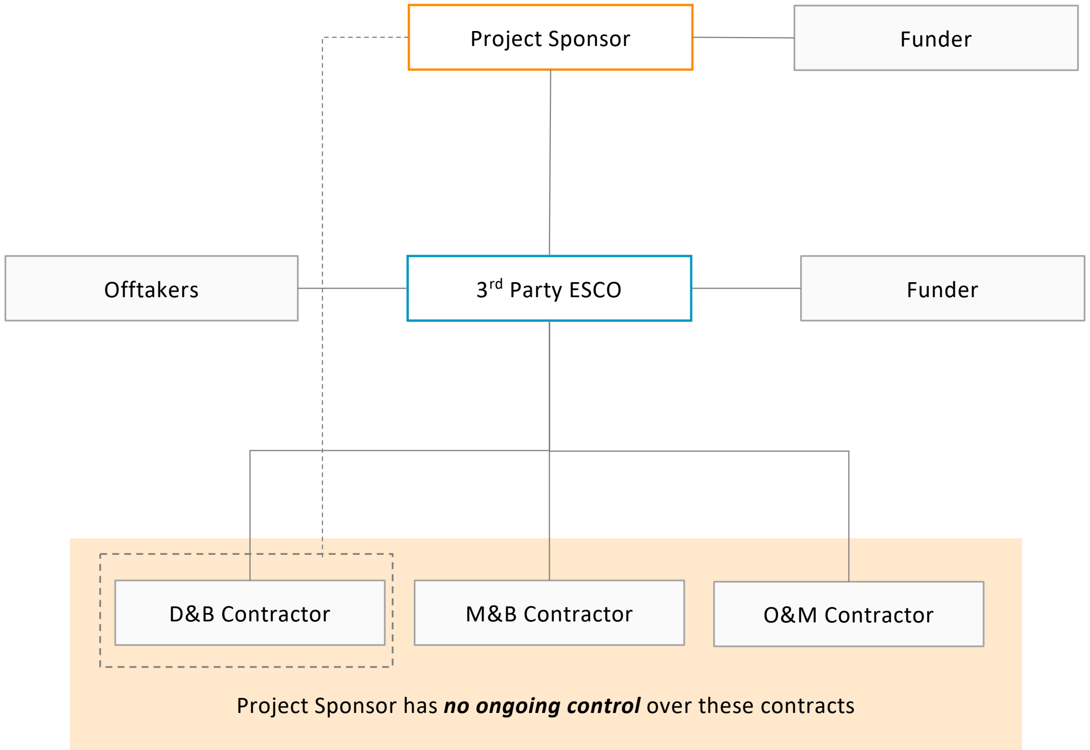
Pros

- Project Sponsor establishes a wholly owned ESCO where the ESCO is owner and operator
- Project Sponsor (via its ESCO) has full control over Contractors, network expansion and energy tariffs
- Project Sponsor receives direct financial benefits of scheme
- Exit or change of approach is a contractually simple process, making this a flexible option for future development
- Usually cheaper energy for the offtakers while under Local Authority Control

Cons

- Project Sponsor is fully responsible to secure funding either directly or to the ESCO
- Project Sponsor bears the commercial risks of ESCO operations

