Lancaster West Estate - Heat Network Feasibility Study

August 2020

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		Signature			

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Contents

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Glossary of terms

Glossary of abbreviations used throughout this report

Abbreviation	Full name	Abbreviation	Full name
BAU	Business As Usual	LTHW	Low Temperature Hot Water
BEIS	Department for Business, Energy & Industrial Strategy	LSOA	Lower layer super output area
CAPEX	Capital Expenditure	MCA	Multi-Criteria Analysis
CHP	Combined Heat and Power	MHCLG	Ministry of Housing, Communities & Local Government
CIBSE	Chartered Institute of Building Services Engineers	MW, kW	Megawatt, kilowatt (units of electrical or thermal power)
COP	Coefficient of Performance	MWh, kWh	Megawatt-hour, kilowatt-hour (units of electrical or thermal energy)
DBOM	Design, Build, Operate and Maintain	MWp, kWp	Megawatt-peak, kilowatt-peak (units of electrical or thermal energy)
EC	Energy Centre	NPV	Net Present Value
EfW	Energy from Waste	OA	Output Area
EPC	Energy Performance Certificate	OPEX	Operational Expenditure
ESCo	Energy Services Company	PW	Private Wire
GIS	Geographic Information System	PM	Particulate Matter
GSHP	Ground Source Heat Pump	REPEX	Replacement Expenditure
HDD	Heating Degree Days	RFI	Request for Information
HNDU	Heat Networks Delivery Unit	RHI	Renewable Heat Incentive
HNIP	Heat Networks Investment Programme	SAP	Standard Assessment Procedure
IRR	Internal Rate of Return	ASHP	Air Source Heat Pump
JV	Joint Venture	SSHP	Sewer Source Heat Pump
kg	kilograms	GSHP	Ground Source Heat Pump
kJ	kilojoules (units of energy)	WSHP	Water Source Heat Pump
kVA	kilovolt-ampere (units of power)		

Executive Summary
Introduction

The Lancaster West Estate, based in the Royal Borough of Kensington and Chelsea (RBKC), is currently undergoing research and analysis for major refurbishment works. The site covers Kensington Leisure Centre, the Aldridge Academy and all housing within the Lancaster West Estate excluding Grenfell Walk and Grenfell Tower (total: 794 homes).

The Lancaster West Estate is owned and managed by RBKC. The council's guiding principles for the refurbishment work include:

- Net zero carbon emissions by 2030
- Inclusion of cost effective and least disruptive solutions.

In this context, Arup was appointed by BEIS to undertake a feasibility study for the development of a district heating network in Lancaster West.

The site currently has two communal heating systems and many of the remaining individual heating systems that are all at or close to the end of their life.

The potential yearly heat demand for all housing was provided by the retrofit analysis work conducted by Carbon Trust and Energiesprong. Two retrofit packages were created (package 1 and 2). Package 2 was the more aggressive of the two scenarios and if implemented could help reduce current space heating demand by ~50%.

RBKC are yet to make the final decision regarding the chosen retrofit, therefore both packages have been included in this analysis.

All heating loads are expected to be connected to the district heating (DH) scheme between 2023 – 2027. Connections to the DH scheme will begin from the east of the estate, as requested by RBKC. More details are available in chapter 2.

Heat supply optioneering and network routing analysis was carried out in parallel. Heat supply optioneering amalgamated all potential low carbon heat sources available within the area. This included Air Source Heat Pumps (ASHPs), Sewage Source Heat Pumps (SSHPs), Ground Source Heat Pumps (GSHPs) and Water Source Heat Pumps (WSHPs). More details are available in chapter 5.

In parallel, the analysis of the network routing was undertaken with the support of surveys and the information gathered during the route-walk to visually assess any areas of potential congestion or complication. More details are available in chapter 4.

The information analysed from the demand, supply and the routing analysis helped develop different scenarios for the heat supply at Lancaster West, which have been compared both technically and financially in chapter 6.

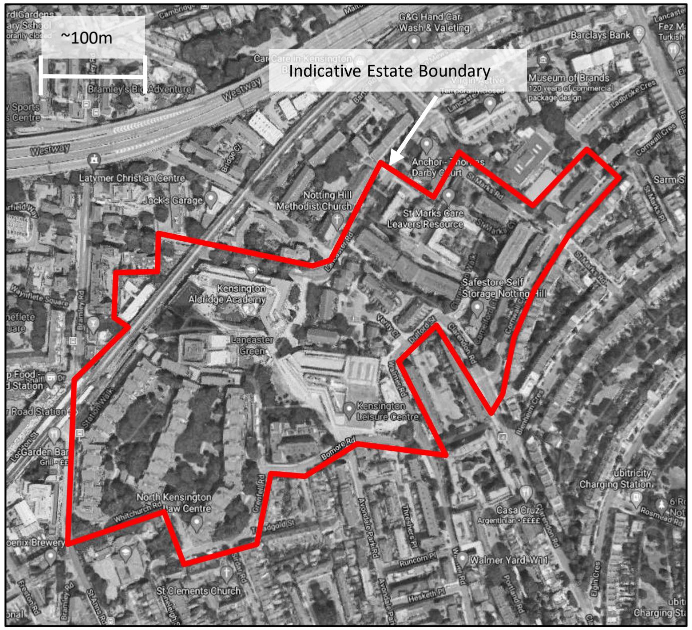

Figure EC1: Lancaster West Estate desktop review extent

Table ES1: Energy demand under Package 1 and 2

Demand assessment	2023	2027
Annual demand (Package 1)	1.2 GWh	10.4 GWh
Peak demand (Package 1)	0.7 MW	9.1 MW
Annual demand (Package 2)	0.6 GWh	7.6 GWh
Peak demand (Package 2)	0.7 MW	5.3 MW

Executive Summary
Introduction

The proposed district network route follows a combined external (within public domain) and internal (within buildings, following the communal heating system pipework) route as shown in Figure ES2 and discussed in chapter 3 and 4.

Four scenarios for the supply of heat were investigated for both retrofit demand package scenarios:

- All ASHP (no alternative low carbon source proven viable)
- SSHP as primary source and ASHP as secondary (use of the identified combined sewer in the estate as source of heat)
- SSHP and GSHP as primary sources and ASHP as secondary (additional use of aquifer water as source of heat)
- Ambient loop with SSHP and GSHP as primary source and individual WSHP in the flats.

Two scenarios without district heating have also been developed to compare the study results with alternative solutions for Lancaster West:

- All individual ASHP for all flats
- A mixed scenario which with communal heat pumps supplying current communal systems and individual heat pumps replacing the current individual boilers in use.

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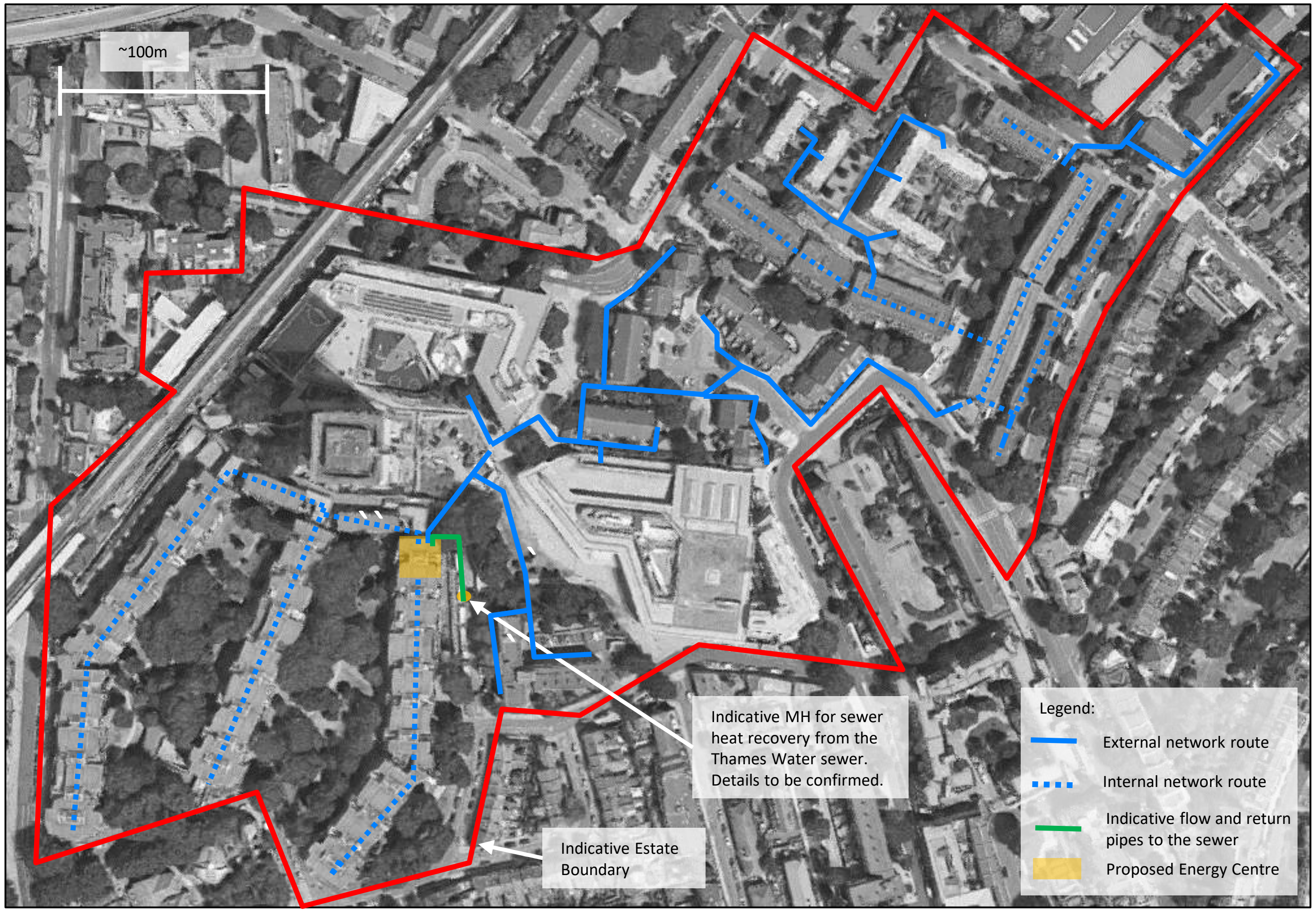

Figure ES2: Proposed external district heating network route

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Executive Summary
Key Findings

Table ES2 and Figure ES3 show the lifetime carbon savings for the different network scenarios analysed.

The carbon savings for all scenarios have been calculated against a “no action” scenario in which the buildings will use the existing system up to the end of their life and move to electric systems in different phases from now to 2030.

The carbon performance of the different options needs to be understood in the context of the current policy environment. The SAP 10 values are representative of the 3-year average carbon factors published in 2019, with the same value used throughout the lifetime of the project. In contrast, the HNDU factors change to reflect changes in grid composition; for example, an increased contribution of renewable energy.

All scenarios show positive carbon savings which are proportional to the heat supplied (Package 1 scenario has a higher demand than package 2) and the percentage of heat supplied by efficient low carbon technologies.

Scenarios with greater use of ASHP show lower savings, with the individual ASHP solution showing the smallest savings due to the lower efficiency of distributed small heating systems.

The use of SSHP and GSHP result in higher carbon savings due to the superior COP of these systems.

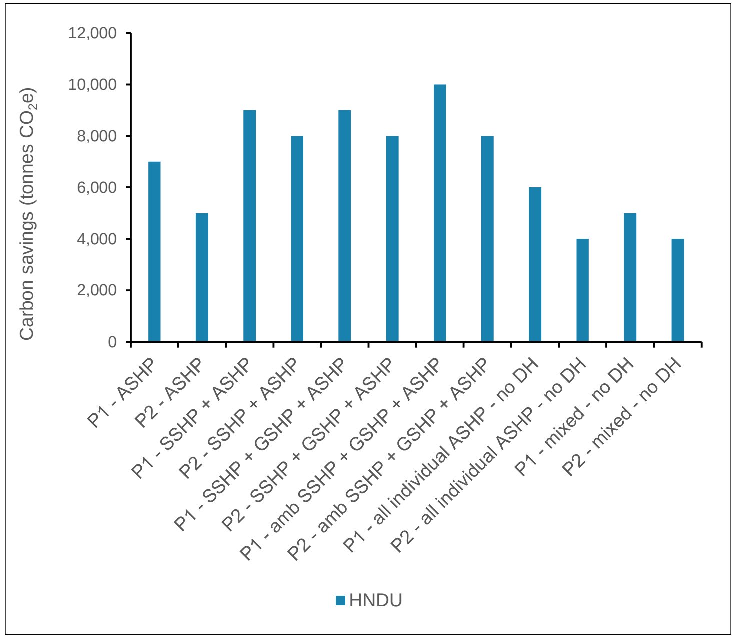

Figure ES3: Carbon Savings Performances – HNDU emissions factors

Table ES2: Carbon savings performances: HNDU and SAP 10

Scenario No.	Scenario	HNDU (tCO_2e) 40 year	SAP 10 (tCO_2e) 40 year
1	P1 - ASHP	7,000	17,000
2	P2 - ASHP	5,000	14,000
3	P1 – SSHP + ASHP	9,000	23,000
4	P2 – SSHP + ASHP	8,000	21,000
5	P1 – SSHP + GSHP + ASHP	9,000	24,000
6	P2 – SSHP + GSHP + ASHP	8,000	21,000
7	P1 - amb SSHP + GSHP + ASHP	10,000	29,000
8	P2 - amb SSHP + GSHP + ASHP	8,000	21,000
9	P1 - all individual ASHP - no DH	6,000	14,000
10	P2 - all individual ASHP - no DH	4,000	10,000
11	P1 - mixed - no DH	5,000	14,000
12	P2 - mixed - no DH	4,000	12,000

Executive Summary
Key Findings

The Lancaster West Estate has a unique economic context in the financial roles of the council and residents. It is anticipated that the council will play a leading role in the CAPEX and OPEX of the heating systems, both for individual systems and in district heating scenarios.

RBKC is responsible for refurbishment (incl. heating system) of the leisure centre and tenanted residential properties, with approximately half of any residential expenditure paid by leaseholders. Rented and leasehold properties comprise around 65% and 30% of all homes respectively. Leaseholders cannot opt for alternative heating solutions.

In a typical commercial heat network arrangement, capital costs would normally be covered in part by a connection charge paid by developers or property owners to the district heating developer (ESCo). In the case of LWE, the council would not receive any connection charges.

In the case of individual systems the council would be responsible for the capital investment and running of the heating systems and tenants would pay electricity bills to the electricity companies. In district heating scenarios the council would generate revenue proportional to the heat sold.

To reflect the context specific situation, all scenarios analysed have been compared in order to have the same annual bills for the tenants for the two demand scenarios, calculated on the basis of the charges the customers will be expected to pay if they move to individual ASHP solutions.

None of the scenarios considered show a positive NPV or IRR. This is due to a combination of factors, driven largely by the fact that the network is in a social housing setting with RBKC being responsible for refurbishment and O&M of heating systems for its tenants. As such, the cost recovery mechanisms that are usually available to scheme operators are not available here.

In scenarios with individual systems, which generate no revenues for the council, the NPV and NPC are equal, while in scenarios with district heating the losses for the council are lower and some costs are recovered.

ASHP heat networks show the best NPV results, followed by SSHP+ASHP heat networks. The full potential of SSHP in this context is currently only partially understood. Small increases in temperature and/or flow rate could make the SSHP+ASHP network as competitive as the ASHP heat network, if not better.

In general Package 1 shows a better IRR than Package 2 but a worse NPV. Package 1 results in a higher demand requiring greater plant capacity and hence cost of supply. However, plant costs for district heating are not linear, so although plant capacity required under Package 2 is lower, economies of scale mean that on a per unit of heat basis it is higher.

Table ES3: Financial Results

Scenario No.	Scenario	CAPEX (£m)	40yr NPV (£m)	40yr NPC (£m)	IRR (%) 40yr	Gap funding (£m) to achieve 3.5 % IRR (40yr)	Commodity Costs (el cost- £/ kWhth)
1	P1 – ASHP	14.5	- 10.1	25.1	-3.8%	10.1	0.042
2	P2 – ASHP	10.7	- 8.0	18.6	-5.9%	8.0	0.040
3	P1 – SSHP + ASHP	17.5	- 12.0	27.0	-3.3%	12.0	0.036
4	P2 – SSHP + ASHP	13.8	- 9.8	20.4	-4.3%	9.8	0.029
5	P1 – SSHP + GSHP + ASHP	18.0	- 12.3	27.4	-3.3%	12.3	0.034
6	P2 – SSHP + GSHP + ASHP	14.1	- 10.2	20.8	-4.5%	10.2	0.030
7	P1 – amb SSHP + GSHP + ASHP	25.7	- 19.7	34.8	-3.3%	19.7	0.047
8	P2 – amb SSHP + GSHP + ASHP	22.2	- 19.6	30.2	-5.3%	19.6	0.044
9	P1 – all individual ASHP - no DH	17.2	- 22.2	22.2	N.A	22.2	0.092
10	P2 – all individual ASHP - no DH	11.6	- 15.1	15.1	N.A	15.1	0.089
11	P1 – mixed - no DH	15.9	- 12.9	22.9	-5.6%	12.9	0.062
12	P2 – mixed - no DH	12.5	- 11.2	17.5	-9.1%	11.2	0.055

Executive Summary
Conclusions and next steps

Environmental and Social Conclusions

- The district heating networks provide Lancaster West an opportunity to decarbonise heat and to reduce local emissions.
- The analysis indicates that all network scenarios would deliver significant carbon savings.
- The analysis resulted in a range of social NPV values of £20m-£50m over a 40-year time horizon (HNDU factors).
- The heat tariffs assumed in the analysis are based on the equivalent costs tenants would have to pay under an individual ASHP solution.
- Despite lower demand due to the refurbishment works, annual costs to tenants of a low carbon heat supply will be higher than those they currently experience. Impacts on fuel poverty will need to be considered by the Council.
- The unit cost of delivered heat (excluding CAPEX) is lower for the DH options than it is for the individual ASHP options. This is due to the economies of scale achievable with a centralised system. These savings could be used to offset the costs to tenants, which could significantly help to address fuel poverty.
- The district heating scenarios represent a more protective environment for the tenants in case they are not able to pay for the heat, since they will deal with the Council and not directly with the electricity companies. In addition to this the council has stronger buying power in relation to electricity and may be able to shield tenants from price fluctuations.

Technical Conclusions

Each part of the potential network was assessed for technical feasibility, including:

- Availability of low carbon heat sources
- Heat network routing
- Connection to heat loads.

The assessment did not identify any major unmitigable risks which would prevent construction and operation of the whole or part of the proposed network, but a variety of risks and uncertainties were identified which could affect the final cost and delivery programme for the network.

The cost model reflects the recommended routing and connection schematics together with provision for risk and optimism bias.

Key technical feasibility considerations include:

- Monitoring the sewer flow rate and temperature
- Development of a plan for the integration of refurbishment works and the replacement of heating systems
- Additional investigations to confirm the route feasibility.

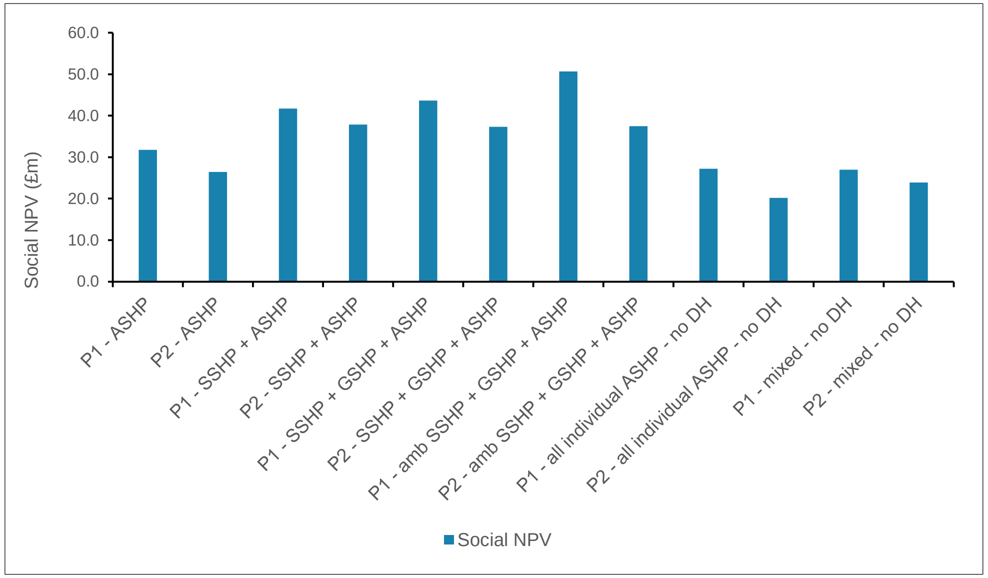

Figure ES4: Social NPV

Executive Summary
Conclusions and next steps

Economic performance

The economic assessment results show that all scenarios show a negative IRR and NPV. This is due to the large proportion of connection costs absorbed by the council. The ASHP heat network followed by SSHP + ASHP heat network provide the best results.

RBKC have to invest in refurbishing the heating system on the estate and have funding available to do this. The extent to which this funding can cover all aspects of sustainability and decarbonisation is to be confirmed; additional finance (e.g. through HNIP) is likely to be required.

The true potential of SSHP as a heat source is currently partially known and it is advised that the sewage network is monitored to understand sewage flow rates, depth and temperature.

Commercial delivery

The commercial delivery of the system differs from other district heating systems. RBKC is the social housing provider and needs to supply tenants with heat. RBKC is today the heat provider for the two communal heating systems and it is expected to be the provider for the future district heating network.

Under this arrangement, it is likely that RBKC would procure an O&M provider to manage the network, as is the case currently with the existing communal systems.

In the event of network expansion outside of Lancaster West boundaries, the commercial delivery may change and a promoter would need to be identified and take the project to the next phases.

Overall conclusions

This feasibility study has identified two feasible heat network schemes which have the potential to deliver significant carbon savings and social benefits. Funding and financial arrangements for the scheme have yet to be determined, however the study suggests that a district heating option could be less expensive for both the council and tenants than an individual ASHP solution.

It is recommended that the SSHP capacity should be monitored over time and in the case of good performance is recommended as the preferred heat source as in scenarios 3 and 4.

In the case of poorer SSHP performance, the ASHP based supply (an in scenarios 1 and 2) is recommended to be taken to the next phase.

The use of GSHP does not improve the financial results and would add risk related to the availability of water from the aquifer. It is therefore not suggested as a supply solution.

The ambient loop scenario is a viable option where heating and cooling loads are balanced in a network. In the Lancaster West context there are no significant cooling loads, therefore the ambient loop scenario, despite some advantages in the carbon savings values, shows the worst economic performances and is not suggested to e taken in the next phase as viable option.

The next project phase should commence with the key actions identified to address critical project risks.

Next steps

- A feasibility study for the SSHP needs to be carried out. It should consider the monitored temperatures and flow rates together with civil works needed for the implementation of the system.
- The engagement with Thames Water for the use of the sewer needs to be taken to the next phase and the NDA needs to be signed.
- Internal heating systems for the use of lower temperature supply need to be included in the refurbishment design.
- A final decision on which refurbishment package to choose needs to be taken by RBKC.
- A coordinated plan for flat refurbishment and district heating system works needs to be developed.
- Stakeholder engagement needs to be actively sought before and during the next phases. Tenants needs to be made aware of the changes occurring on the heating systems and on the billing strategy.
- Deeper investigation on the routing will need to be undertaken. In particular 3D scans in congested areas and key points identified.

Chapter 1 – Introduction

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Introduction

1.1 Introduction and Background

The Lancaster West Estate (LWE) is undergoing a comprehensive refurbishment to deliver on a Government promise that it will be a model social housing estate for the 21st century.

MHCLG is the lead Government department for the project. HNDU reviewed an initial study undertaken by Kensa regarding their 'Shared Ground Loop' system, and is looking to seek guidance on the most suitable strategy moving forward. The council has also committed for the estate to be net-zero carbon by 2030. The council is in the process of putting together a Refurbishment Technical Team which will comprise of: Multi-disciplinary technical designers including lead designer and contract administrators; and a number of specialists including M&E contractors, FRA, Fire, CCDM etc. These are currently being procured with the final award being made in April 2020.

There are two existing communal heating systems on the site, one of which performs particularly badly. The refurbishment includes a new low carbon heating system, with the potential for an upgraded heat network. The council is working closely with the Lancaster West Residents' Association (LWRA) on the refurbishment. Resilience and performance quality are critical design drivers, along with the net zero commitment.

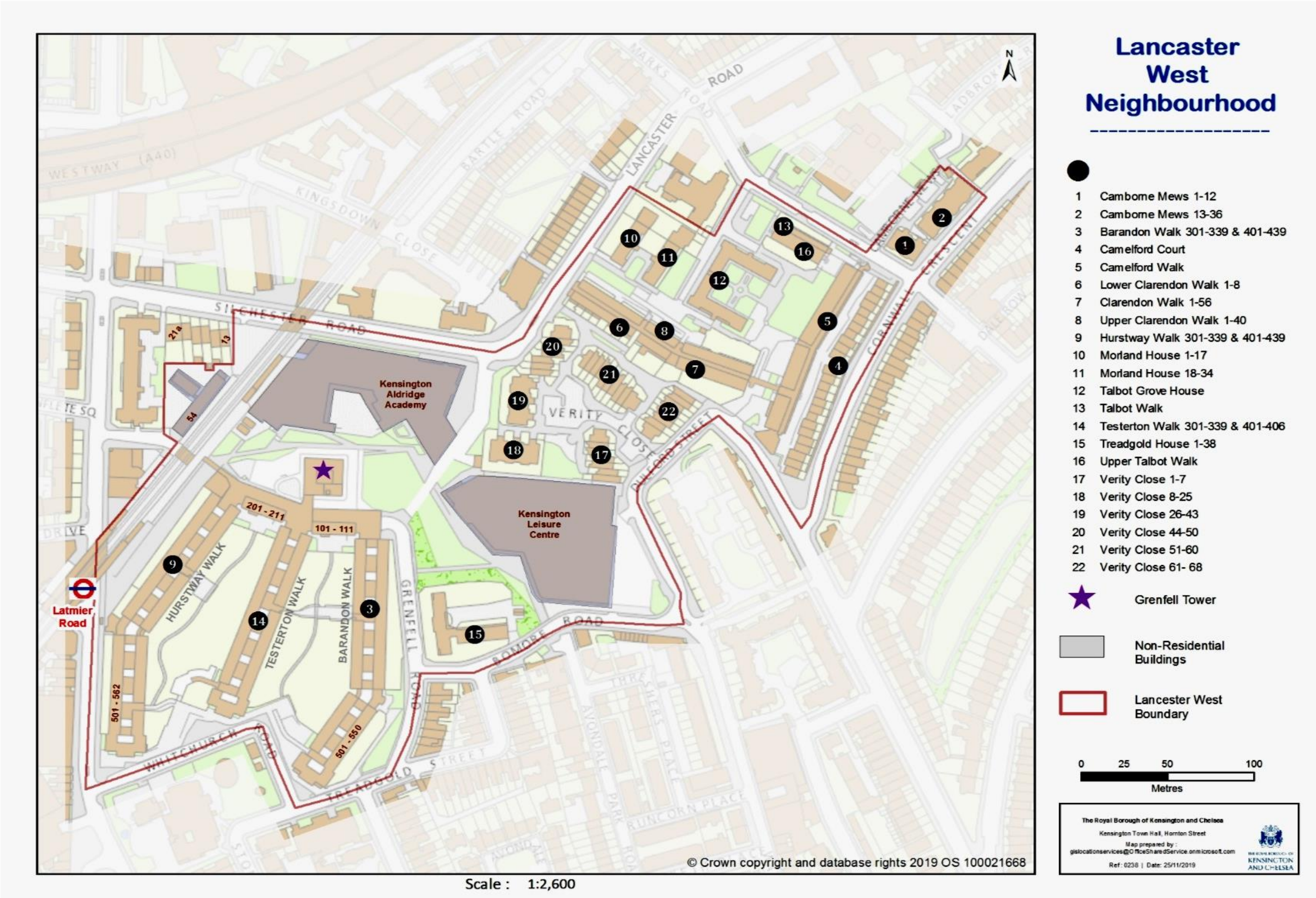

Figure 1.1.1: Lancaster West Estate map

Introduction
1.2 Feasibility Study Scope and Methodology

The primary objective is to determine the technical feasibility and economic viability of a heat network solution on the Lancaster West Estate and to assess the feasibility of balancing the residential load with Kensington Leisure Centre and Kensington Aldridge Academy. This will help guide Lancaster West Estate as to whether a heat network or individual heat pumps is the most viable option for the site. It should be noted that insulation measures will also be installed which therefore might favour a lower temperature building-by-building solution over a heat network.