DELIVERY STRUCTURES: **3RD PARTY ESCO**



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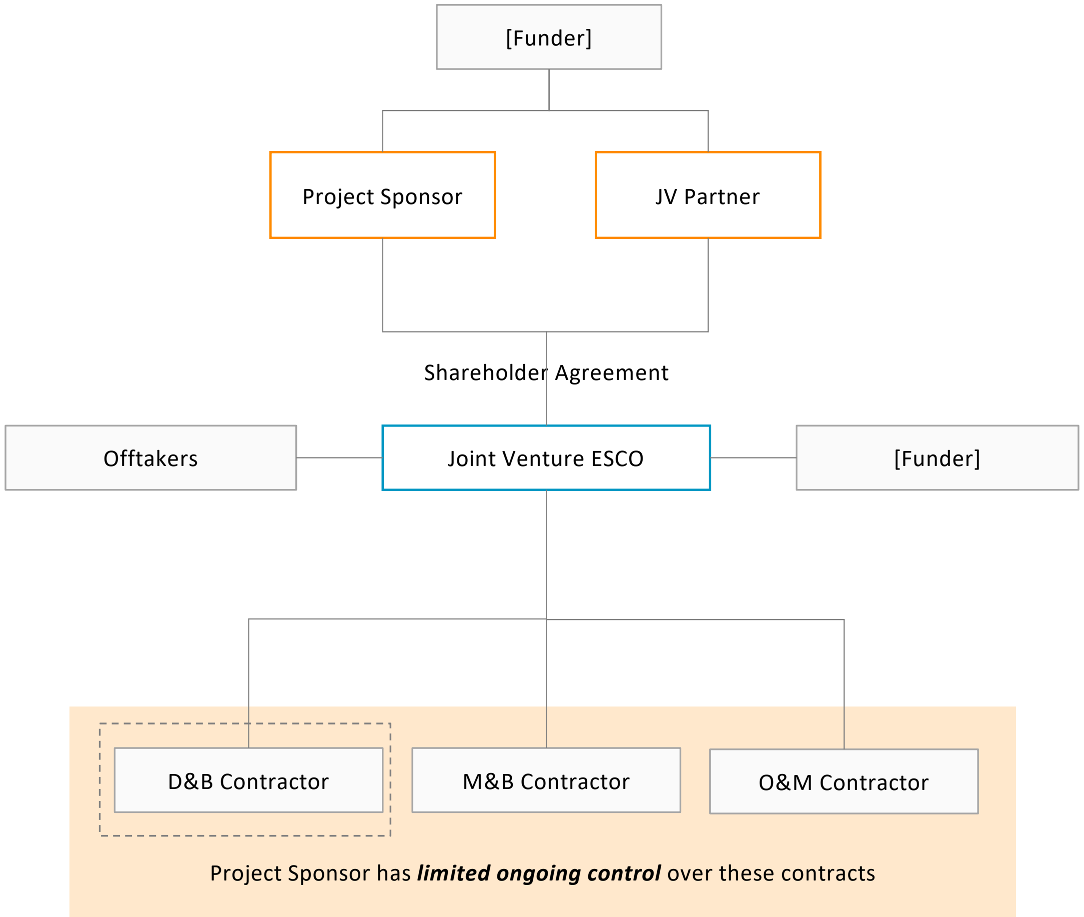
Pros

- Project Sponsor does not own the assets; the ESCO funding the project does
- Project Sponsor is sheltered from funding, delivery and operating risk
- Development activities are transferred to the 3rd party ESCO

Cons

- Value returned to the Project Sponsor is heavily linked to level of development uncertainty and perceived risk.
- Energy to offtakers is usually more expensive, as the 3rd party ESCO typically seek a higher level of commercial return.
- Project Sponsor does not see direct financial benefit (only reduced cost of heat)
- While the Project Sponsor can steer performance via an output specification, there is no control over ESCO operation, including Contractors performance, network expansion and energy tariffs
- Exiting / termination an ESA before expiry of the term is difficult and expensive.

DELIVERY STRUCTURES: **JOINT VENTURE ESCO**



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The JV structure is sensitive to the precise terms of the shareholder agreement. Finalising terms of this agreement can take a long time.

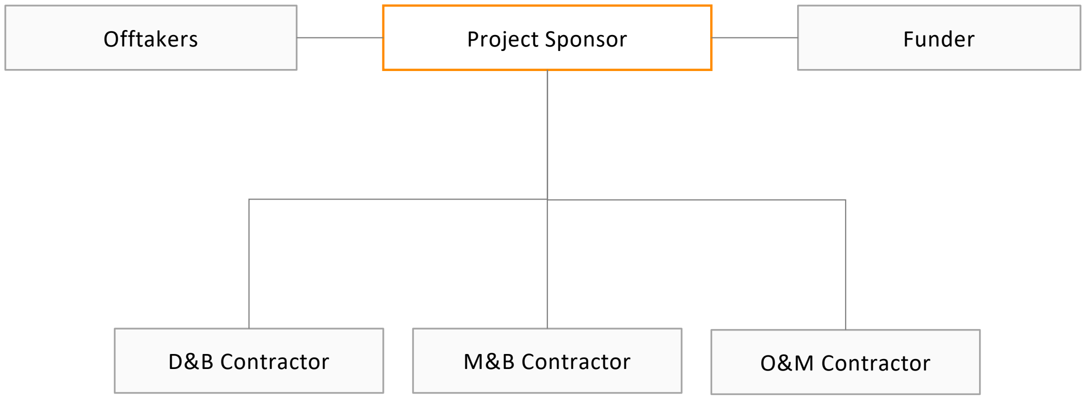
Pros

- JV partners share the risk of development, delivery and operation
- JV partners are responsible to secure funding
- JV partners share the direct financial rewards
- JV partners can shield from recourse as asset ownership is with the JV SPV
- Project Sponsor receives direct financial benefits of scheme
- Exit strategy can be agreed to be flexible

Cons

- Control is shared between the JV partners
- Direct financial rewards is shared between the JV partners
- Lengthier and more complicated process to set up a JV structure