The proposal is to undertake a detailed feasibility study working closely with the RBKC Refurbishment Project Team, the LWRA and their M&E consultants when appointed. The scope of this work will be adapted from the standard HNDU specification to ensure it aligns with the interdependent work and the given budget.

At the end of the study it is intended that the council will apply for HNDU funding to complete the DPD-type work which will likely include developing a financial model for HNIP purposes (if required), commercial optioneering and developing a detailed design specification (KPI/Performance based) to allow them to procure a solution.

Project Methodology

1. **Understanding of the current system.** A high-level diagnostic on the existing two ‘communal’ heat networks within the Lancaster West Estate to see whether they can be repurposed and incorporated into a new site-wide heat network.
2. **Demand assessment.** Information was exchanged with RBKC, the leisure centre and the academy. The likelihood of barriers to connect and demand phasing was assessed. Peak and hourly profiles were created after understanding the impact of retrofits on the demand. Where hourly data was unavailable typology specific Arup heat demand profiles (regularly used in Arup projects) were used.
3. **Network Routing assessment.** Infrastructure barriers and opportunities over and under ground were assessed using information provided by the council, Groundwise/utility maps and site surveys. This analysis identified the selected network routing for the connection of the loads in all demand scenarios.
4. **Supply options assessment.** Potential of low carbon and renewable heat sources including environment constraints was assessed to meet the demand. Hourly modelling of supply/demand interactions were undertaken for all scenarios. This energy modelling determined the sizes of plant components, thermal storages and energy centre. Where necessary different supply scenarios were developed.
5. **Techno-economic and carbon assessment.** A techno-economic and carbon assessment model was created and ran for various iterations of supply, demand, route and cost sensitivities. This analysis revealed the key financial and carbon performance results of the scenarios analysed.

Chapter 2 – Demand Assessment

Demand Assessment
2.1 Demand Information

During the demand assessment process information from RBKC, Carbon Trust, Kensington Academy, Kensington Leisure Centre and Energiesprong UK was used to build a more detailed picture of the demand requirement on site.

Demand and system data gathered

Carbon Trust and Energiesprong were the primary sources of information to best understand the potential future (post retrofit) heat demand for all residential buildings. Two packages were created by them to understand the potential heat demand future of the flats. Table 2.1.1 shows the various retrofits suggested under the two retrofit packages.

It should be noted that this study is focused on the district heating analysis. Retrofit measures have only been considered in the context of estimating heating demand. No costs associated with retrofit works have been included in the study.

Kensington Leisure Centre provided monthly data for two years.

Kensington Aldridge Academy data was unavailable and therefore benchmarks (CIBSE, BEES) were used alongside estimated floor areas to calculate the annual heat demand.

It is important to note that Kensington Leisure Centre and Kensington Aldridge Academy are independent of the Lancaster West Estate. A separate stakeholder engagement exercise was conducted with these entities.

Table 2.1.1: Retrofits within package 1 and package 2

<table>
<tr><th>Building ID</th><th>Name</th><th>Package 1</th><th>Package 2</th></tr>
<tr><td>1</td><td>Camborne Mews 1-12</td><td rowspan="2">Increase loft insulation, High performance triple glazing and air tightness to <0.9ACH (atmospheric).</td><td rowspan="2">Increase loft insulation, High performance triple glazing and air tightness to <0.2ACH (atmospheric).</td></tr>
<tr><td>2</td><td>Camborne Mews 13-36</td></tr>
<tr><td>3</td><td>Barandon Walk 301-339 & 401-439</td><td rowspan="7">High performance triple glazing
New Roof
New Doors
Air tightness and mechanical ventilation measures to <0.9ACH (atmospheric)</td><td rowspan="7">High performance triple glazing
External wall insulation (air tight envelope)
Solid floor insulation
New Roof
New Doors
Air tightness and mechanical ventilation measures to <0.2ACH (atmospheric)</td></tr>
<tr><td>4</td><td>Camelford Court</td></tr>
<tr><td>5</td><td>Camelford Walk</td></tr>
<tr><td>6</td><td>Lower Clarendon Walk 1-8</td></tr>
<tr><td>7</td><td>Clarendon Walk 1-56</td></tr>
<tr><td>8</td><td>Upper Clarendon Walk 1-40</td></tr>
<tr><td>9</td><td>Hurstway Walk 301-339 & 401-439</td></tr>
<tr><td>10</td><td>Morland House 1-17</td><td rowspan="3">Double glazing, new roof, doors & air tightness to <0.9ACH (atmospheric)</td><td rowspan="3">Double glazing, new roof, doors & air tightness & Floor insulation. <0.5ACH (atmospheric).</td></tr>
<tr><td>11</td><td>Morland House 18-34</td></tr>
<tr><td>12</td><td>Talbot Grove House</td></tr>
<tr><td>13</td><td>Talbot Walk</td><td>Retrofit measures similar to Barandon Walk</td><td>Retrofit measures similar to Barandon Walk</td></tr>
<tr><td>14</td><td>Testerton Walk 301-339 & 401-406</td><td>Retrofit measures similar to Barandon Walk</td><td>Retrofit measures similar to Barandon Walk</td></tr>
<tr><td>15</td><td>Treadgold House 1-38</td><td>High performance triple glazing, New Roof, Doors & Air tightness to <0.9ACH (atmospheric)</td><td>High performance triple glazing, New Roof, Doors & Air tightness, Ventilation, Floor insulation and external wall insulation <0.2ACH (atmospheric).</td></tr>
<tr><td>16</td><td>Upper Talbot Walk</td><td>Retrofit measures similar to Barandon Walk</td><td>Retrofit measures similar to Barandon Walk</td></tr>
<tr><td>17</td><td>Verity Close 1-7</td><td rowspan="6">Increase loft insulation, High performance triple glazing and air tightness to <0.9ACH (atmospheric).</td><td rowspan="6">Increase loft insulation, High performance triple glazing and air tightness to <0.2ACH (atmospheric).</td></tr>
<tr><td>18</td><td>Verity Close 8-25</td></tr>
<tr><td>19</td><td>Verity Close 26-43</td></tr>
<tr><td>20</td><td>Verity Close 44-50</td></tr>
<tr><td>21</td><td>Verity Close 51-60</td></tr>
<tr><td>22</td><td>Verity Close 61-68</td></tr>
<tr><td>23</td><td>Kensington Aldridge Academy</td><td>No additional measures</td><td>No additional measures</td></tr>
<tr><td>24</td><td>Kensington Leisure Centre</td><td>No additional measures</td><td>No additional measures</td></tr>
</table>

Demand Assessment
2.1 Demand Information

Where hourly data was not available, the heat demands have been modelled using profiles of similar buildings or similar purpose loads from other projects and using local hourly temperature data.

Where monthly data was available, the summer consumption has been taken as DHW load and then space heating and DHW have been modelled according to the proportion of the energy use.

For residential loads, the diversity factor for the DHW has been modelled according to the Danish DS 439 as specified in the CIBSE Code of Practice for the UK (CP1), while the space heating demand has been calculated according to the local temperatures and the building regulations in case of proposed development.

The total annual heat demand potentially connectable to the district heating was calculated as:

- 10.4 GWh for Package 1
- 7.6 GWh for Package 2.

Table 2.1.2: Heat demands

Building ID	Name	Annual Heat Load (kWhth/year) - Package 1	Peak Heat Load (kW) – Package 1	Annual Heat Load (kWhth/year) - Package 2	Peak Heat Load (kW) – Package 2
1	Camborne Mews 1-12	68,900	120	43,000	86
2	Camborne Mews 13-36	123,000	181	78,500	122
3	Barandon Walk 301-339 & 401-439	950,000	1,090	575,000	602
4	Camelford Court	236,000	324	134,000	192
5	Camelford Walk	582,000	785	309,000	429
6	Lower Clarendon Walk 1-8	62,200	82	34,500	46
7	Clarendon Walk 1-56	435,000	574	241,000	320
8	Upper Clarendon Walk 1-40	311,000	410	172,000	229
9	Hurstway Walk 301-339 & 401-439	1,010,000	1,150	619,000	634
10	Morland House 1-17	108,000	167	97,200	153
11	Morland House 18-34	110,000	169	98,900	155
12	Talbot Grove House	358,000	458	315,000	402
13	Talbot Walk	73,000	94	24,400	34
14	Testerton Walk 301-339 & 401-406	739,000	865	518,000	548
15	Treadgold House 1-38	262,000	391	149,000	243
16	Upper Talbot Walk	111,000	143	59,000	107
17	Verity Close 1-7	88,400	117	44,400	60
18	Verity Close 8-25	94,300	148	60,500	104
19	Verity Close 26-43	93,800	147	51,400	92
20	Verity Close 44-50	75,700	101	38,000	51
21	Verity Close 51-60	114,000	151	57,000	77
22	Verity Close 61-68	101,000	134	50,700	68
23	Kensington Aldridge Academy	881,000	444	881,00	444
24	Kensington Leisure Centre	1,830,000	695	1,830,000	695

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Demand Assessment

2.2 Demand maps – phasing

This page illustrates the potential phasing of the site. It is based on the feedback received from RBKC and site surveys conducted by Arup. RBKC have suggested that they envision site development to occur from the east of the site to the west. This is to mimic the potential retrofit installation on site. The timeline is still under discussion and may change in the future. The potential change will impact the DH demand phasing.

Keeping the above in mind Arup conducted a site survey to understand the potential ease and scale of connection for various buildings within the red line boundary.

Kensington Aldridge Academy is shown as the last connection on site as access to the current plant room is difficult and the current plant room is relatively new.

Figure 2.2.1 shows the recommended phasing on site.

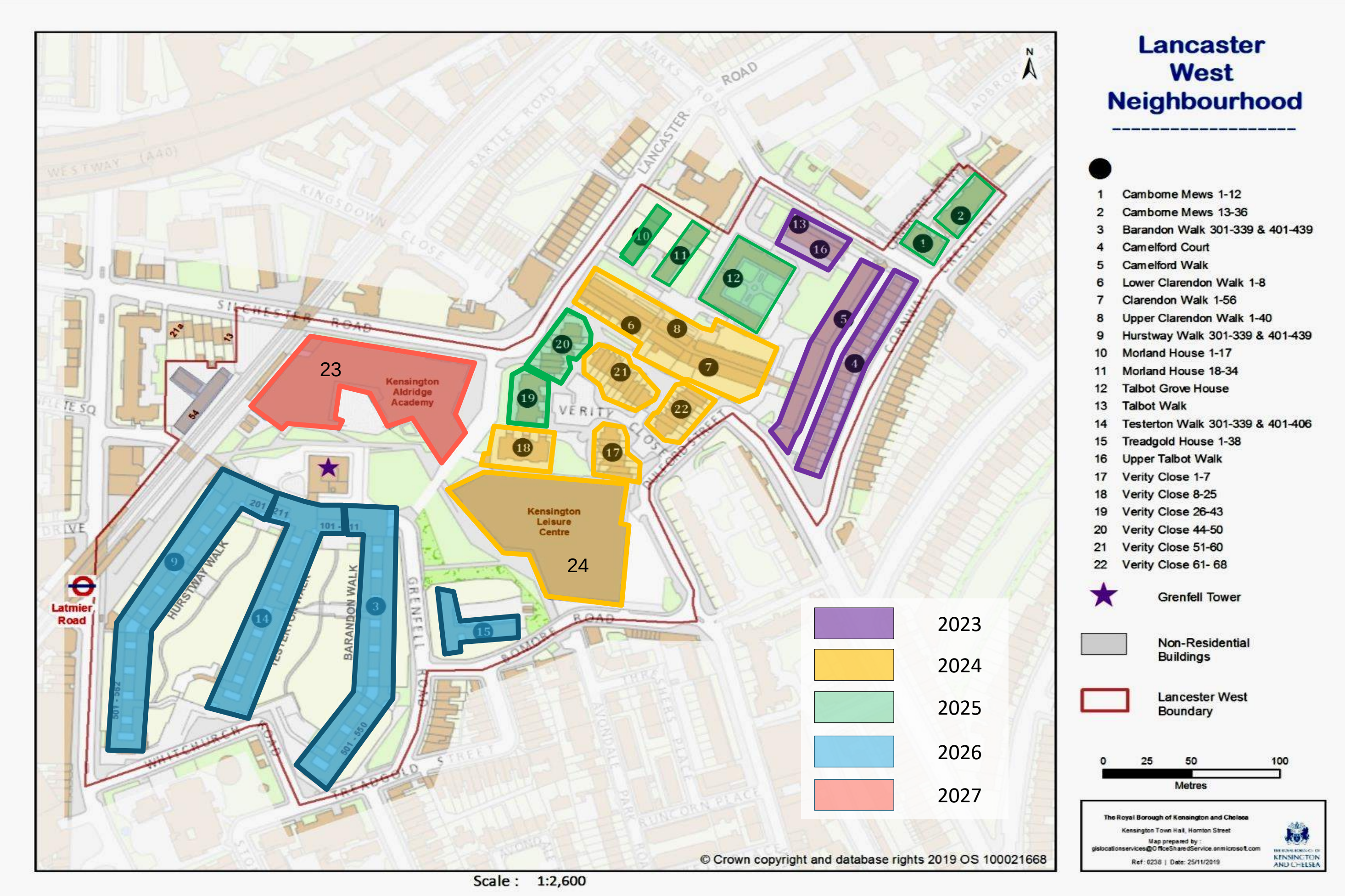

Figure 2.2.1: Phasing of the site

Demand Assessment
2.3 Demand modelling results

Figure 2.3.1 summarises the phased heat demand and heat peak connection to the DH scheme for packages 1 and 2.

As would be expected, both the peak demand and heat demand increase with the increased number of connection sites in all scenarios.

The Kensington Leisure Centre and Kensington Aldridge Academy represent approximately 26% and 35% of all demand in packages 1 and 2 respectively. This is expected as their demand stays constant while demand of the residential buildings reduces post retrofit.

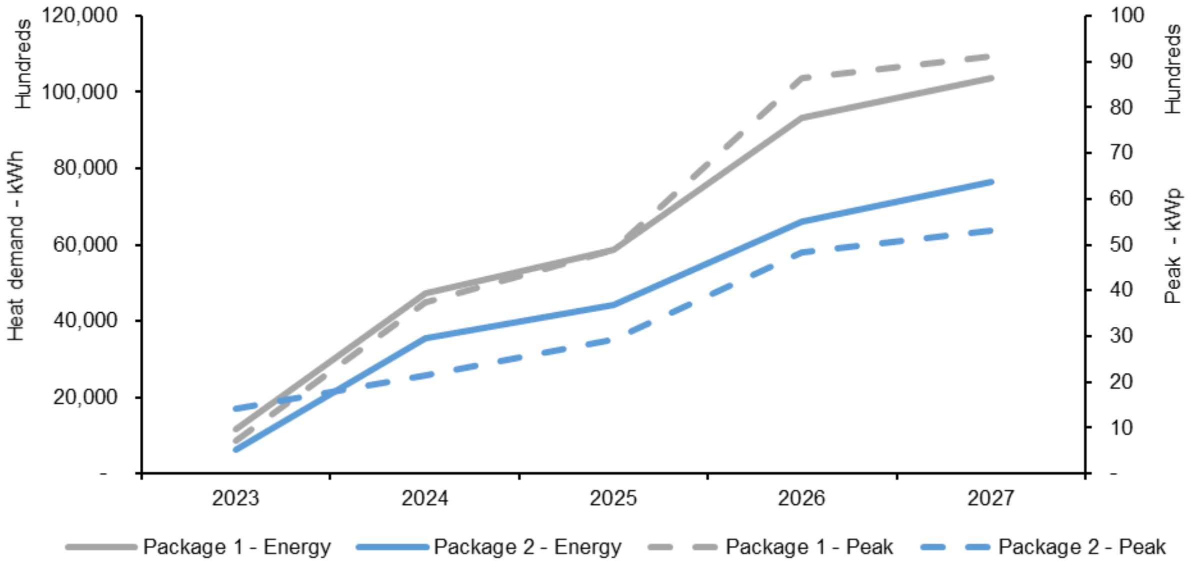

Figure 2.3.1: Networks' phased heat demands

Table 2.3.1: Networks' key numbers

Demand assessment	2023	2024	2025	2026	2027
Annual demand (Package 1)	1.2 GWh	4.7 GWh	5.9 GWh	9.3 GWh	10.4 GWh
Peak demand (Package 1)	0.7 MW	3.7 MW	4.9 MW	8.7 MW	9.1 MW
Annual demand (Package 2)	0.6 GWh	3.5 GWh	4.4 GWh	6.6 GWh	7.6 GWh
Peak demand (Package 2)	0.7 MW	2.1 MW	4.9 MW	4.8 MW	5.3 MW

Demand Assessment
2.4 Demand Risk Register

Table 2.4.1: Demand Risk Register

Title	Risk	Mitigation	Level pre-mitigation	Level post-mitigation
D1 – Projected heat demand data	The heat demand values have been provided by external RBKC consultants and are based on future energy efficiency measures. The real future heat demands can be different from what is assumed in the study.	Two different demand scenarios have been used and additional projection can be made for different demand values. Sensitivity analysis is discussed within Section 6 of the study to explore the case of connecting heat loads being lower than expected, either via operation of new buildings or energy saving measures being undertaken to existing ones.		
D2 – Increased cost of connection to existing buildings	Complications with interfacing heating systems in existing buildings proposed for connection increases the capital cost of connection, reducing the viability and business case for the network.	Site visits have been undertaken during the study and all proposed existing connections are technically feasible; works required have been summarised in section 3; cost of connection has been increased accordingly; a further sensitivity has been developed in Section 5 testing the increase in overall scheme CAPEX up to 30%.		
D3 – Lack of hourly metered data	The Leisure Centre and the Academy have no hourly metered data, but only annual or monthly data meaning the accuracy of the heat demand profiles is not consistent between loads.	Benchmarks and profiles from similar building or developments have been used. It is suggested that prior or during next phase meters have to be installed at least on the main loads plant rooms for increasing the accuracy of data		
D4 – Lack of robust data for new developments	Heat load data for the future buildings in this study has been projected using benchmark data due to absence or unavailability of real data. Benchmarked data may not reflect the actual data, for unforeseen reasons, when these real demands emerge.	The proportion of new development is relatively low: it is only represented by the academy expansion.		
D5 – Connections not materialising	The ultimate developer of the heat network may not be able to negotiate the connection of loads	The majority of the loads in all scenarios are RBKC owned.		

Chapter 3 – Building Connections and Internal Networks

Building Connections and Internal Networks
3.1 Introduction

Introduction

This section considers the connection of the heat network to and within each building. It includes the individual HIUs within each apartment and all the pipework within the buildings (e.g. risers, in basements etc) required to connect to the heat network at the building boundary. The pipework external to the building is discussed in Chapter 4. It should be noted that internal heating systems (radiators etc) are excluded from this study.

As shown in figure 3.1.1 at Lancaster West there are two existing heating network systems which supply heat to residential properties. There are also residential buildings with individual heating systems and non-residential building (the leisure centre and the academy) with their own energy centres.

It is assumed that all flats will be connected to the new low carbon district heating system and the old systems will be totally replaced.

In the following pages, the connection strategy for each building to the heat network is discussed in the context of the current heating system. The current heating systems were checked during site visits.

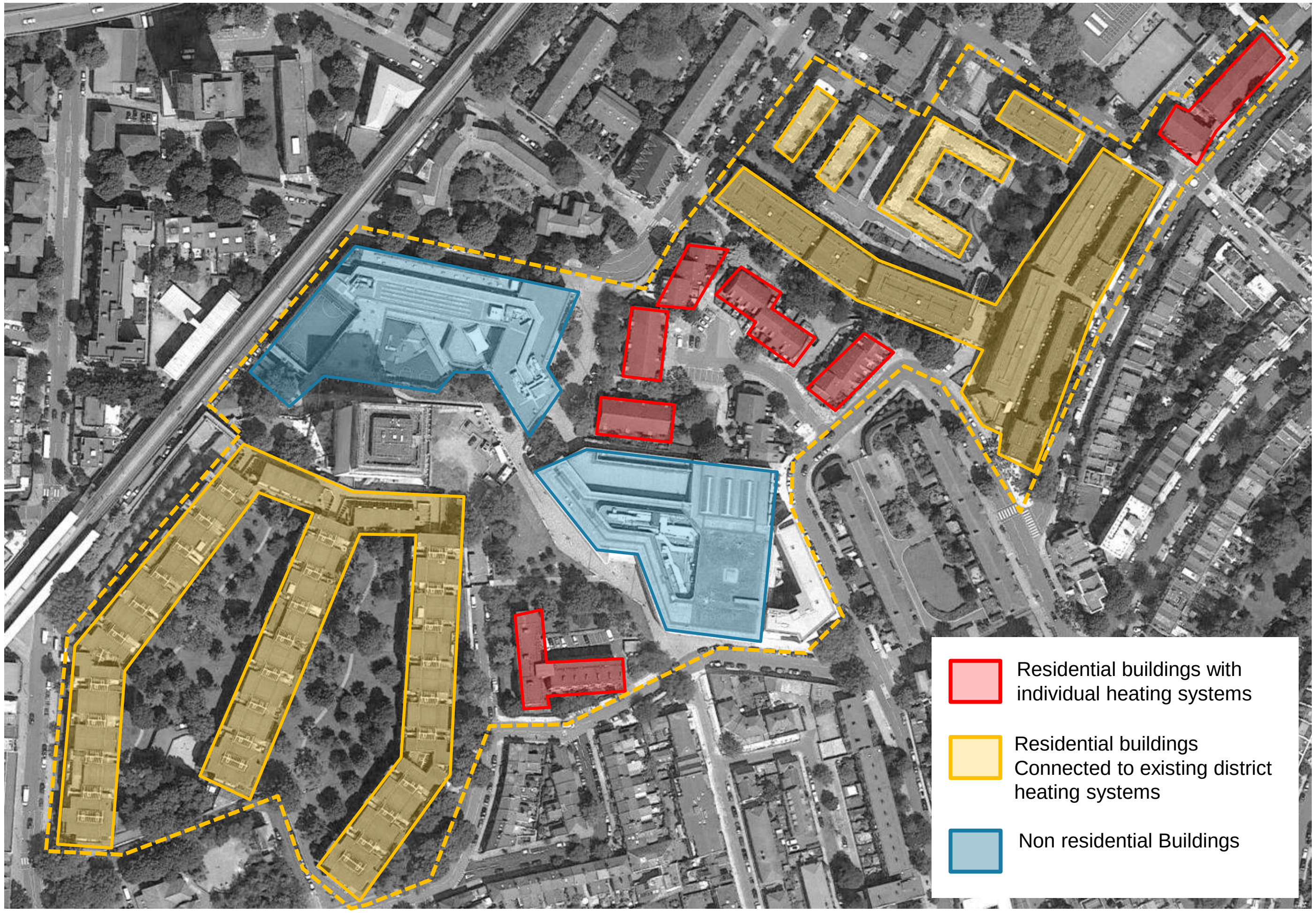

Figure 3.1.1: Site map and existing heating systems configurations

Building Connections and Internal Networks

3.2 Residential Building Connections

Barandon – Hurstway – Testerton Walk

Introduction

Barandon, Hurstway and Testerton Walks are three residential buildings which comprise 367 flats. They are connected at the north east end by two residential buildings known as Grenfell Walk. These buildings are currently (and are expected to remain) unoccupied.

Site survey and existing systems

The three building blocks are connected to a centralised heating system called LW1 operated by Engie. The system in the past was supplying heat also to the Grenfell Tower and to the Grenfell Walks. The energy centre was in the basement of the tower and after the incident, the supply of heat had to be moved to a temporary gas boiler located at the end of Testerton Walk (the central building).

The main distribution pipes run on the basement ceilings of the three buildings and during the site visit it was possible to check the location and to walk the entire length of these.

From the main distribution pipes secondary pipes distribute the heat to the above flats. Each riser serves the apartment in the floors above.

Inside the flats the distribution pipes separate in two sections, one for the space heating, which goes directly to the radiator circuit, the other goes in a water tank for the storage of the DHW.

There are no controls and the winter/summer operation of the heating system is managed by reversing the flow in the pipes. There is a non-return valve in the space heating circuits in all flats which blocks the hot water flow in summer in order to have heat only in the DHW storage section.

All circuits are primary without hydraulic separations. The system is old and in a temporary configuration. Therefore there will be a need to replace it in any future heating configuration scenario.

Figure 3.2.1: (clockwise from the top) aerial image of the building – Existing district network pipes – Temporary boiler in use

Building Connections and Internal Networks
3.2 Residential Building Connections
Barandon – Hurstway – Testerton Walk

Connection strategy

In case of connection to district heating the best strategy for the distribution pipes will be to follow the same location and routing of the actual communal heating pipes. During the site visit it was confirmed that there would be enough space to run the new pipes parallel to the existing ones. This would be required during installation as apartments will remain in occupation throughout and it will be important to ensure residents have heat at all times. The old pipes would be removed once the new system was fully commissioned. Then the flat connection would need to be done riser by riser.

Inside the flats the existing systems (i.e. hot water storage tank and associated pipework) needs to be replaced completely and, depending on the refurbishment strategy, radiators may also need to be replaced. Costs associated with secondary system refurbishment (i.e. radiators and internal piping) are not included in this study.

It is then suggested to plan the works preferably during summer season and to undertake all refurbishments measures to all flats connected to one riser and then pass to the following riser.

Temporary electric boilers need to be connected to the DHW circuits inside the flats while the refurbishment works take place and removed at the end of the works, when the HIU will be installed, tested and operative. The costs of these temporary solutions haven't been included in the model since these solutions will be needed in any refurbishment scenario. They are considered included in the RBKC refurbishment budget, which is not included in this study. It will be important for the council to ensure that these costs are appropriately accounted for within the refurbishment budget.

In terms of planning the works when the refurbishment inside the building starts the district heating network needs to be operative and capable to provide heat to the flats.

If the refurbishment works start before the completion of the main energy centre or the external district heating piping, some temporary boiler solution will need to be put in place.

At the end of all refurbishment works the temporary boiler located at Testerton Walk and the existing old distribution pipes can be removed. The removal of the boiler will happen in any refurbishment plan so the costs associated haven't been included in the model.

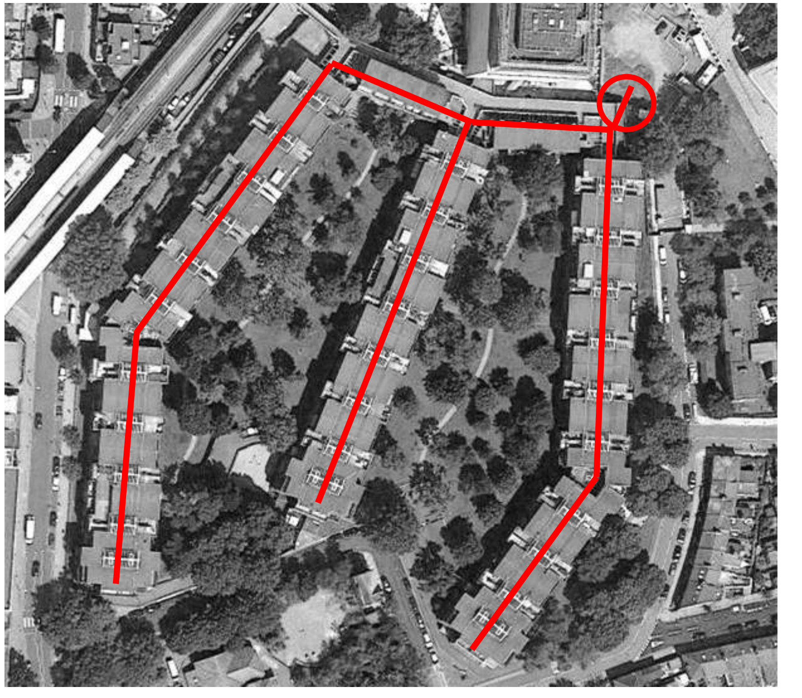

Figure 3.2.2: (clockwise from the top) Proposed internal pipe routing– Existing district network pipes – Temporary electric boiler to be used during the works

Building Connections and Internal Networks

3.2 Residential Building Connections

Camelford – Clarendon – Talbot Walk

Introduction

Camelford, Clarendon and Talbot Walks and Courts are four residential buildings located in the east side of the estate, comprising 206 flats.

Site survey and existing systems

The four buildings are currently connected to a communal heating system called LW3 operated by Engie which also connects to another three buildings in the estate. The energy centre is located at the end of Camelford Walk on the south side.

These four buildings connected to the LW3 can be considered separately because all distribution pipes run underneath the buildings on the ceiling of the basements, the other buildings connected to LW3 are then connected via pipes running along the paths and roads and need different considerations.

During the site visit it was possible to walk along all sections of the distribution pipes; the routing is all visible but comparing to LW1 the space is more congested due to the presence of storage areas.

The heat distribution circuit is similar to the LW1 one: from the main distribution pipes secondary pipes distribute the heat to the above flats. Each riser serves the apartments in the floors above and inside the apartments the circuits are in the same configuration with the non-return valve for the summer operation.

The energy centre is in good condition and with enough space for additional works. At the moment there are two groups of boilers in operation. The first group is composed of two Remeha boilers and the second by 6 Wessex Hamworthy modular boilers.

As for the LW1 all distribution systems are old and need replacement in any future heating configuration scenario.

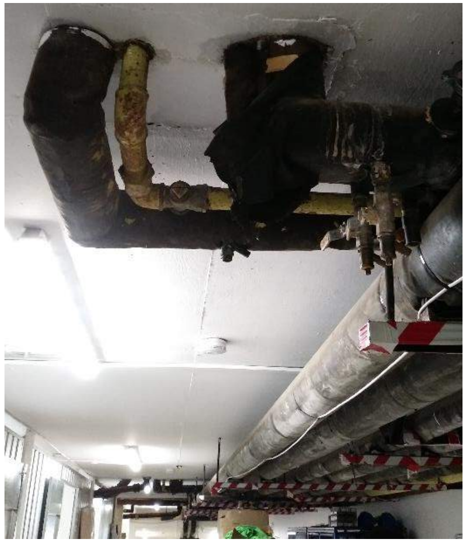

Figure 3.2.3: (clockwise from the top) aerial image of the building – Existing systems in the flats – Existing district heating pipes – Existing Boilers at the Energy Centre

Building Connections and Internal Networks

3.2 Residential Building Connections

Camelford – Clarendon – Talbot Walk

Connection strategy

The connection strategy to the district heating is similar to the LW1 one. The distribution pipes will be at the same location and following the same routing of the actual communal heating pipes. During the site visit it was checked that there is enough space to run the new pipes in parallel to the existing ones. In some sections the new pipes can create congestion with the existing system but it will be a temporary problem solved when the old pipes will be removed.

The connection to the district heating network will be in the same location of the existing energy centre, as shown in Figure 3.2.4.

It needs to be taken in consideration that the two systems must coexist until all the connections in the flats are finished, since the occupiers won't be asked to leave the flats during the refurbishments. Then the flat connections need to be connected riser by riser.

Inside the flats the existing systems (i.e. hot water storage tank and associated pipework) need to be replaced completely and, depending on the refurbishment strategy, radiators may need also to be replaced. Costs associated with secondary system refurbishment (i.e. radiators and internal piping) are not included in this study.

It is then suggested to plan the works preferably during summer season and to undertake all refurbishments measures to all flats connected to one riser and then pass to the following riser.

Temporary electric boilers need to be connected to the DHW circuits inside the flats while the refurbishment works take place and removed at the end of the works, when the HIU will be installed, tested and operative.

In terms of planning the works when the refurbishment inside the building starts the district heating network needs to be operative and capable to provide heat to the flats.

In case the refurbishment works start before the completion of the main energy centre or the external district heating piping, some temporary boiler solution need to be put in place. In the energy centre there is space which can be used for a temporary boiler to provide heat during the works.

At the end of all refurbishment works the old distribution pipes and any temporary solution will be removed.

As in the existing configuration, the network running underneath the building will connect also other buildings and the connection point are shown in the Figure 3.2.4 and analysed in the next section of the report.

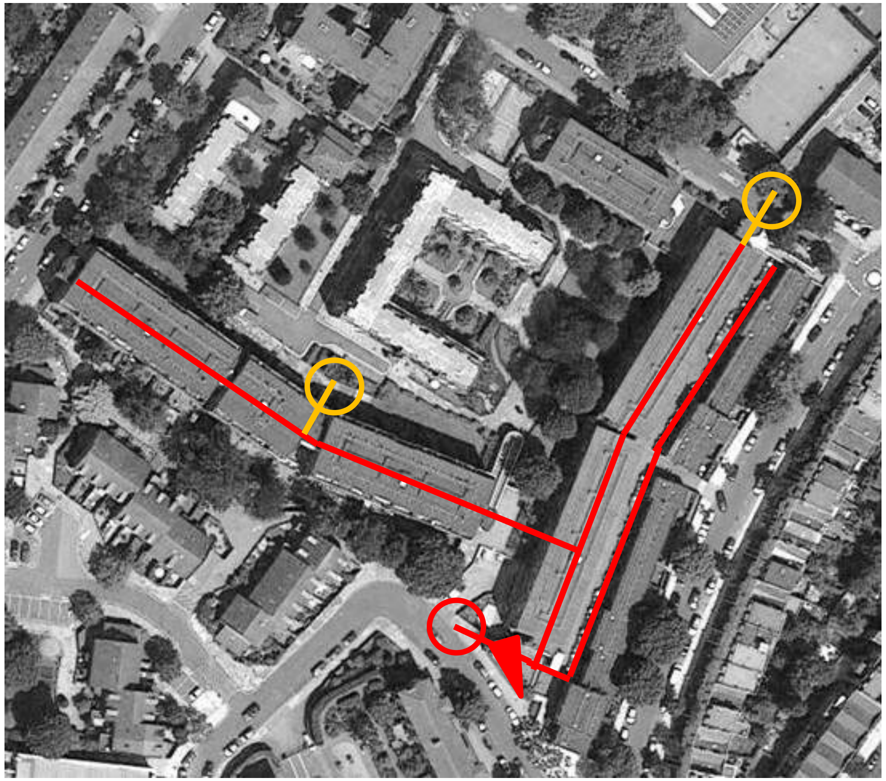

Figure 3.2.4: Proposed internal pipe routing

Building Connections and Internal Networks
3.2 Residential Building Connections
Morland House

Introduction

Morland House complex consists of two residential buildings located in the east side of the estate. The two buildings are symmetrical and host 17 flats each. All flats have a double exposure and the entrance from the balconies on the sides of the stairs.

Site survey and existing systems

Morland House buildings are connected to the LW3 communal heating system.

During the site visit was not possible to access the flat because they were all occupied but the meeting with Engie and RBKC, in addition to the private utilities drawing, gave a clear idea of the existing plant configuration.

The distribution pipes arrive from Clarendon Walk before they are divided in two circuits in the space between Morland House buildings and run up in the central open stairs and then enter in the flats. There can be some overheating problems at present and the new network with a better insulation will reduce this risk.

Inside the flats the heating distribution systems are similar to what already described for the other LW3 connections. There are tanks for the DHW and the non-return valve which excludes the space heating circuit during summer.

As for the other cases analysed all distribution systems are old and need replacement in any future heating configuration scenario

Figure 3.2.5: (clockwise from the top) Aerial image of the building – Existing district network pipes location – Aerial image of the building from the other side

Building Connections and Internal Networks
3.2 Residential Building Connections
Morland House

Connection strategy

The connection strategy for the Morland House building will be a little different from the other cases discussed so far.

The district heating pipes will arrive at the building via a similar route than the one used by the existing network, but the routing inside the buildings will be different. The central stairs can be used as risers as they are today, albeit with the pipes in a slightly different location, but the route into the flats needs to be different. Discussions with Engie confirmed that the best option would be to run the pipes along the balconies from the central stairs and to enter each flat from the ceiling.

It need to be considered that the two heating systems need to coexist during the refurbishment works in order to provide heat to the flats.

As per the other systems analysed, the existing systems needs to be replaced completely and, depending on the refurbishment strategy, radiators may also need to be replaced. It is then suggested to operate preferably during summer season and to operate all refurbishments measures to all flats connected to one riser and then pass to the following riser.

Temporary electric boilers need to be connected to the existing circuits inside the flats while the refurbishment works take places and removed at the end of the works, when the HIU will be installed, tested and operative.

The HIUs will be placed at the same locations used today for the water tank, which are in the first room behind the front wall.

Work will be minimal compared to other solutions and the external pipes can be easily hidden and incorporated in any façade refurbishment work.

In terms of planning the works when the refurbishment inside the building starts the district heating network needs to be operative and capable to provide heat to the flats. It is then suggested to start the works after the completion of the connections of Camelford, Clarendon and Talbot Walks and after the completion of DH external pipes installation.

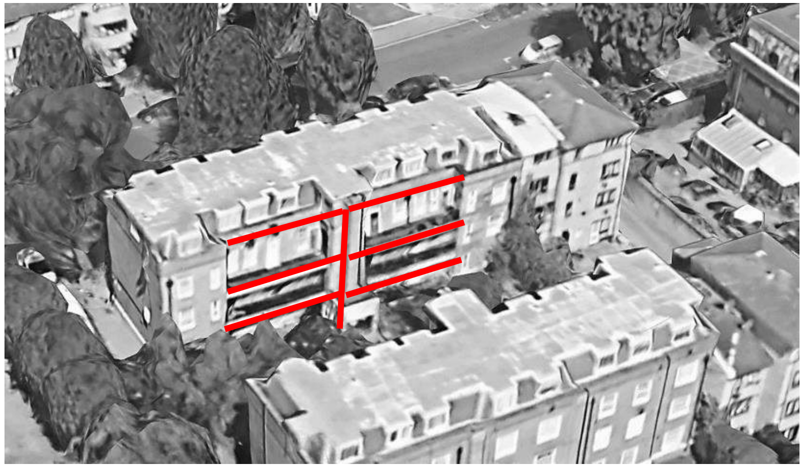

Figure 3.2.6: Top and bottom: Proposed pipe routing

Building Connections and Internal Networks

3.2 Residential Building Connections

Talbot Grove

Introduction

Talbot Grove is a C-shaped residential building located in the east side of the estate which hosts 45 flats. The building has three semi-open stairways in the middle of each side of the building. All flats have a double exposure and the entrance from the balconies on the sides of the stairs.

Site survey and existing systems

Talbot Grove is connected to the LW3 communal heating system.

During the site visit was possible to access unoccupied flats and check the existing heating systems.

The distribution pipes arrive from Clarendon Walk, before they run around the building and run up in each of the central open stairs and then enter in flats.

Inside the flats the heating distribution systems are similar to what already described for the other LW3 connections. There are calorifiers for the DHW and the non-return valve which excludes the space heating circuit during summer.

As for the other cases analysed all distribution systems are old and need replacement in any future heating configuration scenario.

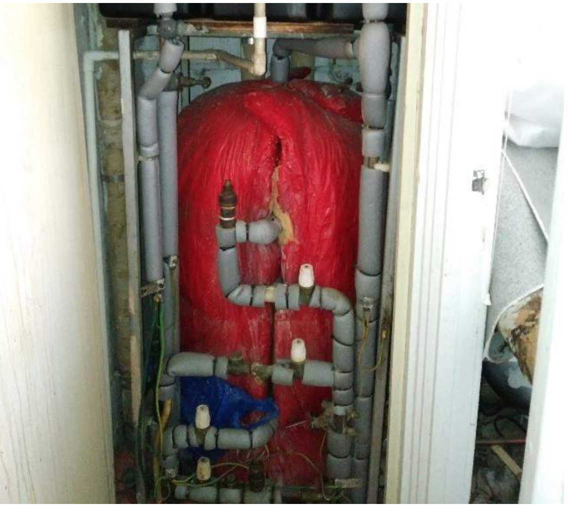

Figure 3.2.7: (clockwise from the top) aerial image of the building – Existing Systems in the flats – External stairs

Building Connections and Internal Networks
3.2 Residential Building Connections
Talbot Grove

Connection strategy

The connection strategy for the Talbot Grove building will be similar to the Morland House one.

The district heating pipes will arrive at the building via a similar route than the one used by the existing network, but the routing inside the buildings will be different. The central stairs can be used as risers as they are today, albeit with the pipes in a slightly different location, but the route into the flats needs to be different. Discussions with Engie confirmed that the best option would be to run the pipes along the balconies from the central stairs and to enter each flat from the ceiling.

It need to be considered that the two heating systems need to coexist during the refurbishment works in order to provide heat to the flats.

As per the other systems analysed, the existing systems needs to be replaced completely and, depending on the refurbishment strategy, radiators may also need to be replaced. It is then suggested to operate preferably during summer season and to operate all refurbishments measures to all flats connected to one riser and then pass to the following riser.

Temporary electric boilers need to be connected to the existing circuits inside the flats while the refurbishment works take place and removed at the end of the works, when the HIU will be installed, tested and operative.

The discussion with Engie about the best plant configuration concluded that the most viable solution will be to run the pipes along the balconies at all floors and enter the flats from the ceiling.

The HIUs will be placed at the same locations used today for the calorifiers, which are in the first room behind the front wall.

Work will be minimal compared to other solutions and the external pipes can be easily hidden and incorporated in any façade refurbishment work.

In terms of planning the works when the refurbishment inside the building starts the district heating network needs to be operative and capable to provide heat to the flats. Iti s then suggested to start the works after the completion of the connections of Camelford, Clarendon and Talbot Walks and after the completion of DH pipes installation.

Figure 3.2.8: Top and bottom: Proposed pipe routing

Building Connections and Internal Networks
3.2 Residential Building Connections
Camborne Mews

Introduction

The Camborne Mews is a complex composed of two residential buildings hosting 36 flats in total. It is located in the eastern side of Lancaster West and it is the only site dissected by a public road: St Marks Road.

Site survey and existing systems

The two buildings have independent heating systems in each flat consisting today in single gas boilers.

During the site visit was not possible to access the single units since there are not unoccupied flats and just and external inspection on the perimeter has been done.

The single boilers have the flue pipes on the façade of the buildings as shown in Figure 3.2.9; this can guarantee an access to the boiler room in case of connection to the district heating.

Being single systems the age of all of them can vary significantly depending on the replacements happened during the years. But in order to comply to the zero carbon targets these systems need to be replaced in any case in the near future with lower carbon systems.

Figure 3.2.9: Top and bottom: Aerial view of the building – Existing boiler flues

Building Connections and Internal Networks
3.2 Residential Building Connections
Camborne Mews

Connection Strategy

As stated before Camborne Mews has today single gas boilers for each flat with the flue pipes on the façade of the buildings. The pipe route inside the flat leads to the boiler location. This route is today occupied by the flue and hidden inside the flat walls and ceiling.

Using this route for the district heating pipes can represent an easy and non disruptive strategy to connect the flats to the central heating system.

From the road the district heating distribution pipes will run along the building, then in correspondence with today's boiler rejection points a twin distribution pipe will be hidden in a metallic pipe, appearing the same as a rain pipe which will run up to the roof.

From the twin pipe, in correspondence with the holes in the wall where the flues are located today smaller twin pipes will reach the place where the boilers are located today and in which the HIU will be installed.

The "false rain pipe" is a connection strategy quite common in the solar thermal industry when the pipes from the plant have to reach the plant room in a less disruptive as possible way.

The boiler and the flue pipe need to be removed before the installation of the new systems so, as for the other connections, is suggested to install a temporary electric boiler during the work and then remove it when the new plant has been installed and commissioned.

The works need to be done in sequence of flats. Being single heating systems it will be easier to operate to the single flats compared to the communal heating systems.

There is no place for locating temporary district heating supply for the connected flats, therefore when the works will start the district heating system heed to be operative and capable to supply heat.

It is then suggested to start the works after the completion of the connections of Camelford, Clarendon and Talbot Walks and after the completion of DH pipes installation.

Figure 3.2.10: (clockwise from the top) Pipe connection on the façade – Another view of pipe connection – Twin DH pipe

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Building Connections and Internal Networks
3.2 Residential Building Connections
Verity Close

Introduction

Verity Close is a complex of 68 flats distributed in 6 blocks of two-storey houses in the centre of the Lancaster West Estate. The complex is the only one in Lancaster West with freeholders (16) which can act independently of the RBKC suggestions. The implications of freeholders opting for different heating solutions would not be significant in terms of the technical feasibility and in the total heat demand.

Site survey and existing systems

All buildings have independent heating systems in each flat consisting today of single gas boilers.

During the site visit it was not possible to access the single units since there are no unoccupied flats and just an external inspection on the perimeter has been carrier out.

The single boilers have the flue pipes on the façade of the buildings located as shown in Figure 3.2.11; this can guarantee an access to the boiler room in case of connection to the district heating.

Being single systems the age of all of them can vary significantly depending on the replacements happened during the years. But in order to comply to the zero carbon targets these systems need to be replaced in any case in the near future with lower carbon systems.

Figure 3.2.11: Top and bottom: Aerial view of the building – Existing boiler flues

Building Connections and Internal Networks

3.2 Residential Building Connections

Verity Close

Connection strategy

The connection strategy to the Verity Close flats will be similar to that for the Camborne Mews flats.

The district heating distribution pipes will run along the buildings on the side of boiler flues and from there the twin pipes will reach the boiler location where the HIU will be installed.

Due to the individual heating systems and the number of freeholders the work can be done in steps regarding the final connections to the flats.

There is no place for locating temporary district heating supply for the connected flats, therefore when the works start the district heating system will need to be operative and capable of supplying heat.

The district heating distribution pipes can be installed during the connection of the Camelford, Clarendon and Talbot Walks to the energy centre and then the work inside the flats can be planned as preferred.

Figure 3.2.12: Internal road at Verity Close

Building Connections and Internal Networks
3.2 Residential Building Connections
Treadgold House

Introduction

Treadgold House is a residential building hosting 38 flats in the western part of Lancaster West Estate, close to Barandon, Hurstway and Testrton Walks.

Site survey and existing systems

All flats at Treadgold House are heated via individual boilers located inside the flats. The exhaust from the boilers are rejected via the flue pipes located in the façade, mostly in the internal balcony side of the building facing the car park. Two rejection points are on the other side as shown in Figure 3.2.13

During the site visit was possible to access two unoccupied flats in the building and check the existing systems.

As per the other flats not connected to a communal heating system, the age of boilers can vary significantly depending on the replacements happened during the years. But in order to comply to the zero carbon targets these systems need to be replaced in any case in the near future with lower carbon systems.

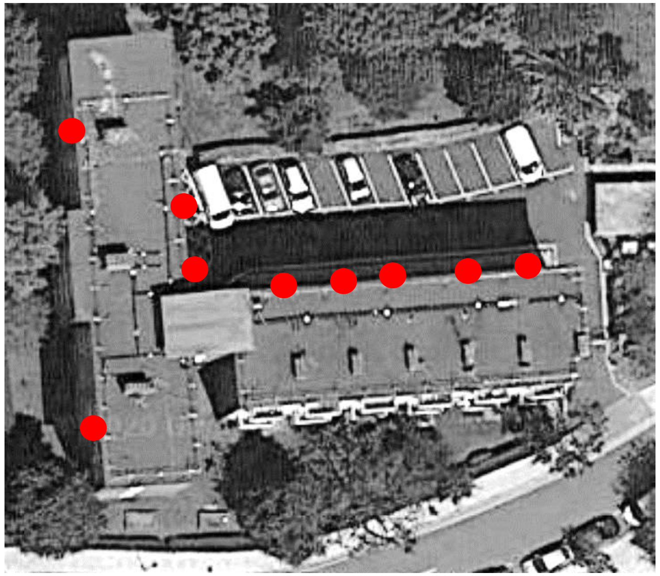


Figure 3.2.13: (clockwise from the top) Aerial image of the building – Existing Systems in the flats – Existing boiler flues locations

Building Connections and Internal Networks

3.2 Residential Building Connections

Treadgold House

Connection Strategy

As stated previously the existing boiler heating systems are rejecting the exhaust via the flue pipes located in the balcony.

As per other building the flue pipe route represents an easy way to access the boiler location in which the HIU will be installed.

In the specific context of Treadgold house, the distribution pipes can run on the façade in correspondence of the balcony ceilings as shown in Figure 3.2.14, then the connection pipes to the HIU will follow the same route used currently by the boiler flue pipes.

The boiler and the flue pipes need to be removed before the installation of the new systems so, as for the other connections, it is suggested to install a temporary electric boiler during the work and then remove it when the new plant has been installed and commissioned.

The works need to be done in sequence of flats. Being single heating systems it will be easier to operate to the single flats comparing to the communal heating systems.

There is no place for locating temporary district heating supply for the connected flats, therefore when the works will start the district heating system will need to be operative and capable of supplying heat.

For the connection points located on the other side of the building the connection strategy needs to be similar to the one used for Camborne Mews, with false rain pipes on the façade.

Figure 3.2.14: Pipe connection on the façade – Another view of pipe connection

ARUP

Building Connections and Internal Networks

3.3 Non-Residential Building Connections

Leisure Centre

Introduction

The Leisure Centre at Lancaster West is owned by RBKC and operated by Better. The complex hosts gyms, 3 swimming pools, sport courts and one café and has been operative since 2015. It is one of the two non residential loads in the estate and as discussed in the demand section of the report, represents an important heat load.

Site survey and existing systems

The heating system today in place is composed by two 850 kW boilers and one 100kWe CHP. All the heat is generated in the same plantroom located in the basement of the centre and then distributed around the building.

During the site survey it was possible to visit the plant room and the possible pipe routing for the connection to the district heating.

The heating system is relatively new and in good conditions but is a high carbon system which will need to be replaced in order to be compliant with the zero carbon targets of RBKC.

The CHP is generating electricity which is consumed by the leisure centre. In case of replacement of it with other systems the additional electricity demand will need to be considered.

The rooftop can host PV panels and during the discussion with the management it became clear that this option was analysed in the past and there are no plans for an expansion on the roof for facilities accessible to the public as sport courts. Therefore the rooftop can be considered available for PV installations.

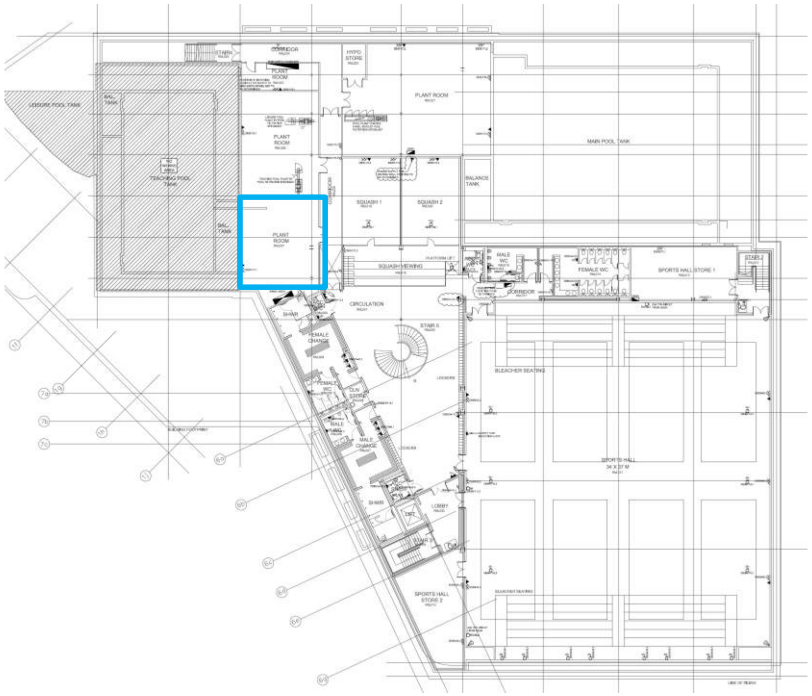


Figure 3.3.1: (clockwise from the top) Aerial image of the building – Existing Boilers – Energy Centre location

Building Connections and Internal Networks

3.3 Non-Residential Building Connections

Leisure Centre

Connection strategy

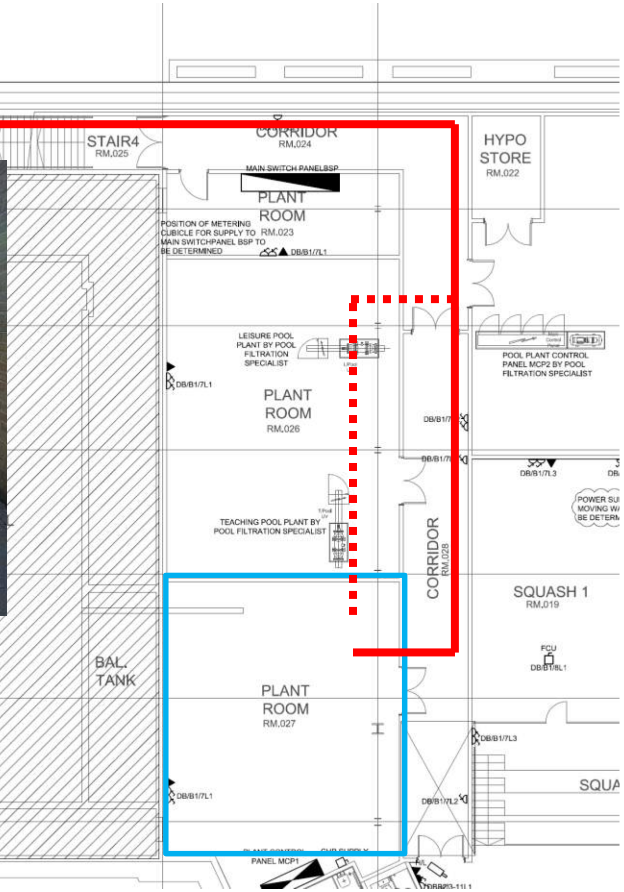
The easier access for the district heating will be from the path on the rear of the Leisure Centre. This path is closed to the public and hosts the connection to the gas network.

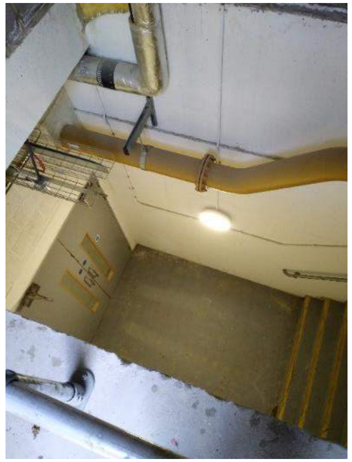
From the path, the district heating pipes can enter in the building using a location close to the gas pipe entrance and then follow the gas pipe route on the celling of the basement corridor up to the energy centre.

The pipe routing presents a more congested area in the proximity of the energy centre; if it will be found too complicated to follow the gas pipe the full length, an alternative routing will be possible entering the second plant room where there are the swimming pool plants and then reach the heating system plant room.

The energy centre has enough space for hosting the heat exchangers needed for the district heating connection without removing the existing boilers. The boilers can then be removed after the completion of works or left in their location to be used as a back-up system. The leisure centre has no planned closures during the year so the old system needs to work while connection works takes place and be removed after the new system is operating.

From the path is also possible to access a riser from where all components can be dropped to the basement level. This riser was used during construction and installations.