DELIVERY STRUCTURES: **IN HOUSE DELIVERY**



Project Sponsor develops the project without setting up an SPV

Pros

- Project Sponsor has full control over delivery and contractors, network expansion and energy tariffs
- Project Sponsor receives direct financial benefits of scheme
- Usually cheaper energy for the offtakers while under Local Authority Control

Cons

- Project Sponsor bears the risk of funding, development, delivery and operation
- Exit strategies are limited or complex, as there is no entity to sell shares or refinance
- As it stands grants may not be available

PROCUREMENT

PROCUREMENT

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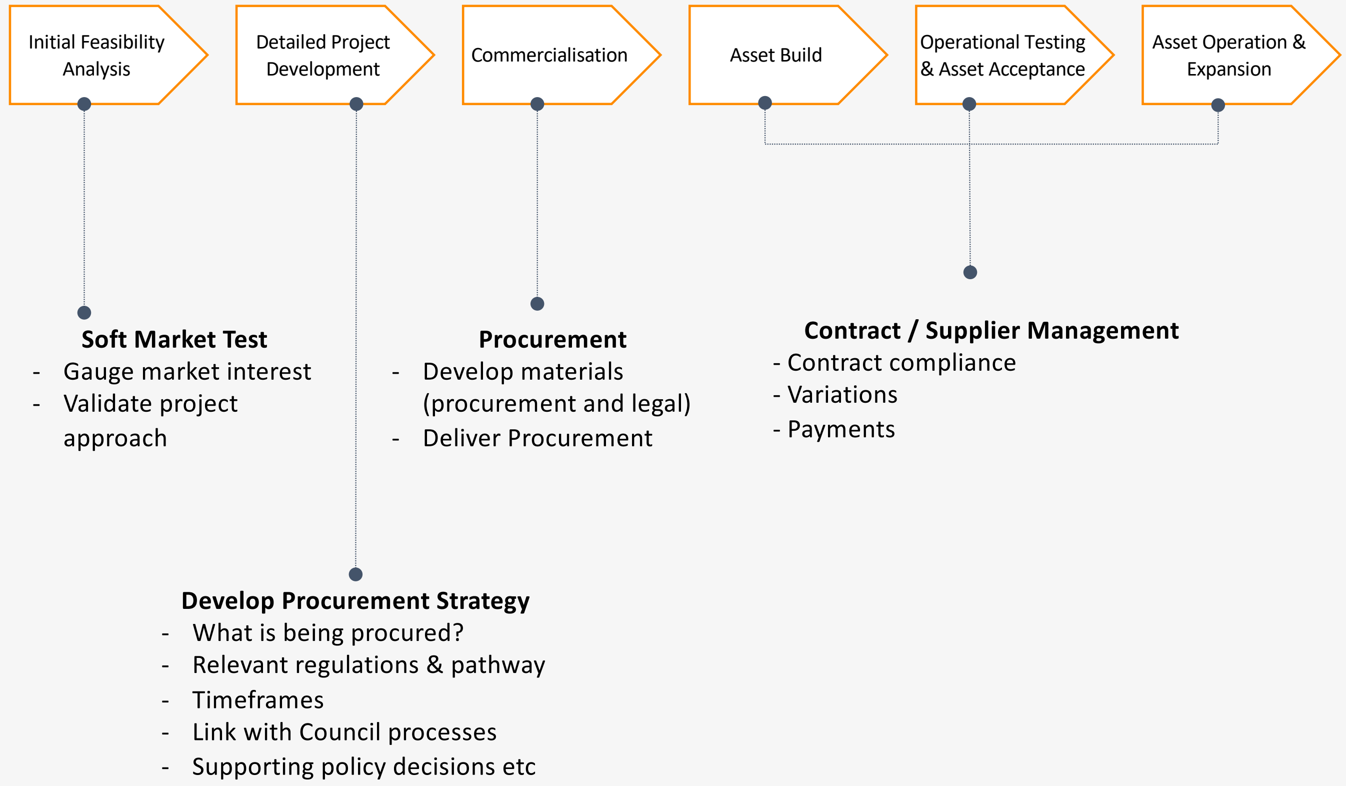
A detailed procurement exercise will be needed irrespective of the delivery structure. The procurement strategy is developed over a number of stages.

- The procurement strategy should take into account:
- Compliance with all relevant regulations
- Programme
- Experience and capacity within the Sponsor
- Alignment with other relevant works
- Use of Frameworks and DPSs



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KIT GILLIBRAND
E: kg@hermeticablack.com
M: 07946 169 909

hermetica
black

DEVELOPMENT & ASSET MANAGEMENT

HERMETICABLACK.COM

aecom.com

aecom.com