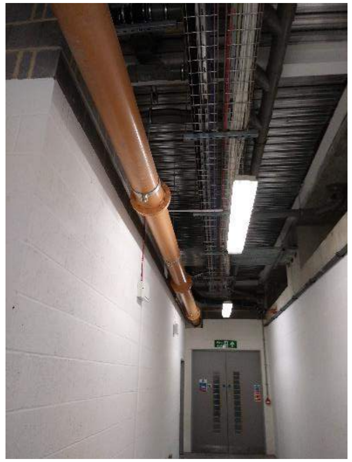


Figure 3.3.2: (clockwise from the top) Gas pipe routing – Gas pipe routing – Proposed DH pipe routing – External view of the connection point

Building Connections and Internal Networks

3.3 Non-Residential Building Connections

Kensington Aldridge Academy

Introduction

The Kensington Aldridge Academy is the second non residential building in Lancaster West Estate and the only building non owned by RBKC in the Estate. It occupies an area of 8400 sqm circa and there is a plan for a further expansion in the near future.

Site survey and existing systems

The heat supply at the academy is provided by a 2,500 kW gas boiler and 50 kWe CHP. All generation systems are located on the rooftop and the heat is then supplied to all the building.

There is also a PV plant located close to the energy centre which supplies electricity to the academy.

The heating system is relatively new and in good condition but it is a high carbon systems which will need to be replaced in order to be compliant with the zero carbon targets of RBKC.

The flow temperature was 67ºC which is acceptable for a heat pump based system, however it is suggested to test the reduction of flow temperatures in order to increase the efficiency of the system in case of connection to the district heating network.

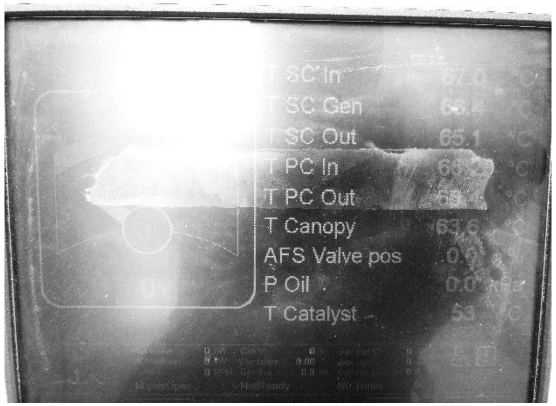


Figure 3.3.3: (clockwise from the top right) Aerial image of the building – Existing Boilers – Temperature of the CHP – Flow temperature of the existing system

Building Connections and Internal Networks
3.3 Non-Residential Building Connections
Kensington Aldridge Academy

Connection strategy

To connect the district heating network to the existing heat distribution systems at the academy the heat exchangers need to be placed on the rooftop close to the same location used today as energy centre.

The pipe route inside the building can be problematic. The risers to the rooftop are very congested and it does not seem possible to use them for the pipe routing. This should be investigated further.

One solution could be to dismiss the gas pipe and follow the same routing used today but this means that the existing system will not be able to operate during the works. Therefore the works need to be planned during a period of closure of the academy, maybe in correspondence with other refurbishment, otherwise a temporary electric boiler needs to be placed on the rooftop and operate during the works.

Another possible pipe routing is in a hidden location up to the external wall. During the site visit it was not possible to access all the perimeter and it is suggested that this opportunity be discussed with the academy management.

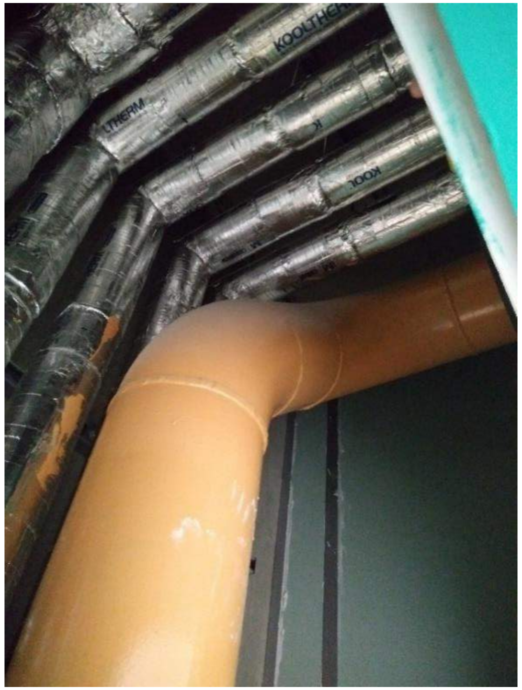


Figure 3.3.4: Left and right: Risers at the Academy

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Building Connections and Internal Networks
3.4 Risk Register

Table 3.4.1: Risk register

Title	Risk	Mitigation	Level pre-mitigation	Level post-mitigation
C1 – Occupied flats during works	The district heating works and the installation of HIU will happen while the flats are occupied. This concomitance can create delays and need additional work coordination	Specific connection strategies has been implemented for each building. The occupiers will be involved to verify that the best solution is suggested		
C2 – Parallel work of new and existing heating systems	Due to the concomitance of occupied flats and refurbishment work the existing heating system need to work in parallel with the new ones. The risk is the creation of congested pipe route, delays of works and unavailable heat for occupiers in case of unplanned issues	The connection strategy includes possible mitigation strategies for all the connected buildings. It is suggested to analyse the installation process in more detail.		
C3 – Connection to the Academy	Reaching the actual energy centre is problematic and the connection problem can cause the exclusion of the Academy as heating load.	The Academy as been considered connected to the DH in this study. There is the possibility to run the pipes externally but a better investigation needs to be undertaken during the next phase of the project. The connection is assumed to happen in 2027, therefore there is time to work on solutions.		
C4 – Building specific connection issues	Each building has several connection issues identified in this section of the report. In case these issues won't be assessed for each building the building won't be suitable for connection.	Specific connections strategies has been implemented for each building. Is suggested to undertake a specific feasibility study for the connection in each building.		
C5 – Internal pipes at the Leisure Centre	Internal pipe routing congested in some sections	Alternative route has been identified		

Chapter 4 – Network Routing

Network Routing
4.1 Introduction

As a part of the district heating network feasibility study for Lancaster West Estate ('the Estate'), Arup have undertaken a review of the feasibility of the external district heating network route from the heat source to the existing buildings at the Estate.

It is proposed that a single district heating network would serve the Estate with part of the network running externally, within the public realm and public/private highways and parts of the network running within the basements of the larger apartment blocks.

Please note that this section of the report covers the external sections of the district heating network only, typically defined as up until 1.0m from the building facade. Details of the building connections and internal parts of the network are covered in Section 3.

Level of detail

The high-level desk-top review of the network route included:

- Analysing buried utility record drawings sourced via Groundwise (Ref. 26041FM Rev 4). Note that CAD composite drawings were not obtained from Groundwise at this stage. Note that the Groundwise utility record reports will be provided separately due to the file sizes being too large.
- Analysing private utility as-built information (where available).
- The proposed network route has been assessed using Google Street View where possible. A site visit should be undertaken by a civil engineer at the next stage of the project to fully assess any above ground constraints.

Note that no horizontal or vertical coordination has been undertaken to date.

Proposed customers

The Royal Borough of Kensington and Chelsea's (RBKC) residential properties within the Estate are the priority for the project.

The non-residential buildings to be connected to the district heating network include the Kensington Leisure Centre and Kensington Aldridge Academy.

Building connection points

Please note that the building connection points for the buildings not currently connected to a communal heating network are assumed, based off existing boiler locations, as described in Section 3. The building connection points are to be confirmed as the design develops.

Key risks

The risks associated with the external network route are detailed in section 4.9. Listed below are three key risks to the proposed network route:

- The presence, condition and exact vertical/horizontal alignment of existing private utilities are a significant risk for the network route.
- The presence of underground features such as buried structures and basements is not yet fully understood and also poses a risk to the external network route.
- The presence of mature trees across the site has the potential to significantly impact on the final network route and the required construction methodology.

To mitigate these risks, a GPR survey should be undertaken which confirms the presence of below ground constraints early in the next stage of the project. A topographical survey confirming the presence of above ground constraints will also be required to develop the district heating network route in a way that minimises the impact on the hard and soft landscaping.

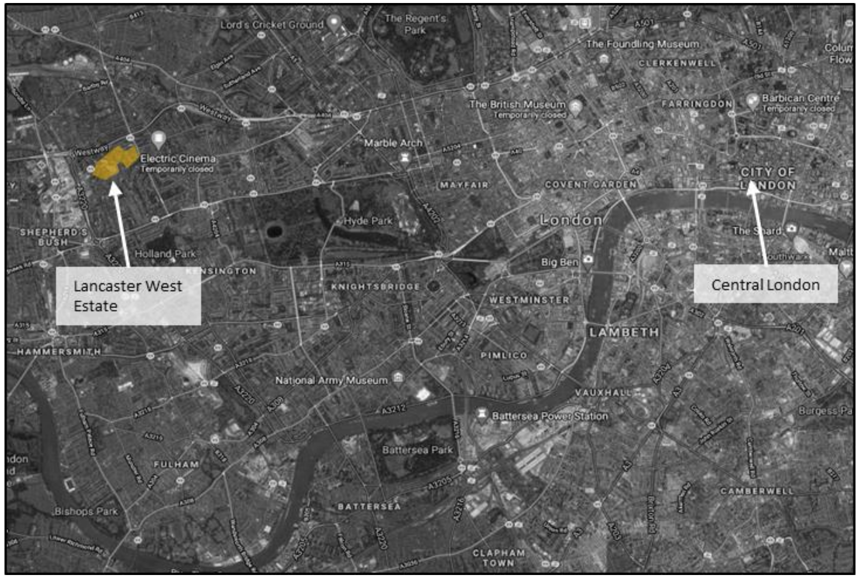

Figure 4.1.1: Lancaster West Estate Site Location Plan *(sourced from Google Maps, April 2020)*

Network Routing
4.1 Introduction

Desktop Review Limitations

Due to the circumstances related to the COVID-19 virus, a site visit by a civil engineer from Arup has not been possible for this study.

Figure 4.1.2 highlights the areas for which Google Street View was available and those where it was not.

In addition to reviewing Google Street View imagery, the following was available:

- RBKC provided site photos to aid the study.
- A senior engineer from the Arup Energy and Climate Change Consulting team provided photos from a site visit and confirmed building connection locations.

It is recommended that the next stage of the project would include a civil engineer undertaking a site visit to visually assess the entire proposed network route and review any above ground constraints.

Refer to Appendix B for a collation of site photos.

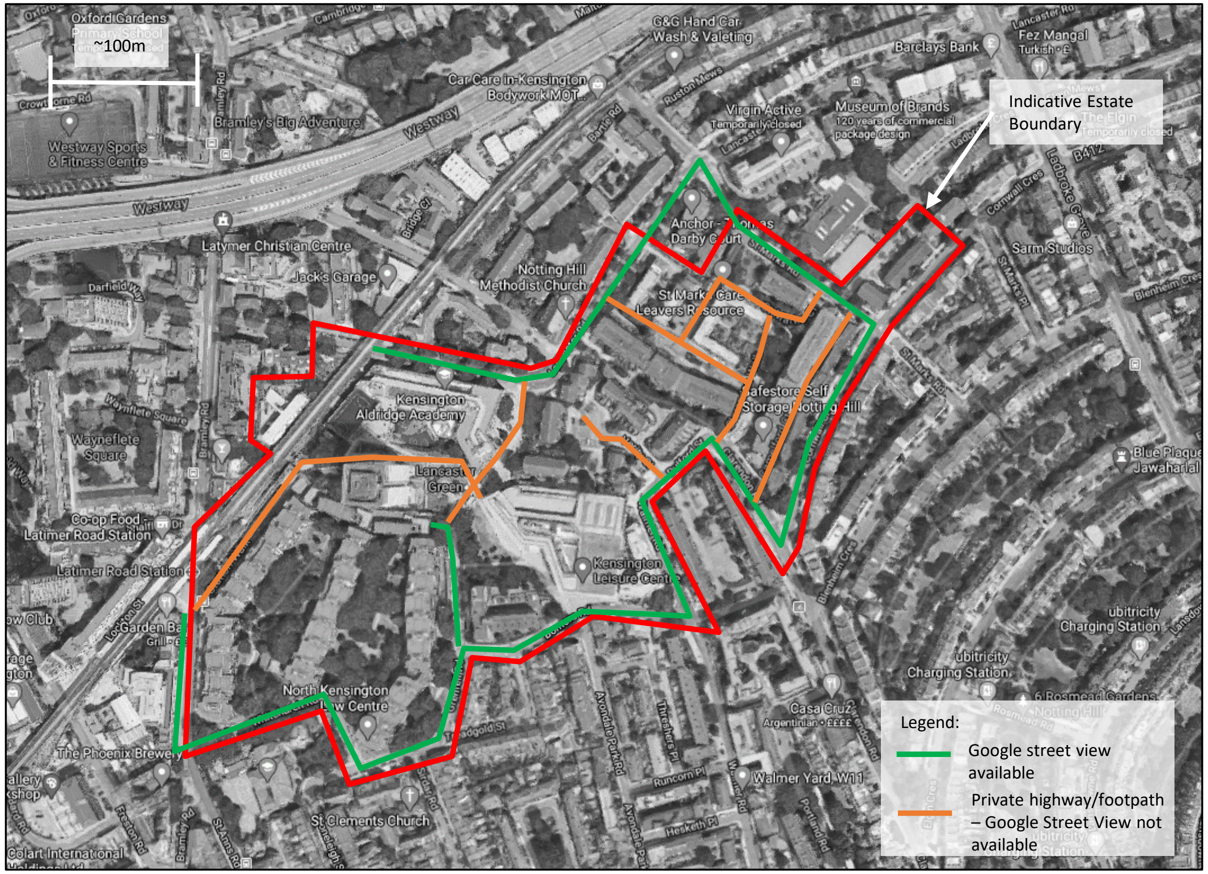

Figure 4.1.2: Lancaster West Estate desktop review extent *(sourced from Google Maps, April 2020)*

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Network Routing

4.2 Proposed Network Customers

Table 4.2.1 summarises the customers for the proposed district heating network. The customers have been defined as the existing buildings, as shown in Figure 4.2.1, to which it is proposed the district heating network will connect.

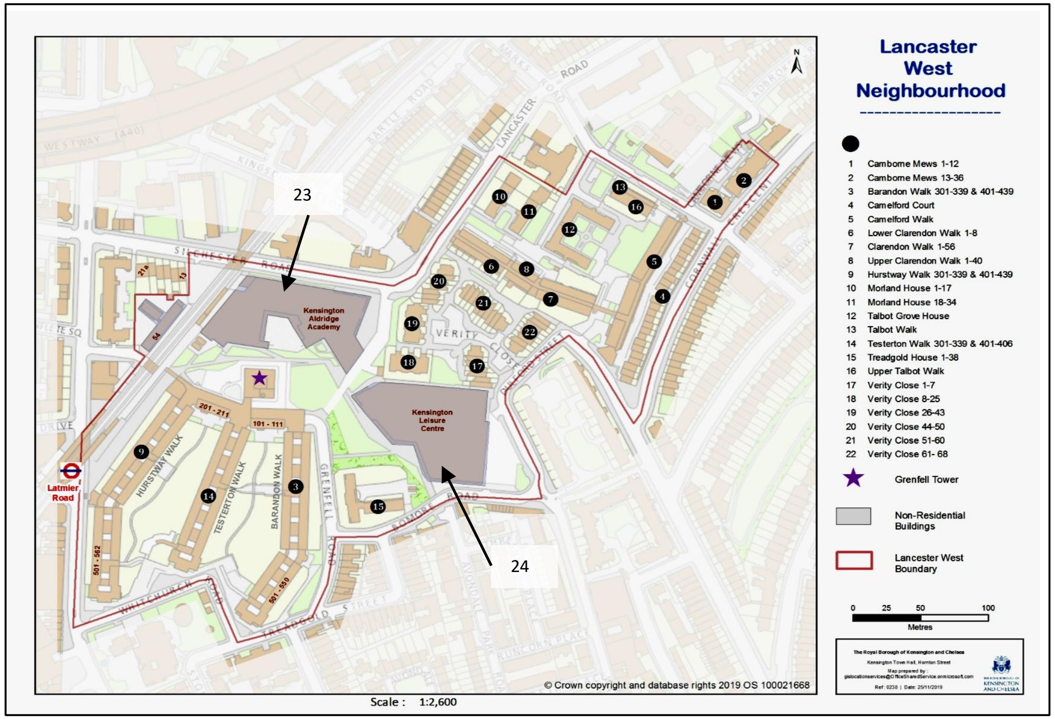

Figure 4.2.1: RBKC Map showing Lancaster West Estate

Table 4.2.1: District heating network route proposed customers

Customer ID #	Building Name	Typology
1	Camborne Mews 1-12	Residential
2	Camborne Mews 13-36	Residential
3	Brandon Walk 301-339 & 401-439	Residential
4	Camelford Court	Residential
5	Camelford Walk	Residential
6	Lower Clarendon Walk 1-8	Residential
7	Clarendon Walk 1-56	Residential
8	Upper Clarendon Walk 1-40	Residential
9	Hurstway Walk 301-339 & 401-439	Residential
10	Morland House 1-17	Residential
11	Morland House 18-34	Residential
12	Talbot Grove House	Residential
13	Talbot Walk	Residential
14	Testerton Walk 301-339 & 401-406	Residential
15	Treadgold House 1-38	Residential
16	Upper Talbot Walk	Residential
17	Verity Close 1-7	Residential
18	Verity Close 8-25	Residential
19	Verity Close 26-43	Residential
20	Verity Close 44-50	Residential
21	Verity Close 51-50	Residential
22	Verity Close 61-68	Residential
23	Kensington Aldridge Academy	Commercial
24	Kensington Leisure Centre	Commercial

Network Routing
4.3 Existing Heating Networks

Existing communal heating networks

The RBKC owned residential buildings within the Estate are currently served by two separate communal heating networks as described below and shown indicatively in Figure 4.3.2. Engie maintains and manages these existing communal heating networks.

LW1 - South-west of the Estate

There is an existing communal heating system serving LW1, originating at Energy Centre 1, as shown in Figure 4.3.2. This network is understood to serve Brandon Walk, Hurstway Walk and Testerton Walk, running internally within the building basements from the existing Energy Centre, which utilises gas boilers as the heat source.

RBKC have provided two drawings (Ref: C423/1/H221 dated 1970 and CRD/1/119 dated 1975) showing the configuration of this network (Appendix C).

It is understood that no part of this network is situated within the public realm or highways.

LW3 - North-east of the Estate

Engie have confirmed the presence of an existing communal heating network, serving LW3, originating at Energy Centre 2. The existing Energy Centre, shown in Figure 4.3.2, utilises gas boilers as the heat source. The heating network is understood to serve Camelford Walk, Camelford Court, Lower Clarendon Walk, Clarendon Walk, Upper Clarendon Walk, Morland House, Talbot Walk, Talbot Grove House and Upper Talbot Walk. The network route is situated internally within building basements, in external public realm and also within private highways.

RBKC have provided a drawing (Ref: 1110 08 A) showing the configuration of this network, dated November 1975 (Appendix C). The flow and return pipes are shown to run in a single trench with at least 540-600mm cover over the pipes. The pipes vary between 62mm - 100mm diameter. There are two valve pits and a bellows pit on the heating network, south of Talbot Grove House. The exact external alignment of this network should be confirmed through a GPR survey at the next stage of the project.

Engie have confirmed that this existing communal heating network is in very poor condition, with several repairs undertaken recently due to leaks. Engie recommend that this network is replaced during the refurbishment works.

Phasing

RBKC have confirmed that although both of these networks will be replaced, they must remain live during the works. The networks would be decommissioned following the completion of the proposed district heating network to minimise disruption to the tenants.

Figure 4.3.1: Existing Energy Centre 2
(sourced from Google Street View April 2020)

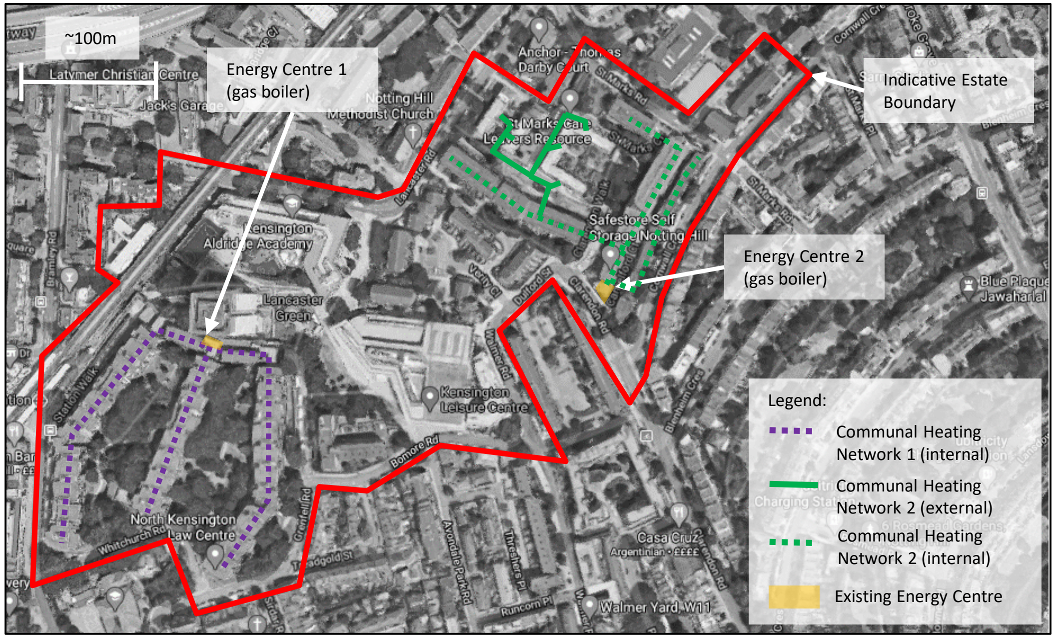

Figure 4.3.2: Indicative existing communal heating network routes

Network Routing
4.4 Private Utility Records

The Groundwise utility record search has provided public utility records but not private utility records. As an example, Figure 4.4.1, showing the RBKC buildings in the north-eastern portion of the Estate, illustrates that only the public sewers are displayed on the Thames Water maps. Figure 4.4.2 shows the private surface water network associated with Morland House, these networks are not displayed on the Thames Water maps.

The RBKC have provided access to various historic design and as-built drawings for the Estate, the vast majority of which are from the 1970s. This information has been used to provide some indication of private utilities within the Estate, including surface water networks and existing communal heating networks. However, it is unclear if these records are complete and it is possible that additions or alternations may have been made to the utility networks since the drawings were completed.

In order to fully understand the impact of these private utility networks on the district heating network route, a utility survey should be undertaken along the proposed network route to confirm the presence of all existing utilities and below ground structures/constraints.

Refer to Appendix C for the most relevant private utility records provided by the RBKC.

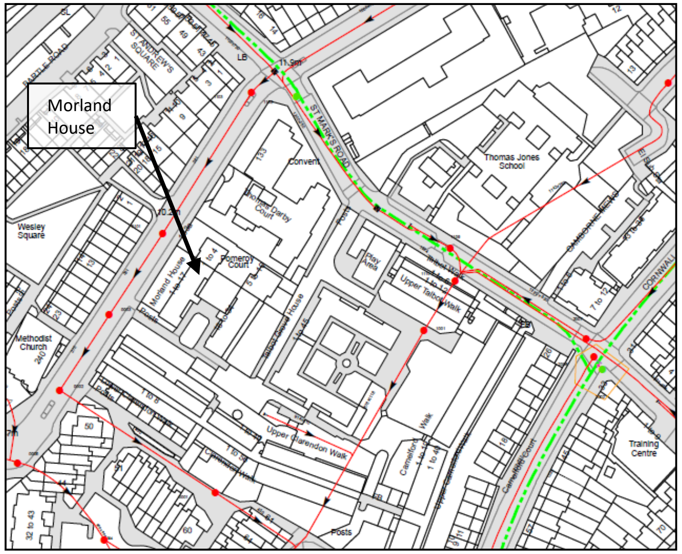

Figure 4.4.1: Thames Water Utility Record for the north-east portion of the Estate

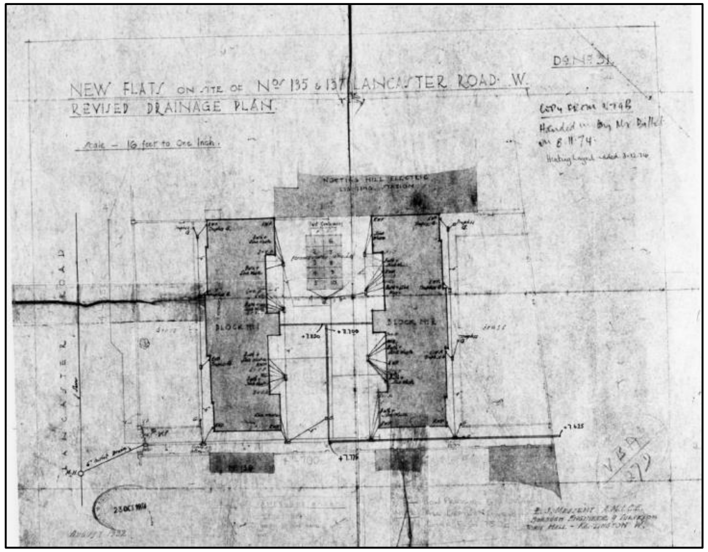

Figure 4.4.2: Historic private surface water record for Morland House *(provided by RBKC)*

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Network Routing
4.5 Proposed External Network Route

The proposed district heating network would replace both of the existing communal heating networks and connect additional buildings that were previously served by individual boilers. The primary focus would be to serve the residential buildings at the Estate and decommission the existing communal heating networks which are in poor condition.

The external, insulated, flow and return pipes would be laid in a single trench along the route shown in Figure 4.5.1, where space permits, with at least 900mm cover. At crossing points with other utilities, the depth of cover may vary. Pipe protection should be considered if the cover depth is reduced. Refer to the tiles on Figure 4.5.1 which show the areas of focus on pages 48-58.

It is likely that either pre-stressed pipes or expansion loops will be required. Space proofing of these network features would follow in later design stages.

Approximately 56% and 44% of all pipework is external and internal hard dig pipework respectively.

Network length

The approximate preliminary lengths of the proposed network, not accounting for vertical changes of alignment, are:

- Internal network: ~1.0 km
- External network: ~1.26 km

Land Ownership

It is anticipated that the network will be routed through the RBKC Estate where possible (footpaths, private highways and public realm). However, there is one public highway crossing required to serve Camborne Mews.

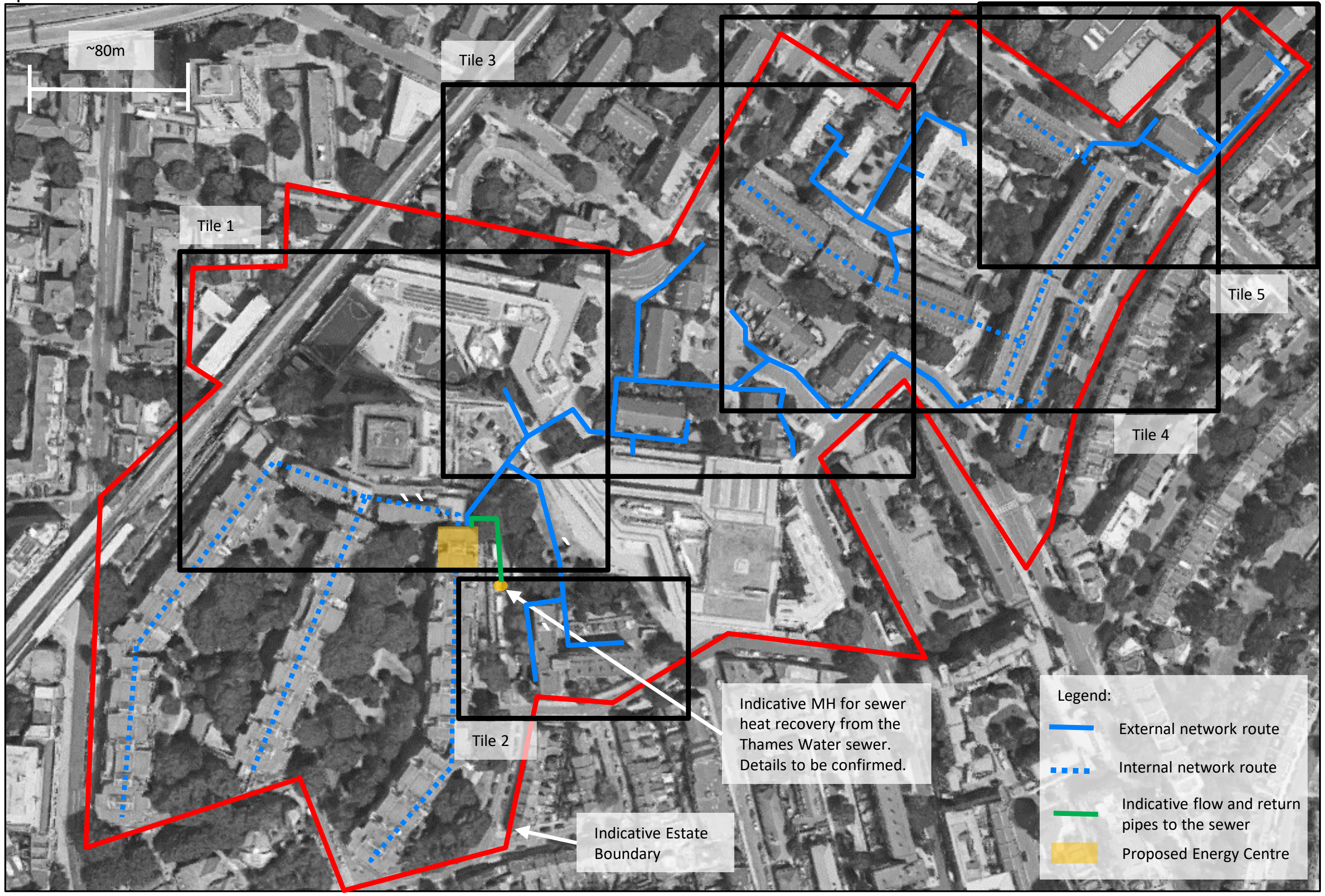

Figure 4.5.1: Proposed External District Heating Network Route

Network Routing

4.6 Network features and constraints

A desktop study has been used to identify existing site features and constraints which impact on the proposed external district heating network as summarised in Tables 4.6.1 – 4.6.11. Refer to Appendix D for indicative utility alignments at pinch points.

Table 4.6.1: Route features and constraints

ID	Route features & constraints	Constraint Notes	Related Risks
1.1	Connection to the Testerton Walk, Hurstway Walk and Brandon Walk	Testerton, Hurstway and Brandon Walk are currently served by communal heating pipes running from the existing Energy Centre (refer figure 4.6.1), through each building attached to the basement level roof as described in section 3. These buildings would be connected to the proposed Energy Centre via an internal network within the basements, following a similar alignment as the existing communal heating network.	R1 and R13
1.2	Proposed Energy Centre	The proposed Energy Centre would be located within the northern basement of Brandon Walk, as shown indicatively in Figure 4.6.1. Refer to section 5 for more details. The flow and return pipes to serve Brandon Walk would be routed internally within the energy centre from the pumps on the northern side to the southern side of the proposed Energy Centre, and continuing south within the basement.	R2
1.3	UKPN network Crossing	The proposed network route crosses an existing UKPN LV and HV network, originating at an existing substation within Grenfell Tower, at these approximate locations.	R4
1.4	Connection to the Kensington Aldridge Academy	A suitable point of connection for the Kensington Aldridge Academy is yet to be agreed. Due to the significant level differences posed by the open basement level courts this building connection may be challenging. The southern side of the Academy was blocked at the time of the RBKC visit in which photos were provided. No obvious plant room access was observed when the Arup (non-civil) site visit was undertaken. Further consultation is required to coordinate the building connection point which minimises disruption to the relatively new building façade and adjacent public realm. The Cadent and UKPN asset maps do not show this recent development so these could not be used to assume a plant room location.	R10

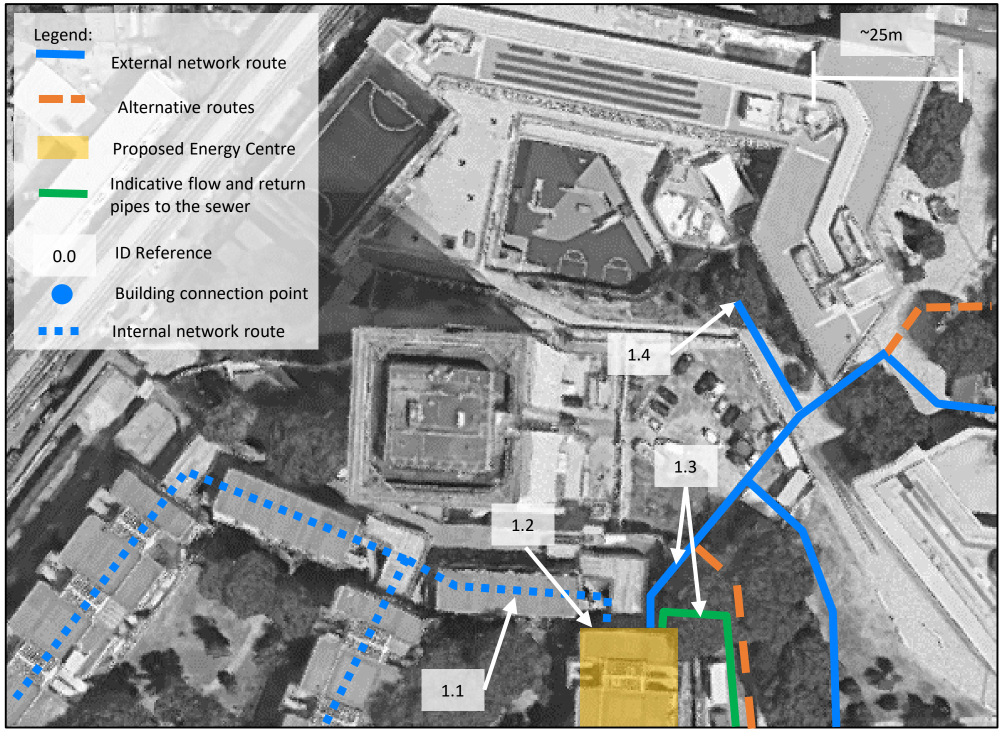

Figure 4.6.1: Proposed external district heating network route features and constraints (Refer Tile 1, Figure 4.5.1)

Network Routing

4.6 Network features and constraints

Table 4.6.2: Route features and constraints

ID	Route features & constraints	Constraint Notes	Related Risks
1.5	Existing BT Cabinets	The BT Openreach asset maps show an existing BT Openreach cabinet and also a second proposed cabinet (which may have been installed by the time the district heating network is installed) directly to the north of Brandon Walk. These cabinets were not visible on Google Street view so their exact locations are not currently understood. Once the final location of these BT cabinets has been confirmed on site, any diversions required as a result of the proposed district heating network and energy centre would need to be agreed with Openreach in advance. If a diversion is needed, BT would likely undertake a site survey of their assets and propose new locations, at the cost of the Client.	R4
1.6	Mature trees	There are mature trees across the site. Minimum typical offsets should be considered when defining the final network route to minimise the impact of the proposed pipes on the soft landscaping. It is likely that where the network passes close to trees, root protection will be required, including hand digging of the utility trench.	R5

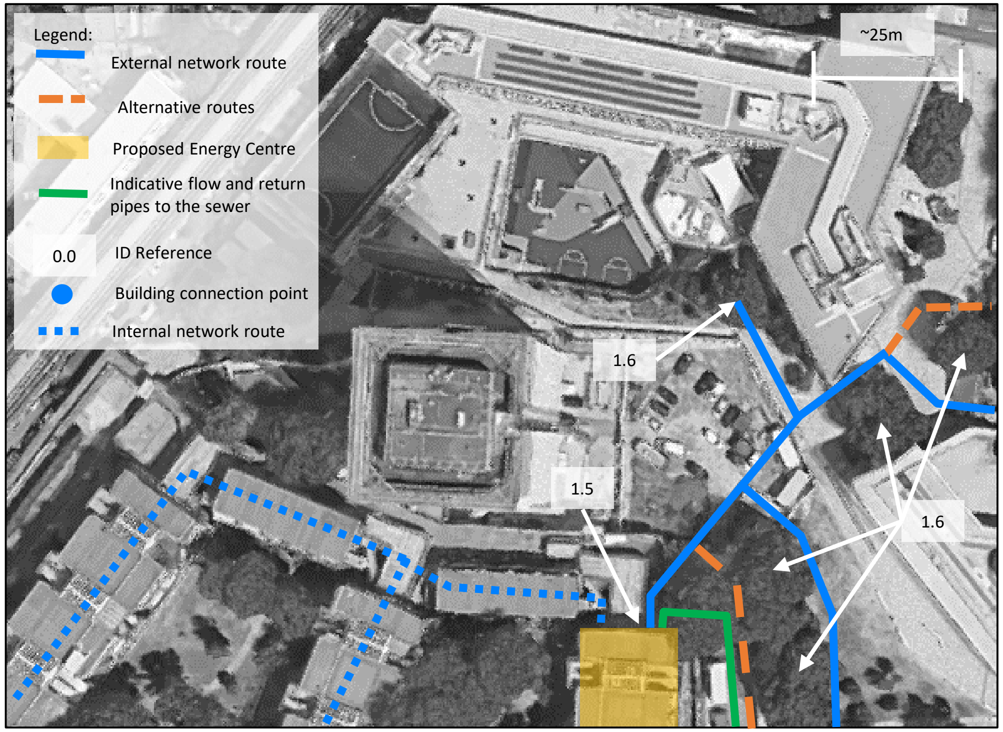

Figure 4.6.2: Proposed external district heating network route features and constraints (Refer Tile 1, Figure 4.5.1)

Network Routing

4.6 Network features and constraints

Table 4.6.3: Route features and constraints

ID	Route features & constraints	Constraint Notes	Related Risks
1.7	Large Sewer	A 1830mm diameter Thames Water combined sewer at an approximate depth of 2.3 m (to soffit) passes through the site in this approximate location. It is proposed that sewer heat recovery will be utilised from this sewer, pending further consultation with Thames Water and design from a suitably qualified consultant (refer section 5). The district heating network would cross above this sewer to serve Treadgold House.	R4
1.8	Alternative route in highway	If the proposed route cannot be proven (following onsite surveys and a site walkover), the alternative route, within the public highway may be considered. It should be noted that where the connection is made from the highway, to the building, a low-lying brick wall and mature hedge will be crossed.	R4 and R6
1.9	Mature trees	Refer to information provided in the constraint notes for ID 1.6 for more details.	R5
1.10	Existing public utilities	The Groundwise utility record report identifies BT, electrical and gas infrastructure in a similar alignment to that of the proposed district heating network. A GPR survey confirming these alignments, undertaken in later design stages, will be used to inform the final district heating network route.	R4
1.11	Existing private utilities	It is anticipated that there will be existing private utilities near to the proposed route (i.e. drainage) which may impact on the final alignment of the district heating network. A site walkover, GPR survey and manhole survey are required to confirm the alignments of these private utilities.	R4
1.12	Expansion Opportunity	Note the 'future expansion' pipe shown in this location. This pipe is provided for potential future expansion to the south, as requested by the RBKC. Details of the RBKC developments to the south are currently unknown and so this part of the network is to be considered at in future design stages and is indicative only. Refer to section 2 for more details.	R2

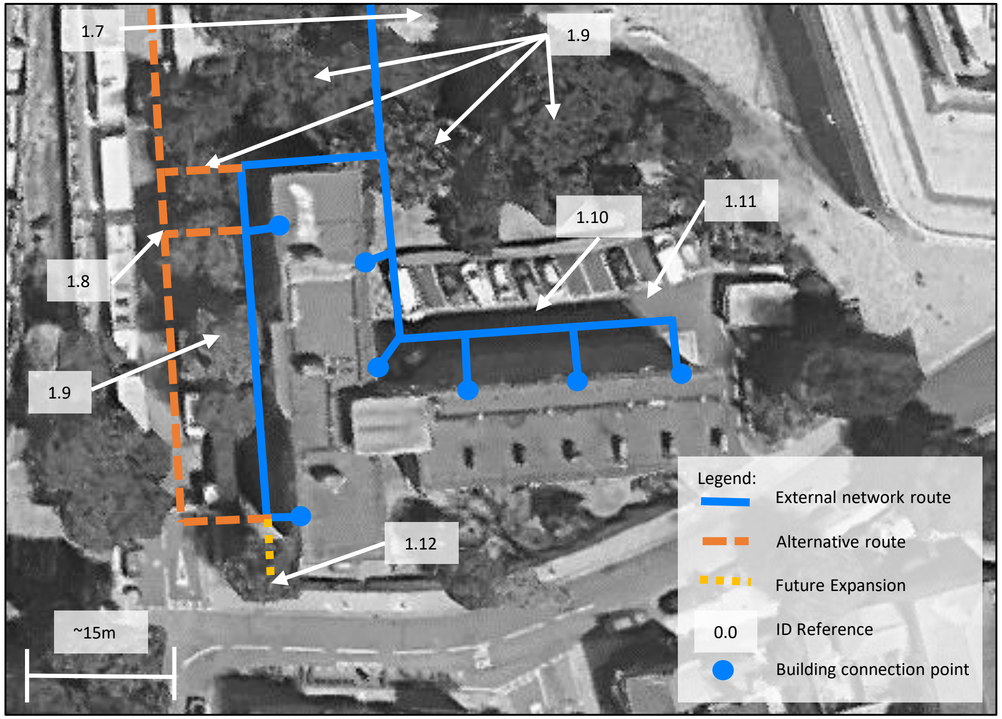

Figure 4.6.3: Proposed external district heating network route features and constraints (Refer Tile 2, Figure 4.5.1)

Network Routing

4.6 Network features and constraints

Table 4.6.4: Route features and constraints

ID	Route features & constraints	Constraint Notes	Related Risks
1.13	Lancaster Green	The proposed network route would cross the south-eastern corner of Lancaster Green. It is understood that it is planned that Lancaster Green is to be used as a memorial space. There is a risk that if the memorial is built prior to the district heating network, the network route may need to be adjusted to avoid crossing Lancaster Green.	R14
1.14	Mature trees	Refer to information provided in the constraint notes for ID 1.6 for more details.	R5
1.15	UKPN Substation	A UKPN Substation is at this location, it is assumed this will remain in-situ.	R4
1.16	UKPN network Crossing	The proposed network route crosses existing UKPN LV and HV duct networks, originating at a substation (as shown by 1.15), at this approximate location.	R4
1.17	Expansion Opportunity	Please note the 'future expansion' pipe shown in this location. This pipe is provided for potential future expansion to the north, as requested by the RBKC. Details of the RBKC developments to the north are currently unknown and so this part of the network is to be considered at in future design stages and is indicative only.	R3

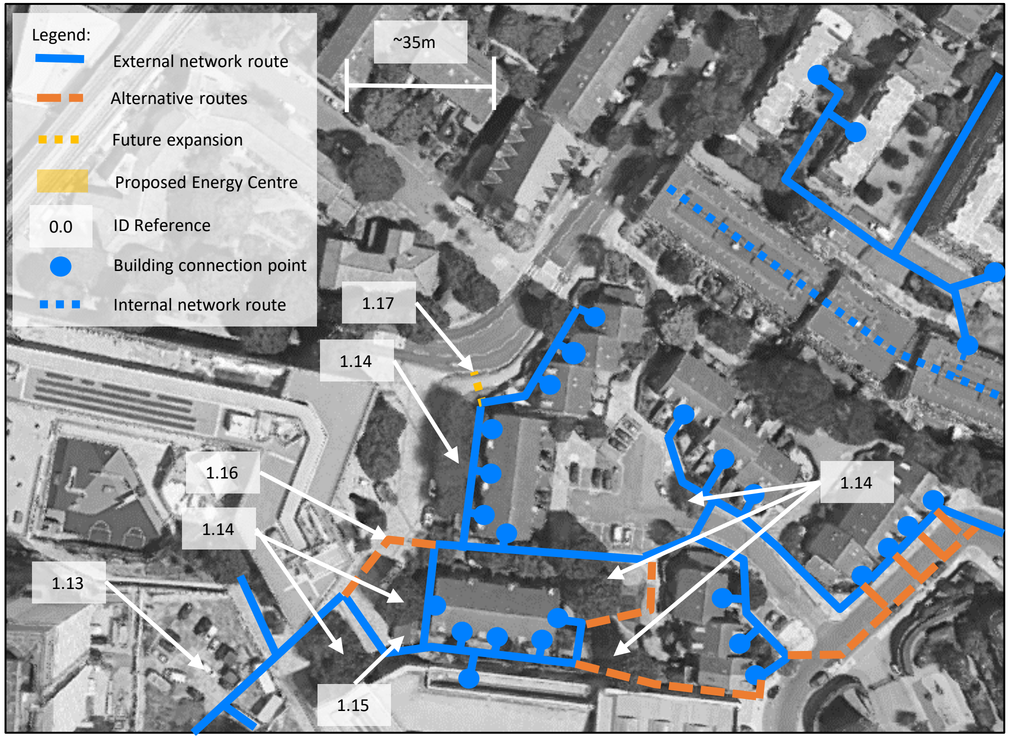

Figure 4.6.4: Proposed external district heating network route features and constraints (Refer Tile 3, Figure 4.5.1)

ARUP

Network Routing
4.6 Network features and constraints

Table 4.6.5: Route features and constraints

ID	Route features & constraints	Constraint Notes	Related Risks
1.18	Large sewer crossing	A 900x600mm Thames Water combined sewer, at an approximate depth of 2.7m (to soffit), passes through the site in this approximate location. It is assumed that the district heating network would cross above this sewer.	R4
1.19	Narrow corridor for network route	The corridors available between the flats at Verity Close are narrow and remain a risk to the network route alignment until accurate utility survey data is available. Alternative building connection points may need to be considered if the proposed routes cant be proven at the next project stage. Further consultation with the RBKC is required to confirm the suitability of the network route within the private gardens.	R4 and R5
1.20	Existing above ground constraints	At the western end of the walkway, between the flats, there is an existing brick wall and densely planted mature trees which would be impacted by the proposed network route. It is likely this wall would have to be rebuilt as a result of the works.	R5
1.21	Connection to the Kensington Leisure Centre (KLC)	The connection to the KLC crosses a narrow walkway to the north of the KLC, from the southern gardens of the flats in Verity Close. This path is understood to include private surface water networks, a Cadent LP gas network and UKPN electrical networks. The connection point is to be coordinated with the gas (to the west of the DH connection point) and electrical (to the east of the DH connection point) connections to the building to minimise the number of existing utilities crossed. The exact building connection location is to be confirmed but would also be coordinated with the existing plant rooms within the KLC. The path directly north of the Kensington Leisure Centre is Pinch Point A (Appendix D).	R5

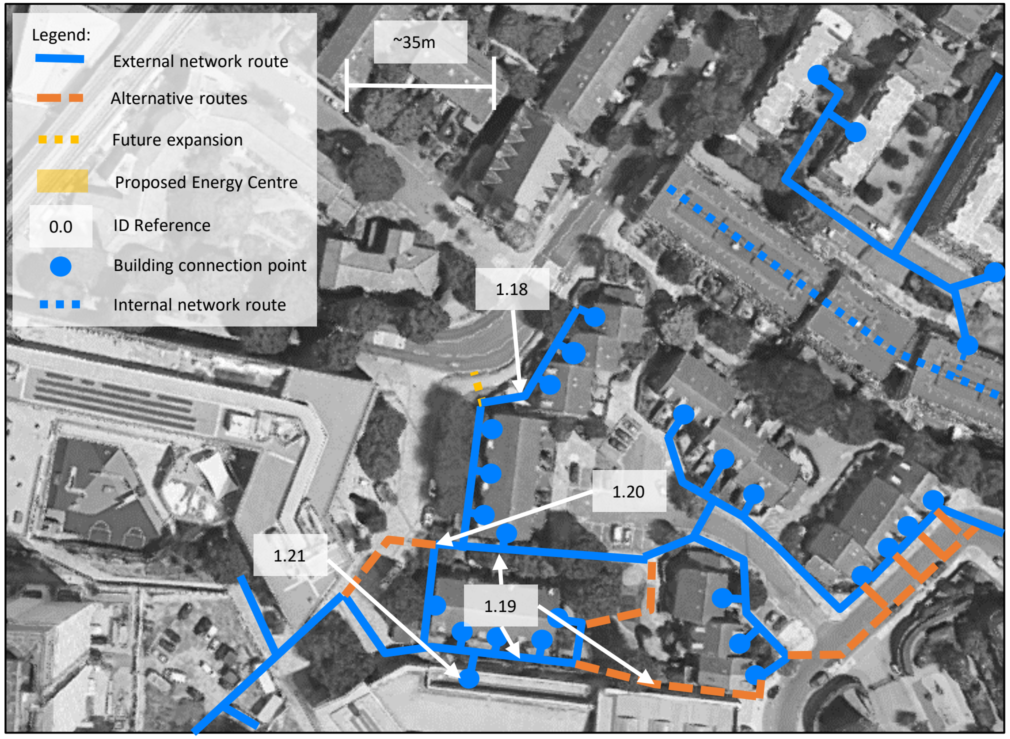

Figure 4.6.5: Proposed external district heating network route features and constraints (Refer Tile 3, Figure 4.5.1)

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Network Routing

4.6 Network features and constraints

Table 4.6.6: Route features and constraints

ID	Route features & constraints	Constraint Notes	Related Risks
1.22	Alternative network route – narrow alleyway	An existing LP gas main, telecoms ducts, LV UKPN network and an assumed drainage network (private) pass through this narrow walkway. This alternative network route may be considered if adequate space is proven through onsite surveys.	R4
1.23	Dulford Street route	There are 2no. large Thames Water sewers within Dulford St at unknown depths and assumed 1676x1118mm and 1219x813mm in size (exact size within Dulford St unknown). It is assumed that a route can be proven, passing above these sewers (1 crossing for proposed network and four crossings for the alternative route). Details to be confirmed following onsite surveys. There are existing telecoms ducts, gas mains and electrical ducts within the footpaths which limit the viability of the network running within the footpath.	R4 and R6
1.24	Network within private gardens	The proposed network route to serve the flats facing Dulford Street would run within the private gardens at the font of the flats, avoiding the existing utilities within the footpath and highway and decreasing the number of highway crossings required. This route would significantly impact the private gardens, likely resulting in the need to replace the existing fences and increased disruption to the hard and soft landscaping, when compared with the alternative route. Refer to Pinch Point B in Appendix D.	R4 and R6

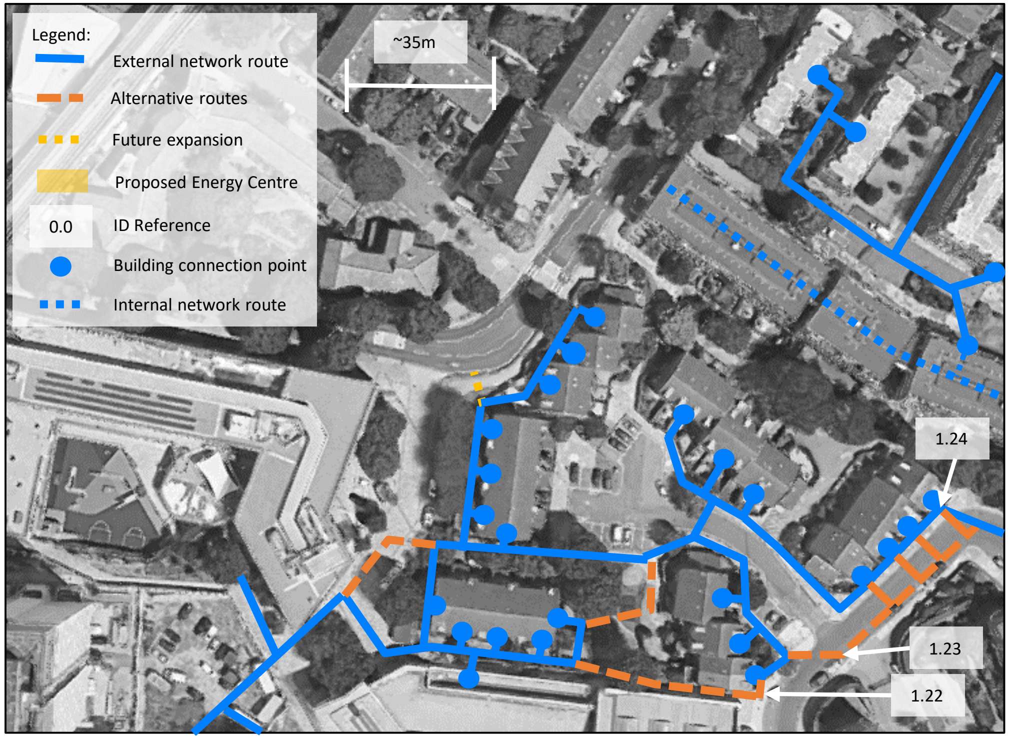

Figure 4.6.6: Proposed external district heating network route features and constraints (Refer Tile 3, Figure 4.5.1)

Network Routing
4.6 Network features and constraints

Table 4.6.7: Route features and constraints

ID	Route features & constraints	Constraint Notes	Related Risks
1.25	Connection to Morland House	Due to the presence of existing utilities within the paved walkways between the two sides of Morland House, the proposed district heating network would be routed within the soft landscaping. This route will impact on the existing mature trees and it is likely the proposed trench would have to be hand-dug to minimise the impact on the tree roots.	R4 and R5
1.26	Existing external heating network route	The RBKC have provided a drawing (Ref: 1110 08 A) showing the configuration of this network, dated November 1975. Refer to section 4.4 for more details. This communal heating network is to remain live during the installation of the new district heating network. Due to the age and condition of this existing heating network, suitable asset protection is required during construction to avoid damage.	R4
1.27	Network route note	It is understood that a private surface water network runs parallel to the existing district heating network from Morland House to the south-east. The proposed district heating network would run parallel to these, on the southern side. The impact of this route on existing brick walls and mature trees is to be confirmed in future design stages.	R4 and R5
1.28	Existing utility crossing	The proposed network would cross the know private utilities at this point (communal heating network and drainage). To mitigate against damaging these old utilities, the contractor will need to ensure suitable construction methodology is used when working near these assets.	R4 and R7
1.29	Internal network passing through basement	It is understood that the internal network is routed as described in section 3.2. The intent is for the proposed network to be routed in a similar way, refer to section 3.2 for details.	R4, R8 and R13
1.30	Existing Energy Centre	The existing energy centre in this location would be decommissioned.	

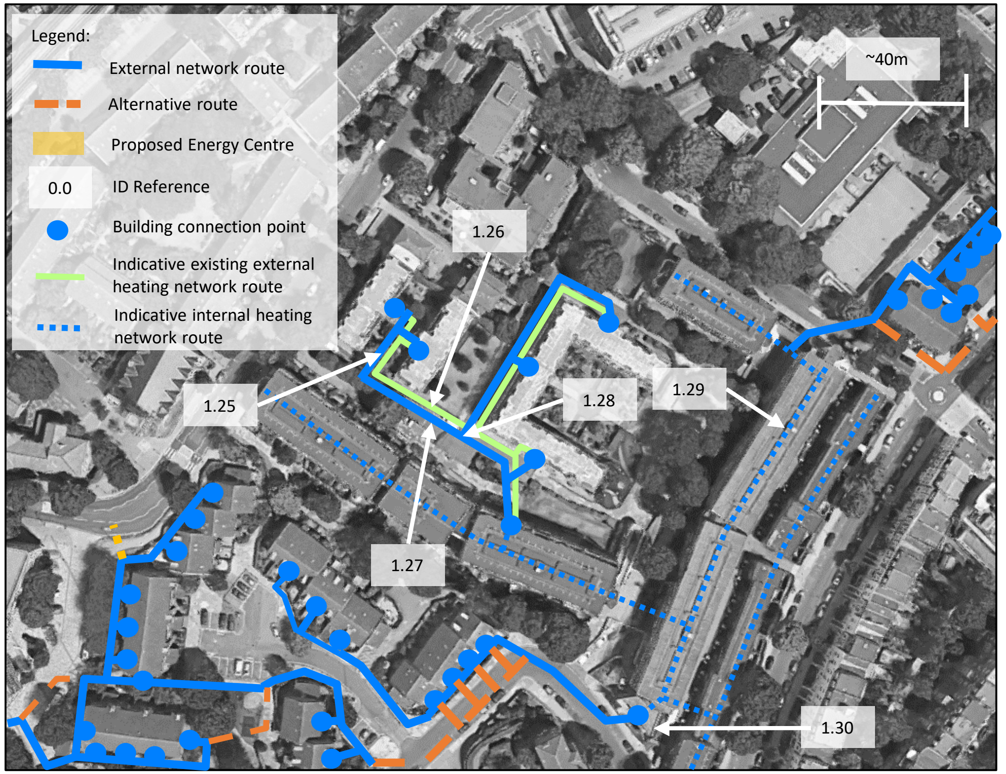

Figure 4.6.7: Proposed external district heating network route features and constraints (Refer Tile 4, Figure 4.5.1)

Network Routing
4.6 Network features and constraints

Table 4.6.8: Route features and constraints

ID	Route features & constraints	Constraint Notes	Related Risks
1.31	Mature Trees	Refer to information provided in the constraint notes for ID 1.6 for more details.	R5
1.32	Network route in private road owned by RBKC	Site photos from RBKC indicate a route is likely achievable within the western side of the private road to the west of Talbot Grove House. Historic private drainage records from RBKC suggest the drainage network runs close to the building, giving more confidence that the western side of the road may be a viable district heating network route.	R4 and R6
1.33	Level differences	The public realm, framed by Camelford Walk and Clarendon Walk is understood to consist of several low-lying retaining walls and level differences achieved via steps or ramped pedestrian access. A civil engineer should visit site to fully review the impact of these on the proposed route. It is also recommended that a topographical survey is undertaken to aid this review.	R5
1.34	UKPN Substation	A UKPN Substation is at this location, it is assumed this will remain in-situ.	R4

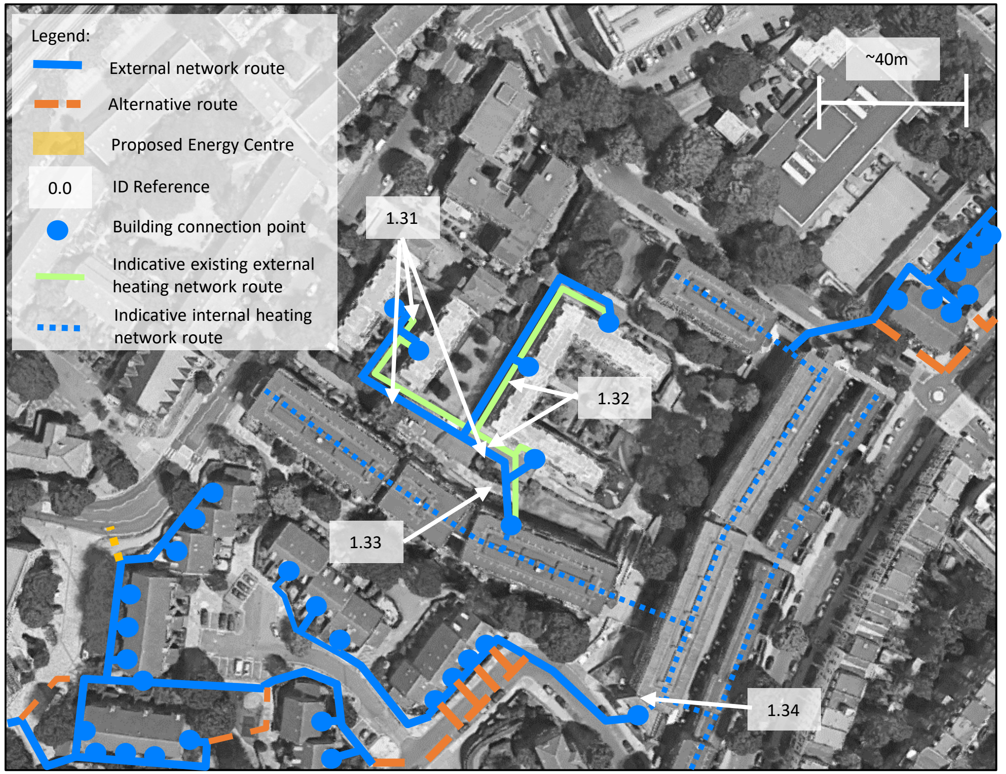

Figure 4.6.8: Proposed external district heating network route features and constraints (Refer Tile 4, Figure 4.5.1)

Network Routing
4.6 Network features and constraints

It should be noted that it will be challenging to connect building Camborne Mews (flats 1 – 36) to the district heating network. It is likely that trial holes within the highways will be required to prove a route. In case of no connection the impact on the total demand will be relatively low. A site walkover to confirm building connection points has not been undertaken to date for these buildings and so all points of connection are assumed, based on the Cadent low pressure gas building connection points at the rear.

Table 4.6.9: Route features and constraints

ID	Route features & constraints	Constraint Notes	Related Risks
1.35	External stairwell	An external staircase is located on the northern side of Camelford Walk. The connection point from the internal network to the external requires coordination with the staircase and the internal network. This is to be reviewed in more detail in future design stages.	R8
1.36	St Marks Road - highway crossing	It is assumed that Camborne Mews would be served from the internal heating pipes within the basement between Camelford Walk and Upper Talbot Walk. This would involve crossing St Marks Road from the basement level internal network. This highway and the adjacent footpaths are heavily congested with utilities. On site surveys and trial holes will be required to investigate the viability of a route across this road. There is limited space available for a thrust bored solution so this is not considered a viable installation method in this case. The district heating flow and return pipes are assumed to pass beneath most existing utilities but above the sewers. The civils works associated with these works will be challenging and the deep trench will likely be hand-dug to protect the existing utilities which will take longer than a typical machine excavation. Refer to Pinch Point C in Appendix D.	R4, R5, R6, R9 and R11
1.37	UKPN HV Crossing	A UKPN HV network crosses the entrance to Cambrone Mews and would be crossed to serve the buildings from the rear. It is assumed that this network runs south-east within the lightwells of the southern building and so it is proposed that a single crossing to the lightwells is used and the flats are served from a route running north of this HV network, within the lightwells.	R4

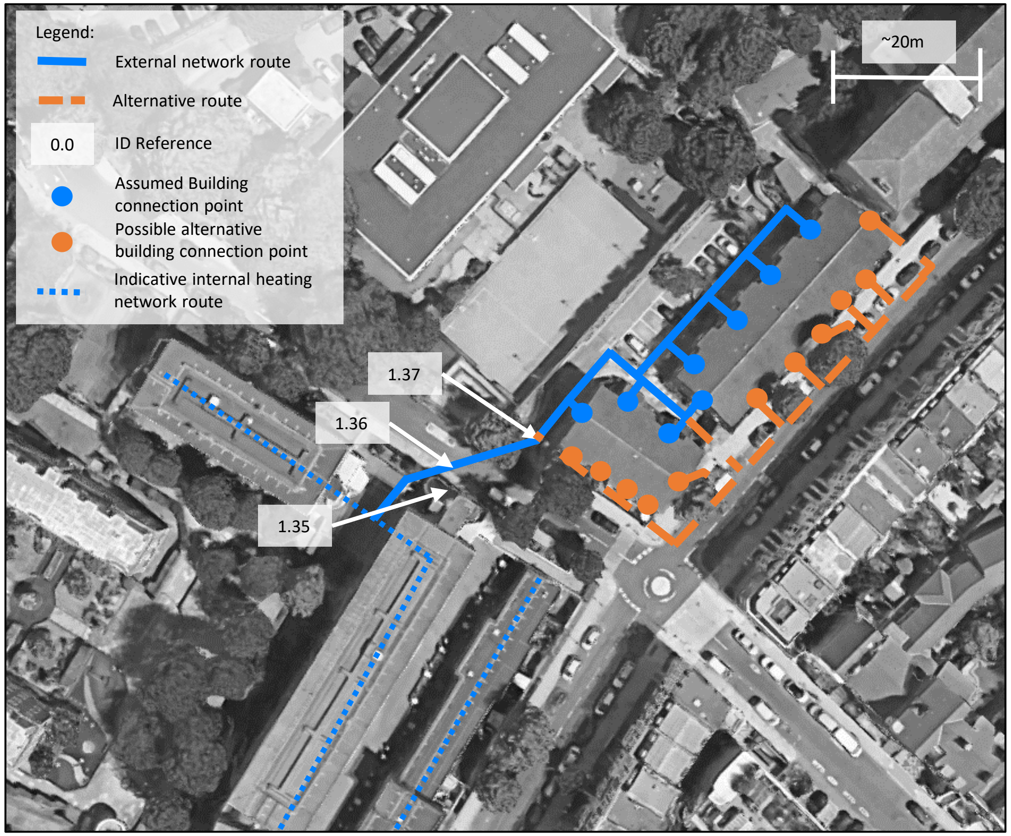

Figure 4.6.9: Proposed external district heating network route features and constraints (Refer Tile 5, Figure 4.5.1)

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Network Routing

4.6 Network features and constraints

Table 4.6.10: Route features and constraints

ID	Route features & constraints	Constraint Notes	Related Risks
1.38	Lightwells	Both buildings have street side lightwells. The coordination between the alternative assumed building connection points and the lightwells would be agreed in later design stages, if required.	R4
1.39	Low-lying courts	Adjacent to the site entrance, Camborne Mews, there is a low-lying tennis court. The northern side of the private entrance, Camborne Mews, consists of a retaining wall.	R4 and R5
1.40	Alternative route	An alternative route, which may be considered pending resolution of building connection points, is to enter the site from the south-east and connect to the buildings from the roadside. Due to the presence of lightwells adjacent to the footpaths and the understanding that the highways and footpaths are congested with utilities, this is not the preferred route. Refer to Pinch Point D in Appendix D.	R4, R6, R10 and R11
1.41	Roundabout	There is an existing roundabout in this location. In order to minimise the impact of the proposed district heating route on traffic, routing the network through the roundabout itself should be avoided.	R6
1.42	Narrow walkway	There is a narrow footway between the buildings which has the potential to be used to connect to the northern building. To confirm this, a GPR survey of existing utilities would be required.	R4

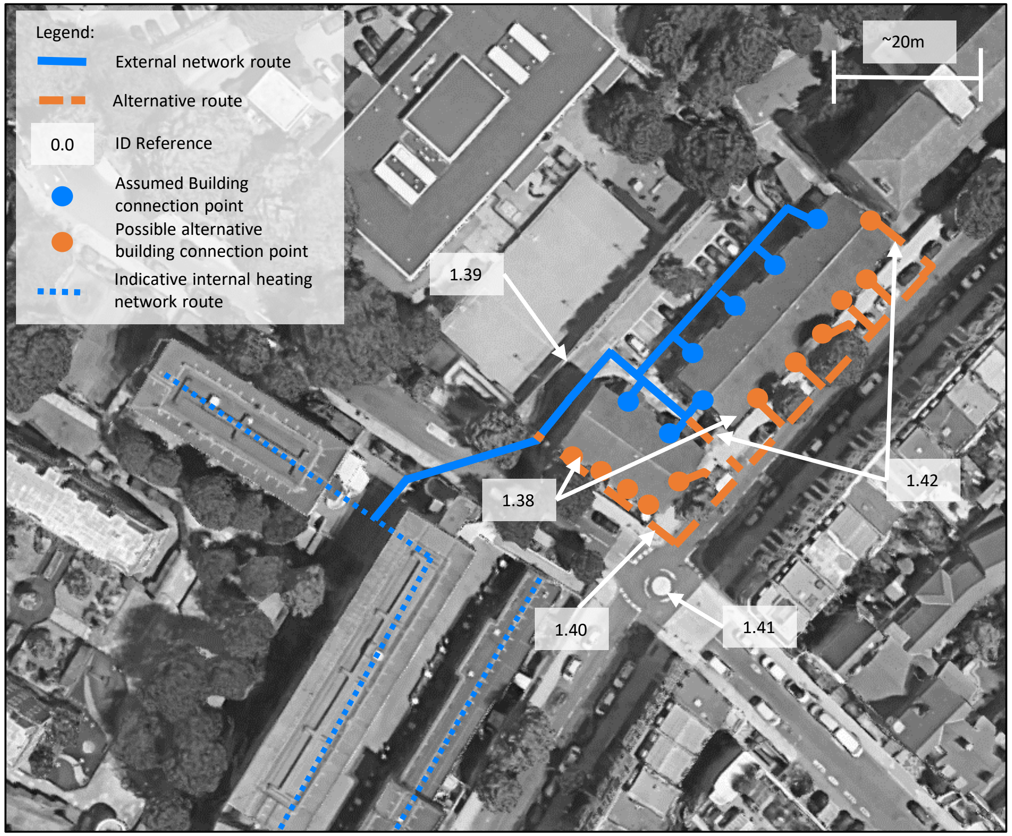

Figure 4.6.10: Proposed external district heating network route features and constraints (Refer Tile 5, Figure 4.5.1)

ARUP

Network Routing
4.6 Network features and constraints

Table 4.6.11: Route features and constraints

ID	Route features & constraints	Constraint Notes	Related Risks
1.43	Mature trees	Refer to information provided in the constraint notes for ID 1.5 for more details.	R5
1.44	UKPN Substation	A UKPN Substation is at this location, it is assumed this will remain in-situ.	R4
1.45	Cornwell Crescent highway	This highway and adjacent footpaths are congested with existing utilities. A preliminary review of the Groundwise utility record information suggests it is unlikely a route can be achieved within the footpath due to existing telecoms and electrical networks. A route may be possible within the western lane of this highway, this is shown as an alternative route on Figure 4.6.11. A GPR survey and trial holes would be required to investigate the feasibility of this alternative route once the building connection points have been defined. Refer to Pinch Point D in Appendix D.	R4 and R6

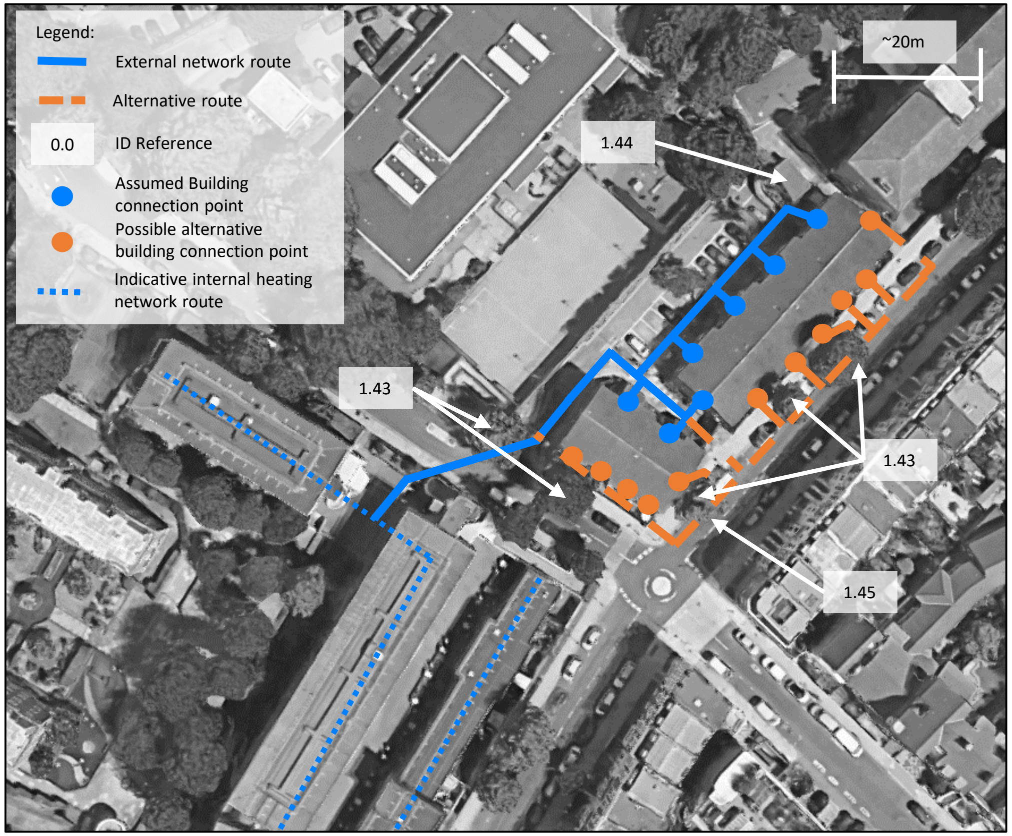

Figure 4.6.11: Proposed external district heating network route features and constraints (Refer Tile 5, Figure 4.5.1)

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Network Routing
4.7 Pipe Sizing

Preliminary pipe sizes have been modelled for the entire network for a temperature delta of 30 and 10. Temperature delta of 10 is for ambient heat networks.

It is anticipated that the pipes will generally be laid within the public realm. The insulated pipes would be laid in a single trench, where space permits, with at least 900mm cover. At crossing points with other utilities, the depth of cover may vary. Pipe protection should be considered if the cover depth is reduced.

Some pipes will also run internally within the building following the current LW1 and LW3 pipe route.

The image on the next page shows all the pipe labels used for pipe calculations. The section post this image outlines the various pipe sizes and the associated costs.

It is also suggested to explore plastic pipe option during the next phase of the project.

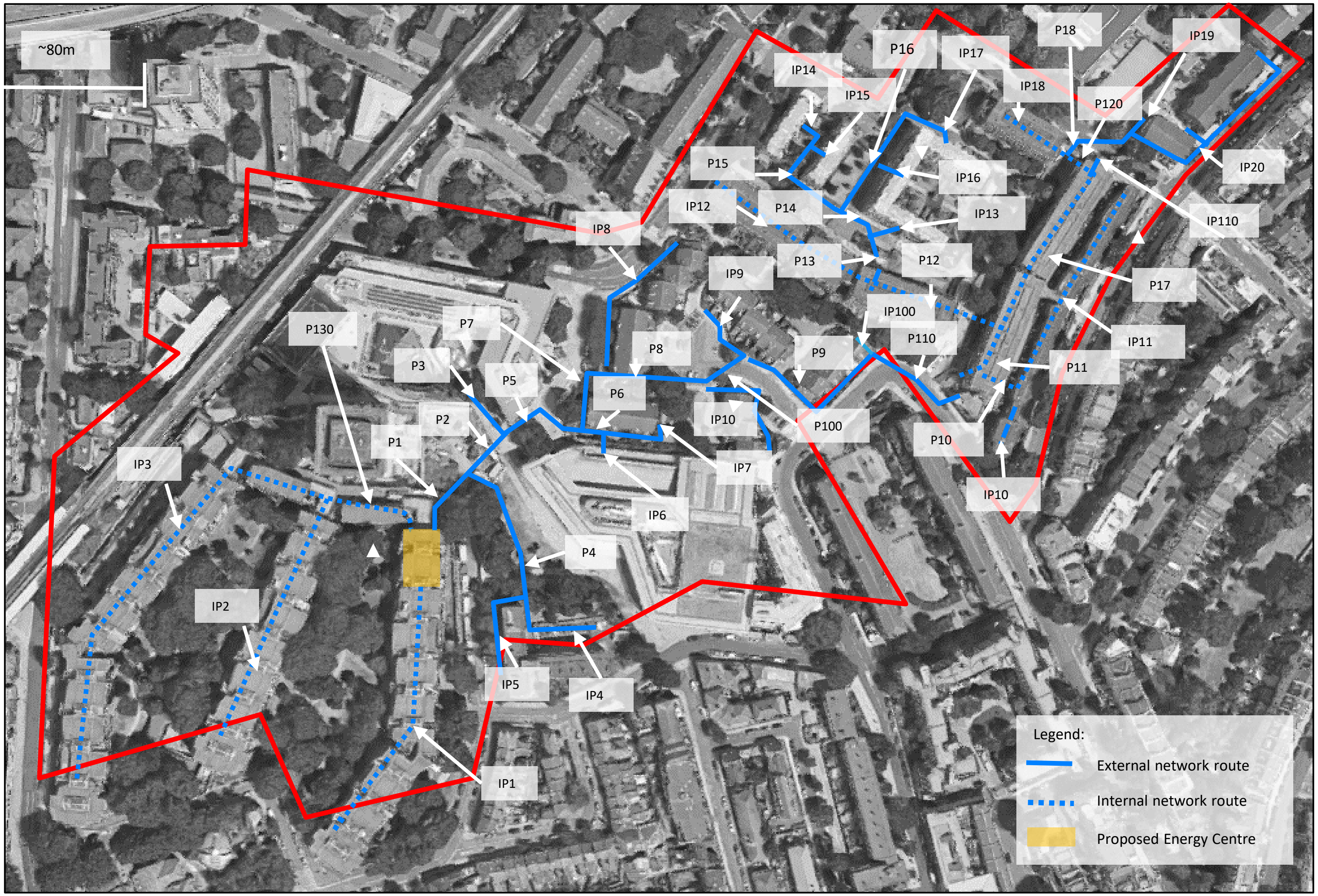

Figure 4.7.1: Proposed External District Heating Network Route

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Network Routing
4.7 Pipe Sizing – delta 30 package 1

The table on the right summarises the pipe calculations results for a package 1 network utilised for delta 30 temperature difference in outgoing and incoming heat from the energy centre.

The total cost of pipes is: £ 2,128k

Table 4.7.1: Pipe sizes package 1 network

Pipe number	Pipe length (m)	Pipe diameter (mm)	Pipe cost (£)
P1	27	200	44,612
P2	25	200	41,308
IP1	130	100	89,708
P130	50	125	35,423
IP2	130	100	89,708
IP3	220	100	151,813
P4	78	65	84,570
P3	35	65	37,948
IP4	70	50	71,478
IP5	62	50	63,309
P5	70	200	115,662
P6	16	100	20,832
IP6	10	80	11,474
IP7	43	40	42,098
P7	35	150	48,405
IP8	90	50	91,900
P8	58	150	80,214
IP9	60	32	56,722
P100	16	150	22,128
IP9	43	40	42,098
P9	80	150	110,640
IP100	17	40	16,644
P110	52	150	71,916
P10	25	65	14,366
IP10	13	25	6,311
IP11	122	50	66,025
P11	32	150	23,456
P12	66	125	46,758

Table 4.7.1 – continue: Pipe sizes package 1 network

Pipe number	Pipe length (m)	Pipe diameter (mm)	Pipe cost (£)
IP12	75	125	51,755
P13	23	125	26,389
IP13	20	65	19,581
P14	11	125	12,621
P15	52	100	56,380
IP14	13	65	13,274
IP15	13	65	13,274
P16	33	100	35,780
IP16	8	65	7,832
IP17	53	65	51,889
P17	82	125	56,585
IP110	5	100	3,040
P120	10	100	6,081
IP18	38	65	20,565
P18	32	80	34,695
IP19	24	50	23,497
IP20	95	65	97,005

ARUP

Network Routing

4.7 Pipe Sizing – delta 30 package 2

The table on the right summarises the pipe calculations results for a package 2 network utilised for delta 30 temperature difference in outgoing and incoming heat from the energy centre.

The total cost of pipes is: £ 1,996k

Table 4.7.2: Pipe sizes package 2

Pipe number	Pipe length (m)	Pipe diameter (mm)	Pipe cost (£)
P1	27	200	44,612
P2	25	150	34,575
IP1	130	80	79,052
P130	50	100	34,503
IP2	130	80	79,052
IP3	220	80	133,781
P4	78	50	79,646
P3	35	65	37,948
IP4	70	40	68,532
IP5	62	40	60,699
P5	70	150	96,810
P6	16	80	18,357
IP6	10	80	11,473
IP7	43	32	40,650
P7	35	125	46,784
IP8	90	40	88,112
P8	58	125	77,529
IP9	60	25	54,954
P100	16	125	21,387
IP9	43	32	40,650
P9	80	125	106,936
IP100	17	32	16,071
P110	52	125	69,508
P10	25	40	12,972
IP10	13	20	6,310
IP11	122	32	61,127
P11	32	125	22,670
P12	66	100	45,543

Table 4.7.2 – continue: Pipe sizes package 2

Pipe number	Pipe length (m)	Pipe diameter (mm)	Pipe cost (£)
IP12	80	75	45,607
P13	80	23	26,389
IP13	40	20	19,580
P14	80	11	12,620
P15	65	52	56,379
IP14	40	13	12,727
IP15	50	13	13,274
P16	50	33	33,696
IP16	40	8	7,832
IP17	40	53	51,888
P17	80	82	49,863
IP110	65	5	2,873
P120	65	10	5,746
IP18	40	38	19,717
P18	50	32	32,675
IP19	32	24	22,688
IP20	40	95	93,007

ARUP

Network Routing

4.7 Pipe Sizing – ambient network package 1

The table on the right summarises the pipe calculations results for a package 1 ambient network (temperature delta of 10 between outgoing and incoming flows).

The total cost of pipes is: £ 2,481k

Table 4.7.3: Pipe sizes package 1 ambient network

Pipe number	Pipe length (m)	Pipe diameter (mm)	Pipe cost (£)
P1	27	250	55,974
P2	25	250	51,828
IP1	130	125	95,289
P130	50	150	43,786
IP2	130	125	92,099
IP3	220	125	161,258
P4	78	80	101,556
P3	35	100	45,570
IP4	70	65	80,315
IP5	62	65	71,136
P5	70	250	128,870
P6	16	125	21,387
IP6	10	125	13,367
IP7	43	65	46,622
P7	35	200	64,435
IP8	90	65	103,262
P8	58	200	106,778
IP9	60	50	65,054
P100	16	200	29,456
IP9	43	50	46,622
P9	80	200	147,280
IP100	17	50	18,432
P110	52	200	95,732
P10	25	65	17,252
IP10	13	25	6,514
IP11	122	65	84,187
P11	32	200	31,223
P12	66	150	57,798

Table 4.7.3 – continue: Pipe sizes package 1 ambient 30 network

Pipe number	Pipe length (m)	Pipe diameter (mm)	Pipe cost (£)
IP12	75	125	54,974
P13	23	125	30,744
IP13	20	65	21,685
P14	11	125	14,704
P15	52	100	67,704
IP14	13	65	14,095
IP15	13	65	14,095
P16	33	100	42,966
IP16	8	65	8,674
IP17	53	65	57,464
P17	82	125	60,105
IP110	5	100	3,542
P120	10	100	7,085
IP18	38	65	23,108
P18	32	80	41,664
IP19	24	50	26,022
IP20	95	65	108,998

Network Routing

4.7 Pipe Sizing – ambient network package 2

The table on the right summarises the pipe calculations results for a package 2 ambient network (temperature delta of 10 between outgoing and incoming flows).

The total cost of pipes is: £ 2,326k

Table 4.7.4: Pipe sizes package 2 ambient network

Pipe number	Pipe length (m)	Pipe diameter (mm)	Pipe cost (£)
P1	27	250	49,707
P2	25	250	46,025
IP1	130	125	92,099
P130	50	150	36,649
IP2	130	125	92,099
IP3	220	125	155,860
P4	78	80	89,493
P3	35	100	45,570
IP4	70	65	75,896
IP5	62	65	67,222
P5	70	250	128,870
P6	16	125	21,387
IP6	10	125	13,367
IP7	43	65	46,621
P7	35	200	57,830
IP8	90	65	97,580
P8	58	200	95,833
IP9	60	50	61,266
P100	16	200	26,436
IP9	43	50	43,907
P9	80	200	132,184
IP100	17	50	17,358
P110	52	200	85,920
P10	25	65	14,366
IP10	13	25	6,310
IP11	122	65	70,106
P11	32	200	28,023
P12	66	150	48,377

Table 4.7.4 – continue: Pipe sizes package 2 ambient network

Pipe number	Pipe length (m)	Pipe diameter (mm)	Pipe cost (£)
IP12	75	125	53,134
P13	23	125	30,744
IP13	20	65	21,684
P14	11	125	14,703
P15	52	100	67,704
IP14	13	65	14,094
IP15	13	65	14,094
P16	33	100	42,966
IP16	8	65	8,673
IP17	53	65	57,464
P17	82	125	58,093
IP110	5	100	3,450
P120	10	100	6,900
IP18	38	65	21,836
P18	32	80	36,715
IP19	24	50	24,506
IP20	95	65	103,001

Network Routing
4.8 Risk Evaluation

Methodology

Risks have been assessed by likelihood of occurrence and the consequence, as defined in Table 4.8.1 and Table 4.8.2.

In this assessment, significant risks are those assessed to be either Medium or High. Where significant adverse risks have been identified, further mitigation is required to reduce risks to acceptable level. The mitigation measures put in place should be managed to ensure risks are as low as practically possible (ALARP).

Table 4.8.1: Risk Magnitude description

Risk Magnitude	Description/action
High	There is a high probability that the risk may be realised, or sufficient uncertainty remains. Additional mitigation is required as a priority and may include further investigation/assessment to understand and, if appropriate, reassess the significance of the risk. There is sufficient uncertainty before the proposed route can be confirmed as viable.
Medium	Risks must be acted upon, but do not pose an immediate threat and thus the project can continue while the risk response measures are integrated and/or performed. Additional mitigation may be required, and mitigation may require further investigation/assessment to understand, and, if appropriate, reassess the significance of the risk.
Low	Risks may not require additional responses – it may be effective enough simply to monitor the risk to ensure that it does not arise during the project.

Table 4.8.2: Risk Magnitude Matrix

Likelihood		Consequence: Very Low	Consequence: Low	Consequence: Medium	Consequence: High
	High	Low	Medium	High	High
	Medium	Low	Medium	Medium	High
	Low	Low	Low	Medium	Medium
	Very Low	Low	Low	Low	Medium

Network Routing

4.9 Risk Register

This table outlines the key engineering design/delivery risks to project, including effects on cost, programme and network routing. General construction and health and safety risks have not been outlined. Additional risks may be identified as the project progresses.

Table 4.9.1: Detailed Risk Register

Risk Title		Risk	Mitigation	Level pre-mitigation	Level post-mitigation
R1	Undercroft	The existing undercroft, on the northern side of Brandon Walk and Testerton Walk, results in reduced headroom which poses a constructability constraint to be considered by the contractor. This risk remains until an appropriate construction methodology, without large machinery is prepared by the contractor for any parts of the network extending into/near this area.	This risk is mitigated through the thorough understanding of the network constraints by the contractor, ensuring appropriate methodology is put in place. Where possible, the network would be routed above ground within the undercroft to remove the need for excavation in this area.		
R2	Energy centre location and heat source	There is no existing heat source suitable for the proposed district heating network. The proposed heat source is detailed in section 5.3. The GSHP system has not yet been constructed and so there remains uncertainty in the cost and programme of this system. If this GSHP can't be installed, the heat source may need to be re-designed resulting in a programming and financial risk to the project.	Preliminary consultation with a GSHP specialist has commenced and the proposal is understood to be viable. Consultation with the GSHP specialist should continue into the next design stage to confirm the details of the system. Any ground investigations required should be undertaken early in the project.		
		The sewer heat recovery portion of the heat source involves a significant amount of consultation with Thames Water. Although Thames Water are generally supportive of the proposal, there is a risk that approval will not be granted following on-site condition surveys of the existing sewer and modelling of the flows. It is likely that Thames Water will require line, level and condition surveys of the sewer from which the heat would be recovered. These surveys can be expensive and can pose a programming risk due to the extended duration of the survey, data processing and ongoing consultation with Thames Water. Until a pre-app meeting has been formally held with Thames Water the extent of these risks is not fully understood.	Consultation with Thames Water has begun at feasibility stage and should continue through into the next stage of the project. Any surveys required by Thames Water should be undertaken at the earliest opportunity to reduce the risk to project programme.		
		There is no existing Energy Centre which is suitable for the district heating network. Until the proposed energy centre is designed and fully understood this is a financial and programming risk to the project.	Preliminary sizing of the Energy Centre has begun to ensure the available space within the Brandon Walk basement is suitable. Design of the Energy Centre should progress at the next project stage to ensure the project needs are met.		

Network Routing

4.9 Risk Register

Table 4.9.1 – continued: Detailed Risk Register

Risk Title		Risk	Mitigation	Level pre-mitigation	Level post-mitigation
R3	Future RBKC developments	Limited information is available currently for the possible RBKC future developments to the north and south of the Estate as outlined in section 2. Although the district heating pipes have been sized to accommodate these connections (using assumed heating demands), a re-design of the pipe sizing may be required once more information is available, resulting in a programming risk to the project. It should be noted that, due to the inclusion of these assumed future developments, some pipes within the network are oversized. The flow within these sections of the network will be lower than other parts of the network as a result.	This risk can be mitigated through the RBKC providing information on these connections ahead of the next design stage to reduce the impact of network route changes. In addition to the next step surveys that are required for the entire network, the future developments proposed by RBKC would also require a Groundwise utility record search as some parts of these developments would be outside of the original Groundwise search area.		
R4	Existing below ground constraints	From experience, significant risk remains until the horizontal and vertical alignment of the existing utilities along the district heating network are accurately defined. The exact in-situ location of existing utilities may impact the proposed network alignment which resulting in additional cost, diversions of existing utilities or changes to the route alignment. Diversions of public utilities can increase project costs and delay the program due to liaising with utility providers. The diversion of some existing utilities may make the route unfeasible.	Typically, as part of the design, a topographical survey would be undertaken and compared with a CAD composite of the Groundwise utility records. This information will confirm the horizontal constraints imposed by the various existing public utilities. In addition, an underground services survey will be required along the proposed district heating network route to further reduce the risk of any identified clashes with existing utilities. This will allow any required diversions to be identified and consultation with the Statutory Authorities to begin, reducing the programming and financial risk to the project. Trial holes can further reduce the risk as the exact vertical and horizontal alignment can be confirmed. This would only be required in areas of concern which are identified following the GPR survey and highway crossing points. Note that all utility surveys should be in accordance with PAS 128: 2014. The additional survey work should be undertaken at the earliest opportunity by a suitably qualified survey company in order to confirm the proposed network route is viable and where not, investigate alternatives.		

Network Routing
4.9 Risk Register

Table 4.9.1 – continued: Detailed Risk Register

Risk Title		Risk	Mitigation	Level pre-mitigation	Level post-mitigation
R4 - Cont.	Existing below ground constraints	Groundwise utility searches only provide information on public utilities. The RBKC has provided a collection of historic private utility records, consisting of as-builts and design drawings dating back to the 1970s. It is unclear if these records are complete and up-to-date. As-built records were not provided for some parts of the site, but it is understood the RBKC are reviewing the information available for the site and full access to these records will be possible for the next project stage. Until the alignments of the private utilities are confirmed, there is a risk that the network route will be affected potentially resulting in programming delays or increased cost.	In order to reduce the risk posed by private utilities to the proposed network route, all private utility as-builts should be obtained and reviewed in full. It is understood that this will be possible at the next stage of the project. A GPR survey should be undertaken along the proposed network route to confirm the private utility alignments. Following this, in areas of congestion, trial holes may be necessary to confirm the horizontal and vertical spatial availability.		
		The presence of historic or current underground features such as buried structures, retaining walls, foundations and basements is not yet fully understood and also poses a risk to the external network route. The presence of unknown below ground structures may result in re-routing of the proposed network route, potentially increasing the overall cost.	A GPR survey of the proposed network route should be undertaken to confirm the below ground constrains at the site at the next design stage so that the below ground constraints on the network route can be better understood.		
R5	Landscaping	From a review of the available information, Google Street View and site photos, it is clear that the hard landscaping across the site includes various level differences achieved through retaining walls, steps and ramps. Until a civil engineering site walkover and a topographical survey has been completed the impact of these features to the network route are not fully understood, resulting in potential future changes to the network route. It should also be noted that the public realm near the Kensington Aldridge Academy and the Kensington Leisure centre appears to have been recently re-laid. Where the district heating network is routed through these areas, the pavement will have to be re-laid and tied into the existing. Depending on the paving slabs currently in place, this could be a significant cost for the project and should be accounted for.	This risk can be mitigated by an early topographical survey and site walkover by a civil engineer at the next phase of the project. All civils related costs such as replacing the paving, and any other hard landscaping like-for-like with existing should be accounted for in preliminary project costing.		

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Network Routing
4.9 Risk Register

Table 4.9.1 – continued: Detailed Risk Register

Risk Title		Risk	Mitigation	Level pre-mitigation	Level post-mitigation
R5 – Cont.	Landscaping	The Estates soft landscaping consists of a vast number of mature trees. In some locations along the proposed district heating network route, the pipes would be routed in close proximity to these trees. During the design phases of the project, minimum typical offsets from these trees should be considered to reduce the impact of the proposed pipes on the soft landscaping. NJUG volume 4 “Guidelines for the planning, installation and maintenance of utility apparatus in proximity to trees” should be considered as the design progresses. Any trees which are protected must be highlighted, by the Client, early in the design so that this does not impact on the pipe route late in the project, resulting in financial and programming risk if the network route has to be re-designed. It is understood that the district heating network would be managed and maintained by Engie, as per the existing communal heating networks. Engie should be consulted for preferred minimum offsets from trees. It is likely that where the network passes close to existing trees, the utility trench would be hand-dug to avoid damaging the tree roots. This will slow down the installation of the route and should be factored into the construction programme to avoid causing delays.	The network route should, where possible, be aligned to minimise impact on existing trees. To minimise the risk posed by protected trees, these should be identified to the design team early in the design phase to reduce the impact on the network route. The risks associated with the soft landscaping should be communicated clearly to the contractor so that the construction programme reflects the extra effort required to hand-dig sections of the utility trenches.		

Network Routing

4.9 Risk Register

Table 4.9.1 – continued: Detailed Risk Register

Risk Title		Risk	Mitigation	Level pre-mitigation	Level post-mitigation
R6	Traffic management	Traffic management will be necessary for works within the highway. Local authority highway engagement is necessary to ensure all correct permits have been obtained. Specific consideration would need to be made to works near the roundabouts in order to minimise the disruption. The process of obtaining permits may pose a programming risk to the project. Where the network crosses St Marks Road, it is expected that the utility trench would need to be hand-dug to protect the existing utilities. This process will take longer than standard mechanical excavation, which should be accounted for when applying for permits. The local highway authority should be aware of the need for extended construction periods and road closures to avoid the licence expiring during the works.	Early consultation with the local Highway Authority, the RBKC, is recommended so that fees and programme can be confirmed for both the private and public highways. A section 50 licence, under the New Roads and Street Works Act 1991 (NRSWA), will be required for excavations within the public Highway. The cost of this licence is to be confirmed with the local Highway Authority and may vary depending on network length and road classification.		
		Works within any highway pose a health and safety risk to both construction and O&M contractors, particularly due to the need to hand-dig around existing utilities.	Pending the receipt of a GPR survey, where space permits, the pipes would be best located within footpaths where possible. Where this is not achievable careful consideration to construction methodology is required and suitably trained contractors should be selected to reduce this health and safety risk.		
R7	Existing old utilities in poor condition	The presence of fragile, old utilities can pose a risk to the project. Any works near to old utilities, such as the existing communal heating networks, may result in the need for specific design, agreements or non-standard construction methodology which is a programming and financial risk to the project until better understood.	Early consultation with the various utility companies and private utility owners is recommended to determine the presence of any old/fragile utilities and any specific requirements relating to these.		
R8	Internal network routes	A preliminary review of the internal district heating network route, as detailed in section 3, has been undertaken and it is proposed that the district heating network would follow the same internal route to serve these buildings. Until an MEP engineer has fully assessed the network route and the as-built drawings or a building survey, there is a risk that there may be pinch points. This may result in changes to the proposed internal network route and therefore building connection points for the external part of the network.	A preliminary site visit has been undertaken to review the available space within the basements for the proposed district heating pipes and it is understood that it is likely a network route can be achieved. This should be reviewed in detail by an MEP engineer in future design stages so that any limitations to this proposal can be fully understood early in the project.		

Network Routing
4.9 Risk Register

Table 4.9.1 – continued: Detailed Risk Register

Risk Title		Risk	Mitigation	Level pre-mitigation	Level post-mitigation
R9	Deep excavations and tunnelling	Where the proposed network crosses areas congested with exisitng utilities, such as St Marks Road, it is likely that the district heating network will typically pass beneath the existing utilities. This may require either deep trenches or headings. There is a risk that the constructability and cost of the public highway crossings may result in the connection to Camborne Mews becoming unfeasible.	The requirement for tunnels or deep trenches has not yet been defined. Following the additional recommend work, if necessary, deep trenches or tunnels can be designed by a specialist to reduce the associated risk. The construction methodology should be considered early buy the contractor to avoid programme delays and ensure the safety of the workers.		
R10	Building connections	The building connection points have generally been assumed based on existing boiler locations and the existing communal heating network building connection points. Until these are confirmed, there is a risk that the proposed network route may need to be revised, resulting in a financial and programming risk to the project.	The building connection points are to be confirmed by an MEP engineer following a building survey or a review of as-built information.		
		Limited information is currently available for the Kensington Aldridge Academy and so the point of connection has not yet been confirmed. This connection is anticipated to be quite complex due to the nature of the southern side of the building, including a lower level open basement court. Until this connection point is better understood and agreed there is a risk the building connection will result in a much longer network route (i.e. around the northern side of the building).	This risk can be mitigated through continued consultation with the management team of the Academy and obtaining building plans which show the plant rooms ahead of the next design stage to reduce the impact of network route changes.		
R11	Safeguarding space	Other projects proposed near the network route may reduce available space, particularly for the future expansion parts of the network and the more congested areas in public highways. Until this is better understood, there is a risk that other projects will proceed before these district heating networks are confirmed, resulting in additional spatial constraints.	Once a feasible route is confirmed, early liaison with the council planning department, highways authority and other significant bodies is crucial to safe-guard the route for future installation.		

Network Routing
4.9 Risk Register

Table 4.9.1 – continued: Detailed Risk Register

Risk Title		Risk	Mitigation	Level pre-mitigation	Level post-mitigation
R12	Construction phasing	Careful planning of the construction programme is required to ensure the site-wide refurbishment works, external network installation and the internal network installation are phased appropriately to avoid on-site delays.	The contractor planning the works must understand clearly the impact of any licences or agreements with statutory authorities so that the phasing is appropriate and delays are avoided.		
R13	Network resilience	Operational resilience may be compromised due to the network being partially routed internally to building (e.g. one building supplied from a pipe passing through a second building)	The buildings in which the internal network is routed are understood to have been constructed after most of the other residential buildings on the Estate. It is considered unlikely these buildings would be decommissioned before the others. In addition, all buildings at the site are being re-furbished to extend the expected building life-spans.		
R14	Lancaster Green Memorial	It is understood that a memorial is proposed at Lancaster Green. The details of this proposal are unknown and so the impact on the district heating network route is unknown. The currently proposed network route crosses the south-eastern corner of Lancaster Green. There is a risk that if the memorial is constructed prior to the district heating network the route may need to be updated to avoid the memorial. This may increase the network route length slightly, resulting in additional cost.	Details of any exclusion zones due to the memorial should be provided at the next design stage so that the impact can be assessed and the route updated early in the project, if needed. If the two projects are phased so that the district heating network is installed prior to the memorial is in place, any foundations/structures required for the memorial should be considered when finalising the network route.		

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Network Routing
4.10 Next Steps

A preliminary review of the proposed district heating network route within the Lancaster West Estate has been undertaken. The available information was reviewed and key features, constraints and risks have been highlighted.

There are several significant project risks that require further investigation. Should these risks render the proposed route unfeasible, an alternative route will need to be considered.

Risks identified as 'High' should be given priority for further evaluation of feasibility.

To confirm the feasibility of this project, additional desktop study and survey work is required. This additional information will need to be obtained at or before design stage to reduce the overall design risk for the project to as low as reasonable practical (ALRP). At minimum, these additional works are expected to include:

Utility Surveys

1. Obtain a topographical survey of the proposed network route. This provides accurate ground levels, spatial information and surface feature locations which can be compared with the utility records to reduce risk. A formal quote is to be obtained prior to engagement of a survey company.
2. Obtain or develop a CAD composite drawing for the existing utility networks and overlay on to the topographical survey so that horizontal spatial district heating route availability can be better assessed, and utility constraints can be defined. A formal quote for this is to be obtained at the next project stage.
3. Following the above, a GPR Survey of utilities along congested sections of the route should be obtained which provides more accurate horizontal and vertical utility positioning for detailed design. A formal survey quote is to be obtained once survey steps 1 and 2 are complete.
4. Following the receipt of the vertical alignment data, 3D modelling of the network would be undertaken to confirm vertical constraints, requirements for tunnels, utility diversions etc (typically undertaken as part of detailed design).
5. In areas particularly congested with utilities, where a network route is challenging to prove, trial holes would be carried out. These ensure accurate horizontal and vertical information and improve confidence in design. Quotes are to be obtained once these areas are better understood.

Refer to Table 4.10.1 for indicative next step survey costs.

Consultation

Further consultation is required with:

- The local Highway Authority, RBKC, to understand traffic management issues.
- Utility providers, RBKC and Engie to agree suitable network routes and obtain further information on existing asset alignments and building connections.
- RBKC to understand the intent for the soft landscaping and site specific requirements relating to protected trees or network routing within private gardens.
- Continued consultation with stakeholders such as the RBKC, Kensington leisure Centre and the Kensington Aldridge Academy as well as with residents is required to ensure the proposed infrastructure is co-ordinated with the existing infrastructure and plant rooms in the commercial buildings.

Network Routing
4.10 Next Steps

Next Step Survey Costs

It is recommended that the first survey to be undertaken is a topographical survey. Once the topographical survey has been overlain with a CAD campsite of the utility records, additional surveys will be required such as a underground utility surveys and trial holes. The underground utility surveys could be undertaken at the next stage of the project or in later design stages.

The utility surveys would be in accordance with PAS128: Specification for Underground Utility Detection, Verification and Location published 2014. A minimum of two (Type B) methods of detection would be used, in accordance with PAS:128, at 2m intervals. These two, Survey Type B (Detection) methods are Ground Penetrating Radar (GPR) and Electro Magnetic Locating (EML).

Refer to Table 4.10.1for indicative next step costs.

Note that utility record information older than 90 days should be used with caution and so a new utility record search might be necessary in later stages of the project.

Table 4.10.1: Next Step Survey Indicative Costs for the currently proposed route (not including future expansion of the network)

Task	Indicative Cost provided by 3rd party survey company*
Obtain utility record CAD composite drawings for the entire network route (not including additional utility record searches for the future expansion development areas proposed by RBKC)	Approximately £930.00 including VAT (expected delivery is 12 working days from order).
Topographical Survey of route (UAV & Infill) 3D	Estimated to be in the region of £12,000- £15,000+ VAT.
Underground utility survey PAS128 M2 3D deliverables	Estimated to be in the region of £40,000-£45,000 + VAT
GPR Data Capture and Processing 3D deliverable	Estimated to be in the region of £22,000- £25,000+ VAT.
Traffic Management/parking suspensions**	Estimated to be in the region of £18,000-£20,000 + VAT
Trial Holes (Survey Type A - Verification)	The number and location of trial holes is to be confirmed once CAD composite and survey information is in hand and critical locations are identified. A cost can therefore not be estimated at this stage.

** It should be noted that these costs are indicative only, based on previous experience or preliminary budget estimates, and subject to change. Formal quotes are to be obtained prior to engagement of a survey company.*

*** Note, if the associated suspensions or permits can be provided via the local authority these fees would be reduced.*

Chapter 5 – Supply Options

Supply Options

5.1 Introduction

As stated in the previous sections of this report, RBKC has committed for the Lancaster West Estate to be net zero-carbon by 2030. The heat supply technology is one of the key parts of the carbon reduction for the estate both for individual heating solutions and for district or communal ones. The objective of the study is the feasibility of a district heating network, so individual solutions have not been analysed in detail in this section and will be only considered as a counterfactual in the techno-economic section.

Different supply technologies have been considered for the project and some of them have been selected for the analysis based on general and project related characteristics. A summary of the technologies is shown in table 5.1.1.

As visible in the table, the supply schemes analysed will be based on heat pumps (using different heat source) with back-up and/or top-up systems based on electric boilers.

Energy Centre

For all the supply options analysed the energy centre for the district heating will be located in the area under Barandon Walk. This area is owned by the council and hosts garages not in use at the moment. It has been identified as viable option for the location of the energy centre.

Table 5.1.1: Energy supply solutions

Energy Solution	Comment	Considered (Yes/No)
CHP	Not considered as a low carbon option as the national electricity grid is decarbonising in an accelerated rate. Additionally, typically NOx emissions from a CHP are higher than a natural gas boiler. Depending on the conditions, PM emissions could occur which would be an increase in emissions compared with a natural gas boiler. Selective catalytic reduction could be used to treat some emissions but would result in some additional costs.	No
ASHP	Air Source Heat Pumps use the air as a source of heat. There are no local emissions related to their use and their use is possible in almost all locations. Total emissions are dependent on the grid electricity factor.	Yes
GSHP	Ground Source Heat Pumps use the ground as source of heat, they can be closed loop or open loop depending on the ground heat use technology. There are no local emissions related to their use their use is possible in many context but need proper investigation. Total emissions are dependent on the grid electricity factor.	Yes
SSHP	Sewer Source Heat Pumps use the water in the sewer as source of heat. There are no local emissions related to their use and there is the need to a sewer with enough flow to justify the installation. Total emissions are dependent on the grid electricity factor.	Yes
RSHP	River Source Heat Pumps use the river water as source of heat. There are no local emissions related to their use. Total emissions are dependent on the grid electricity factor. There are no rivers or canals with enough flow in the proximity of the estate.	No
Energy from Waste	No additional local emissions. No local source of waste heat has been identified during the study.	No
Electric boiler	No local emissions. Total emissions are dependent on the grid electricity factor. Considered as a replacement for gas boilers.	Yes
Biomass boiler	Likely increases in NOx emissions. There will be increases in PM emissions compared with natural gas boilers.	No

Supply Options
5.2 Introduction to Heat Pumps

Heat pumps are a method of electric heating and are classed as a renewable technology, as the heat sources they use are replenishable. Heat pumps operate using the vapour-compression cycle, similar to that of a domestic refrigerator, consuming a unit of electrical energy to turn low temperature heat into multiple units of higher temperature heat. A high level schematic of the components of a heat pump is shown in Figure 5.2.1.

The relatively constant temperature of the sources used means that heat can be extracted for the majority of the year.

There are a number of different sources that heat pumps can use. The heat pumps looked at in this study include:

- Ground Source Heat Pumps (GSHPs), using heat from the ground, which maintains a relatively constant temperature over the year.
- Water Source Heat Pumps (WSHPs) using a body of water as a heat source. In this case the lake in the centre of the site could be used.
- Air Source Heat Pumps (ASHPs) using the outside air as a heat source.
- Sewer Source Heat Pumps (SSHPs) are an emerging technology which use heat pump technology either with a heat exchanger wrapped around sewer pipes, or diverting the sewer flow through a treatment process and heat exchanger.

Heat pumps use electrical energy for part of their operation meaning that they will benefit from the anticipated decarbonisation of the national electricity grid in the UK.

The efficiency of a heat pump is denoted as the coefficient of performance (COP), which states how many units of heat can be supplied per unit of electricity consumed (e.g. a unit with COP of 4 would give four units of heat for a unit of electricity). The COP depends highly on the temperatures between which the unit operates, i.e. the source and heating supply temperatures.

Higher temperature sources have better COPs. Furthermore, the more constant the temperature of the source, the less variation there will be in the COP. For example, GSHPs have higher COPs than ASHPs because the average temperature of the ground is higher than that of the air.

The heat pump technology is reliable and proven, and heat pump installations of this scale have been successfully undertaken. However, certain technology risk come with the different heat sources, for example ASHPs are used on a much wider scale than SSHPs, which have not seen as many installations

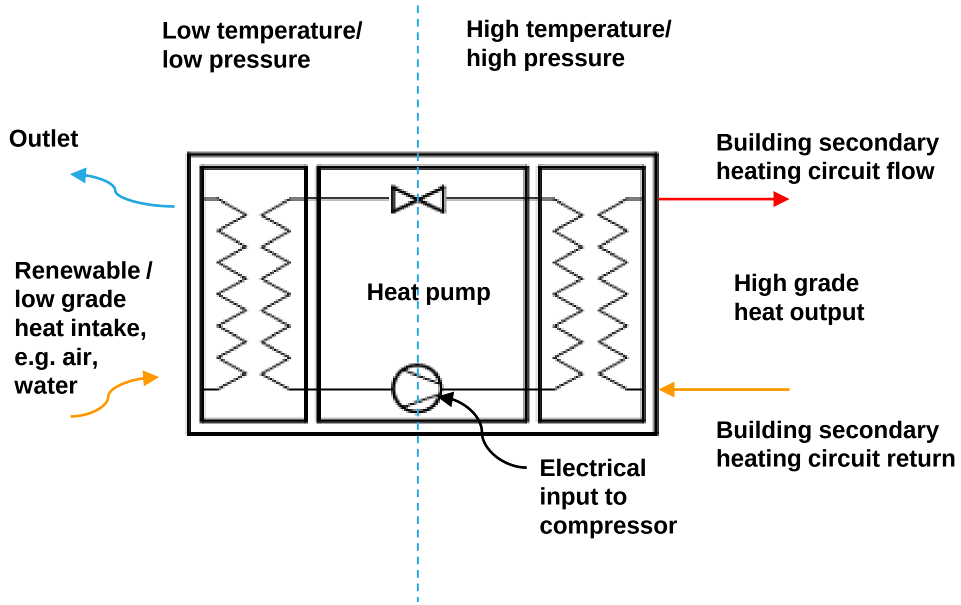

Figure 5.2.1. Heat pump concept schematic

Supply Options
5.3 Supply options analysis

As stated in the introduction, in the specific context of Lancaster West, the supply options are limited to heat pump solutions. In this section the potential of each technology applied at Lancaster West will be analysed.

Air Source Heat Pumps (ASHP)

Air Source Heat Pumps use air as source of heat. They do not have specific limitations due to the context of application as a part of the space take of the external units. At Lancaster West they will be used as primary or secondary sources of heat, depending on the availability of other low carbon heat generation technologies.

Ground Source Heat Pumps (GSHP)

Ground Source Heat Pumps can be either open or closed loop. Closed loop GSHPs use a pipe circuit containing brine which exchanges heat with the ground. This circuit can be horizontal at a low depth or vertical using boreholes which can reach a depth of 150 metres. The open loop systems use water from aquifers as source of heat; they need wells to be dug but in much smaller numbers compared to the closed loop systems. Closed systems present a lower performance risk since their efficiency depends on the ground conductivity; open loop systems present an higher performance risk due to the dependence on the availability of water from the aquifer, but lower overall costs.

In the specific context of Lancaster West closed loop systems have not been considered as viable, mainly due to the space take of the installation, the complex ground level configuration which makes the presence and operation of excavations equipment difficult, and the concurrence presence of inhabitants of the estate during the works. A previous feasibility study calculated a required 194 boreholes around the estate which seems impractical due to the context.

For an open loop system, the presence of an aquifer underneath the estate has been investigated. The analysis reveals that even if the site is located in a low transmissivity zone, there are existing GSHP project nearby the site with good well yields. The owners of the extraction licences have been contacted and the extraction rates in the licences have been confirmed consistent with the actual data. It was also confirmed that the systems have not shown any problems in the past.

The result of the analysis and of the investigation with extraction licences owners showed extraction rates from 11 l/s to 25 l/s in an area with 1 km of radius around Lancaster West. These results reduce the risk of a lack of usable water from aquifer but do not eliminate the need of a numerical model of the site and abstraction tests on the wells.

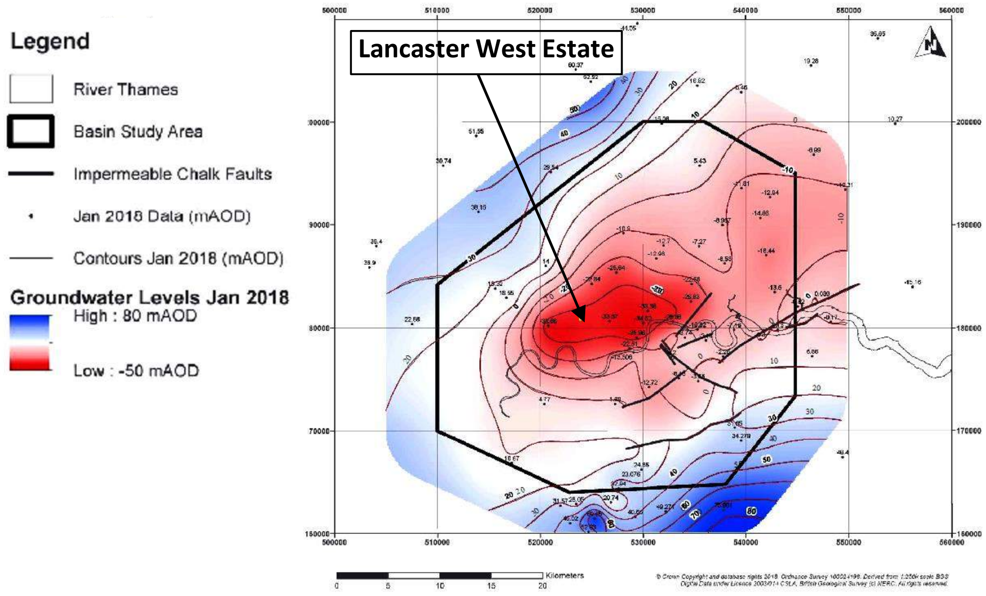

Figure 5.3.1. Underground water level

Supply Options
5.3 Supply options analysis

It should also be considered that GSHP systems show better performance in the case of balanced use between winter and summer, with both heating and cooling systems used during the year. The heat extraction in winter and heat rejection in summer makes the system more balanced and can guarantee constant performance over time. In the specific context of Lancaster West there are no expected cooling loads, so no heat rejection in summer. Therefore the open loop system can be used as a secondary heat source used mainly in winter in case of presence of an alternative low carbon source, or a connection for the supply of coolth to the academy or the leisure centre needs to be investigated in future phases of the project.

It should be noted that for efficiency reasons the wells used for open loop systems need to be at least 100 metres apart and in some cases there is the need of a third well for a good balance of the system.

At Lancaster West a first well can be dug in the energy centre area and a second one can be dug in the area today used by the temporary boiler for Camelford, Clarendon and Talbot Walks. Both areas are accessible from the roads and also for heavy machinery.

The distance between the two areas is around 180 metres therefore is enough to avoid interference between water extraction an rejection.

The second well can be reached using a similar routing to the one used by the heat distribution systems, hung on the basement roof of Testerton Walk, with no need for pipe trenching and a consequent reduction in costs.

The location of a third well is more complex and need further investigation: it can be in the east side of the estate and for the connection to it the same strategy of following the district heating pipes can be considered.

The water extraction rates and the need of a third well can only be checked via abstraction tests needed in any open loop systems. Tests are expensive (around £150,000) but the costs are mainly for excavation which will be actual costs of the system in case of decision to go ahead.

As next steps for the project it is suggested to undertake a specific geotechnics investigation with a numerical model of the site and water abstraction tests for the identified wells.

At this stage of the study two wells (one abstraction and one rejection) have been assumed and an extraction rate of 11 l/s has been used with a maximum heat output of 270 kW.

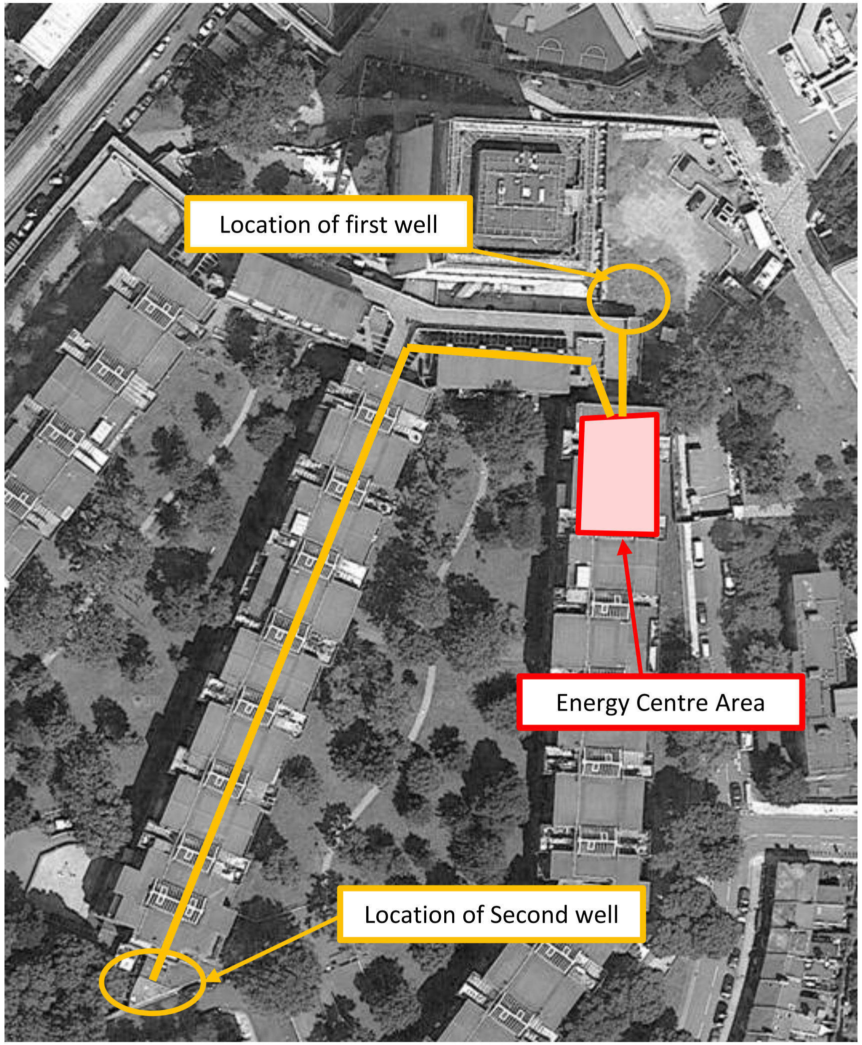

Figure 5.3.2. Heat pump concept schematic

Supply Options
5.3 Supply options analysis

Sewer Source Heat Pump

Sewer source heat pumps use the heat recovered from the sewers as a heat source. The heat available is then linked to the size, flow rate and temperature of the sewer.

During the investigations for the existing utilities for the pipe routing it emerged that a large combined sewer runs underneath the estate, passing close to the Leisure Centre and to the Barandon, Hurstway and Testerton Walks. Thames Water has been involved in the investigation and the use of this sewer for the heat generation at Lancaster West has been considered feasible. There is no metered data regarding the flow and the temperatures for this sewer and these measurements will be needed before and during the next phases of the project. At the moment a procedure for the sharing of this data is being developed and during next phase the data will be available for a more accurate investigation.

With the publicly available data available at this stage of the project, some high level calculations about the depth flow rate and temperature of the sewer have been made.

Checking the depth of the access shafts on the sewer route it has been calculated that the depth of the sewer floor is around 4.5 metres deep and the cover is around 2.5 metres deep. The depth of the access shafts also enables calculation of an average gradient and considering different filling levels of the sewer, also calculation of the flow rates of the sewer. Three different conservative filling levels have been considered at 5%, 10% and 15%, with flowrates of 15 l/s, 65 l/s and 150 l/s.

Being a combined sewer the flow rate is probably higher but it has been preferred to use lower values which show cautious energy generation values, leaving the modelling of greater energy generation for the next phase when the metered data will be available.

The discussion with Landmark (sewer heat pump supplier) concluded that a very conservative flow rate of 50 l/s can be used for the study. It should be noted that the costs for a SSHP include a large component related to civil works which have similar values for the different flow rates and capacities. Therefore increasing the size of the heat pump in case of a higher flow rate will lead to a significant reduction of the unit costs for the technology.

For the sewer temperature three different average values have been used: 12 degrees for winter, 22 for summer and 17.5 for mid seasons, according to London average sewer temperatures.

With the flow rate and the temperature used the SSHP analysed will be able to produce 1.2MW of heat.

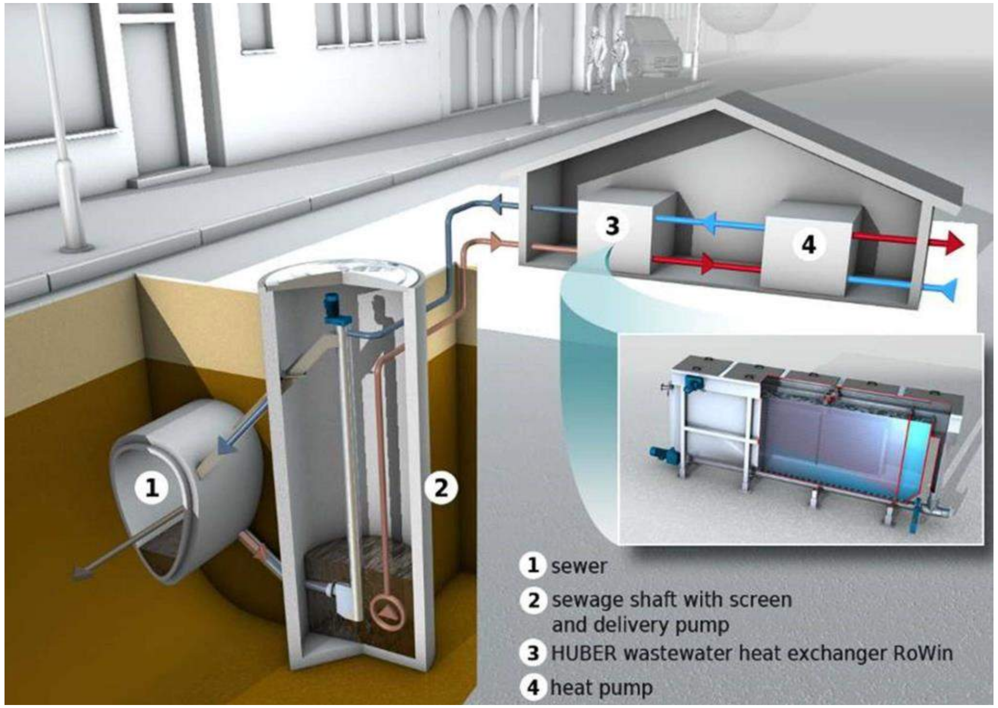

Figure 5.3.3. Sewer heat pump concept schematic

Supply Options
5.3 Supply options analysis

It should also bee noted that with the publicly available data it is not possible to model hourly profiles of the sewer temperatures and flow rates which will show the additional advantage of this kind of technology. If the sewers have a higher flow rate and higher temperatures during the hours of peak heat demand for the domestic hot water, then the heat production will have greater values in the period of higher demand.

For this, more granular hourly modelling of actual flow rate and temperatures is needed. This is why it is suggested to proceed with measurements before and during the next phase of the project.

As visible in Figure 5.3.4, the sewer route is relatively close to the identified area for the energy centre and the land between the two location is free from building and construction. Lancaster West's context represents a good scenario for the implementation of a SSHP.

An alternative connection location has been identified closer to the energy centre, in the garages of Barandon Walk. This option will be better for the lower pipe length but it should be investigated further due to the possible complexity of the excavation works.

There are two technologies for sewer heat pumps, one using a heat exchanger wrapped around sewer pipes, and the other which diverts the sewer flow through a treatment process and heat exchanger. For Lancaster West the second technology has been chosen and contact with Landmark Wastewater Solutions has been made in order to check the feasibility of the plant.

The plant diagram in Figure 5.3.3 in the previous page shows the main components of the sewer heat recovery plant. A shaft is built close to the sewer and part of the sewer flow is diverted into it. Then a pumping system circulates the sewage into special heat exchangers hosted in the energy centre and reject it back in the sewer.

These kinds of systems are relatively new in the UK but they have been used in Europe and particularly in Germany in the last ten years demonstrating good efficiency and reliability.

The preliminary work done with Landmark has produced the potential heat extraction from the sewer at the condition specified previously.

It is suggested to request an additional feasibility of the plant in the next phase when metered data for temperature and flow rate will be available.

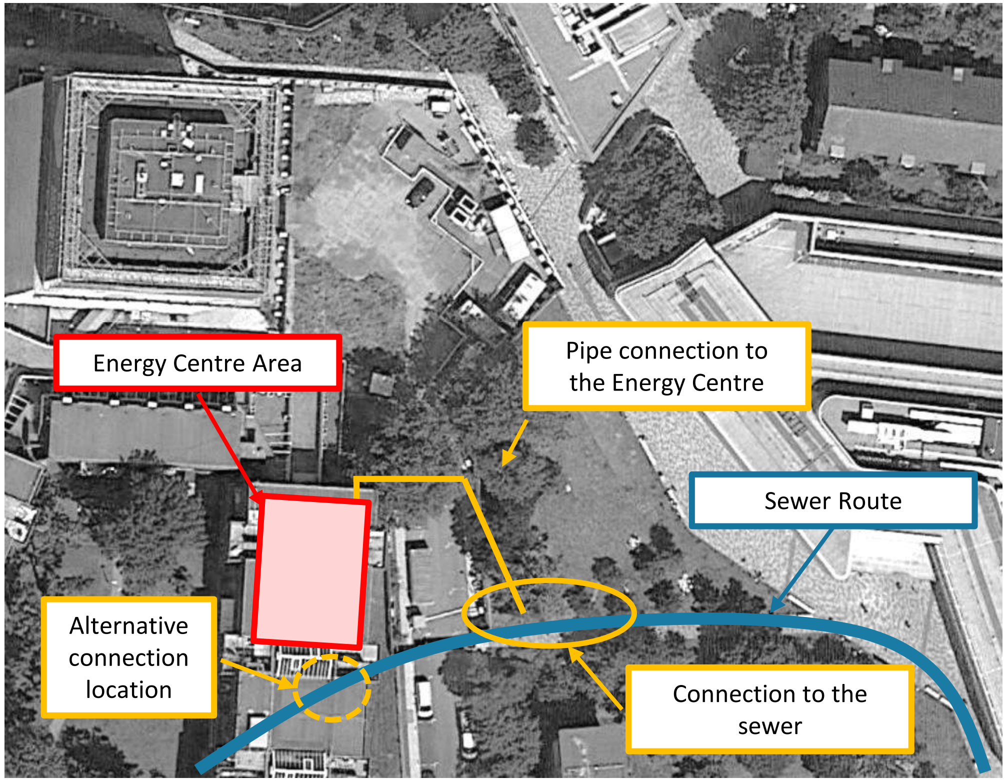

Figure 5.3.4. Sewer heat pump connection

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Supply Options
5.4 Supply Strategy

Key Requirements

Different supply strategies are possible with the technologies described in the previous sections and the plant modelling and sizing, including the sizing of pumps, boilers and thermal stores has been undertaken for all demand and supply configurations. All supply scenarios developed follow a common design basis:

- Heat pumps will supply the majority of the heat.
- Back-up electric boilers shall be capable of meeting the peak network load. For resilience, in all scenarios the boilers have been sized in n+1 configuration.
- Thermal stores are used to balance the system and maximise the heat production from heat pumps.
- This design allows for future potential expansion.

Operating Temperatures

From the demand data provided for the residential buildings and analysed in the previous section it is clear that the refurbishment works planned will improve the thermal efficiency of the buildings and reduce the thermal losses.

The estimated energy performance after the refurbishments will be in the area of EPC B, with some better value close to A and some worse close to C, depending on the level of refurbishment.

The new demands will allow a reduction on the supply temperature comparing to the ones used today but this reduction will not be as significant as expected for better performing buildings as passive houses.

With regards to the non domestic buildings, tests on temperature reduction should be undertaken when the plants are back to full operation.

For the energy modelling we estimated two ranges of network temperatures depending on the refurbishment scenarios. 70-40 for scenario 1 and 65-35 for scenario 2.

In the case of ambient loop a primary flow and return temperatures of 15-25 have been chosen with individual water source heat pumps providing the temperature top-up in the single apartments.

The sizes and the capacity of the new heat distribution systems inside the flats to supply enough heat using the estimated supply temperatures need to be investigated by the refurbishment team and is not in the scope of this project.

Phasing

Demand will increase as more buildings are connected to the network. As the intention is for connections to be made over a relatively short period in line with the refurbishment works (2022-2027), it is assumed that the plant could be installed at full capacity in year 1 for all main components. In some scenario additional heat pumps and back up boilers (used for resilience) can be added together with the increase of the demand.

In case of future expansions of the network additional equipment will need to be implemented in the energy centre. At the moment is not possible to estimate whether this expansion will happen and when.

Network Losses

Network losses have been estimated around 15% for the network operating at 65 and 70 degrees C supply temperatures (considering the fact that lots of pipes will run externally) and have not been considered in case of ambient loop network.

Maintenance

All components require planned maintenance. Some of them such as boilers or air source heat pumps are present in more than one unit and require relatively low maintenance. It is assumed that they will be maintained during the normal operation of the plant, without any disruption of the operation, by planning maintenance during low demand periods and alternating the heat supply units.

In the case of SSHPs the maintenance is more significant. It is assumed that the heat pump will be maintained for 2 weeks per year and it will not operate for that period.

Electric Network Capacity

Today all heating systems at Lancaster West use gas. All the low carbon options modelled here, both district systems and individual ones, involve a shift to electricity as a lower carbon option. As such, it is likely that the capacity of the local electricity distribution network will need to be increased. UKPN has been contacted and a quotations for different capacities have been sent to Arup and included in the techno-economic model. It is suggested to recheck the quotation during next phases.

ARUP

Supply Options
5.5 Plant Concept

Figure 5.5.1 shows the plant configuration which includes all the technologies described previously. It is the most ambitious plant configuration and all other supply scenarios will use similar but simpler schemes.

- The plant configuration is developed to maximise the production of heat from the heat pumps
- The heat pumps will be connected to the thermal storage units in order to balance the production and run them as much as possible during the year
- The top-up and back-up boilers will be in n+1 configuration with other components. In case of failure of an heat pump, the other heat pumps plus the boiler will always bee able to supply the peak demand.
- The boilers will be connected directly to the supply network and used in case the heat pumps are not able to supply all the heat.
- The thermal storage units are connected to the distribution circuit and they act as heat sources.
- The thermal storage size is has been modelled during the plant optimisation simulations.

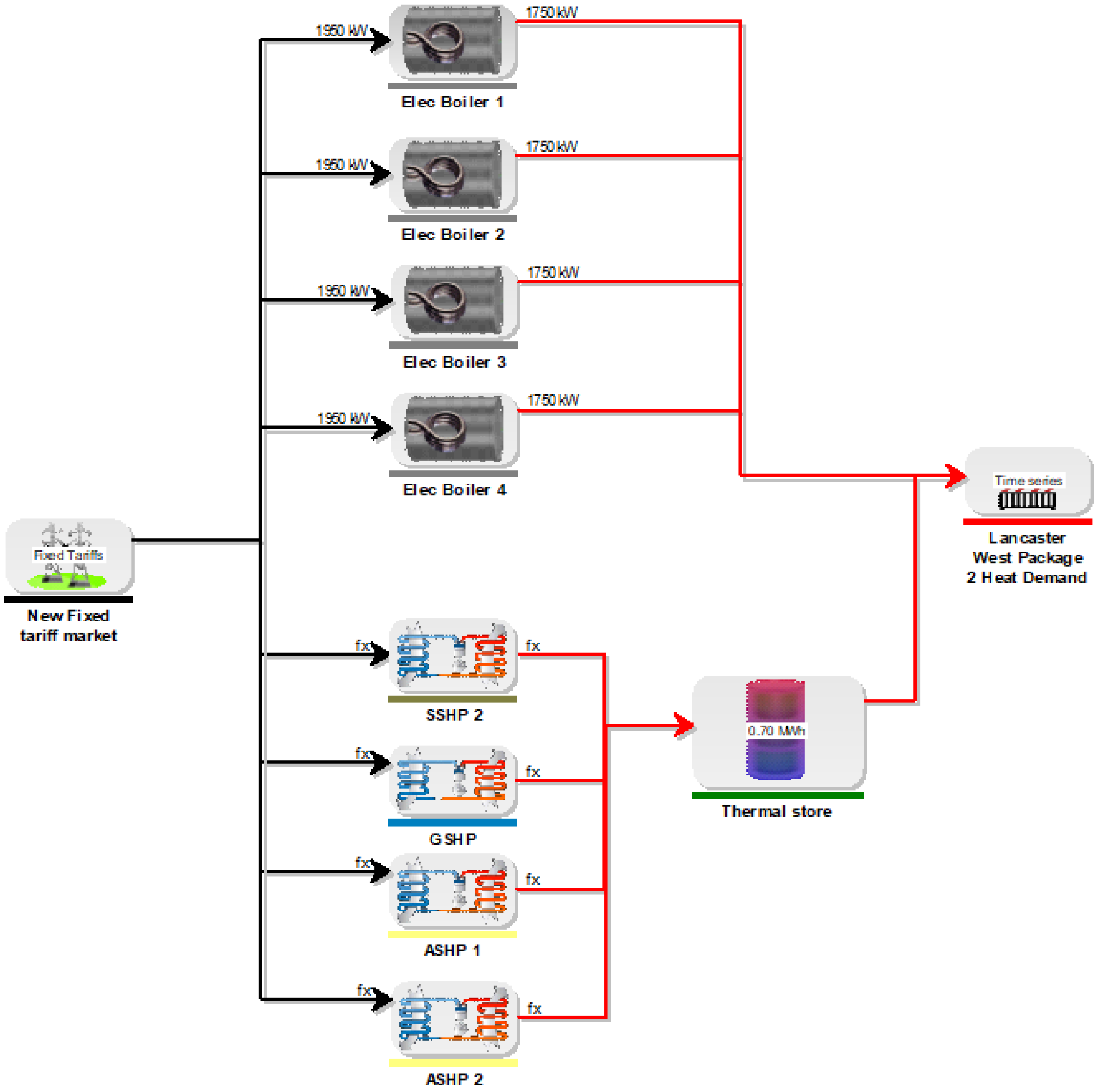

Figure 5.5.1: Plant Configuration

Supply Options
5.6 Supply Scenarios

Four different supply scenarios for each demand scenario have been developed for the district heating configurations all based on heat pumps using different combinations of supply technologies:

1. ASHP: Only air source heat pumps used as low carbon source of heat. This scenario represents a solution in case SSHP and GSHP will be proven as infeasible.
2. SSHP + ASHP: Sewer source heat pump used as base load and air source heat pumps used as top up.
3. SSHP + GSHP + ASHP: Sewer source heat pump used as base load, ground source heat pump used as secondary source in winter and air source heat pump used as top up.
4. Ambient Loop: SSHP + GSHP as primary heat pumps and individual water source heat pumps in the flats.

Two non heat network scenarios have been modelled as counterfactual:

- Individual supply: Single air source heat pumps for the flats.
- Mixed supply: Communal heat pumps for the existing communal heating systems and individual heat pumps for the flat having today individual systems.

These two scenarios have not been fully modelled since the individual solutions are not in the scope of work but they have been considered for the economic modelling to compare the results of the district heating solutions with the possible counterfactuals.

Sizes of the main plant components for the developed scenarios are shown in Table 5.5.1

Table 5.6.1: Plant sizes configurations at full capacity

Supply Scenario	Demand Scenario	SSHP Total Capacity (MW)	GSHP Total Capacity (MW)	ASHP Total Capacity (MW)	Boiler Total Capacity (MW)	Thermal storage total capacity (m^3)
ASHP only	P1			4.8	9	30
ASHP only	P2			2.4	5.25	20
SSHP + ASHP	P1	1.2		3.6	9	30
SSHP + ASHP	P2	1.2		1.5	5.25	20
SSHP + GSHP + ASHP	P1	1.2	0.27	3.6	9	30
SSHP + GSHP + ASHP	P2	1.2	0.27	1	5.25	20
SSHP + GSHP + ASHP ambient loop	P1	1.2	0.27	2.4	9	30
SSHP + GSHP + ASHP ambient loop	P2	1.2	0.27	1	5.25	20

Supply Options
5.7 Plant Optimisation

The plant sizing optimisation was carried out using an energy simulation software (EnergyPro). Several models were created to review the usage of the plant in each scenario on an hourly basis, over the full lifetime of the plant.

The demand-supply curves in Figure 5.6.1 and Figure 5.6.2 show the most ambitious scenario (with sewer, ground and air source heat pumps in use) at full load for package 1 and package 2, and can be used as reference for other scenarios.

As can be seen, the limited capacity of the sewer heat pump and the ground source heat pump contribute to the overall supply in different quantities in the two demand scenarios. Package 2 with a reduced demand will benefit more from the use of these technologies.

Most of the heat is supplied by heat pumps in all scenarios with top-up boilers suppling around 5% of the annual demand.

Although the capacity of the HPs is 50% of the peak, they can supply 95% of annual demand. This is because of the spread of demand over time. To meet the remaining 5% of annual demand (at the coldest times of the year), the HP capacity would have to double. As electric boilers are cheaper than HPs (even though higher carbon), it is assumed that they will be used to meet the peak.

The hourly simulation was also used to calculate the volume of thermal storage units to ensure the heat network customers' heating requirements are met and to balance supply and demand profiles.

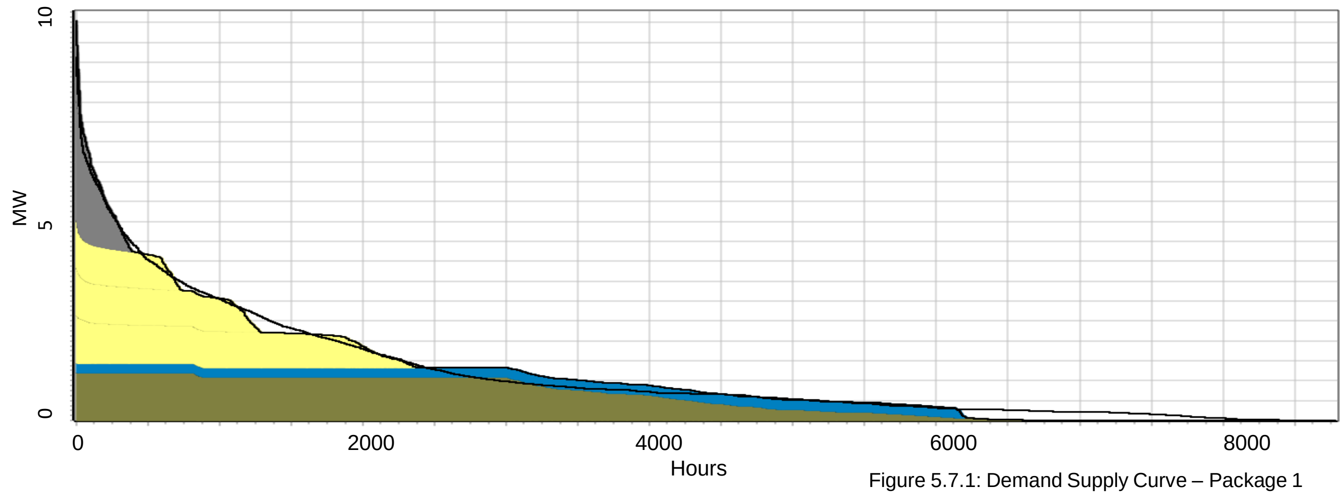

Figure 5.7.1: Demand Supply Curve – Package 1

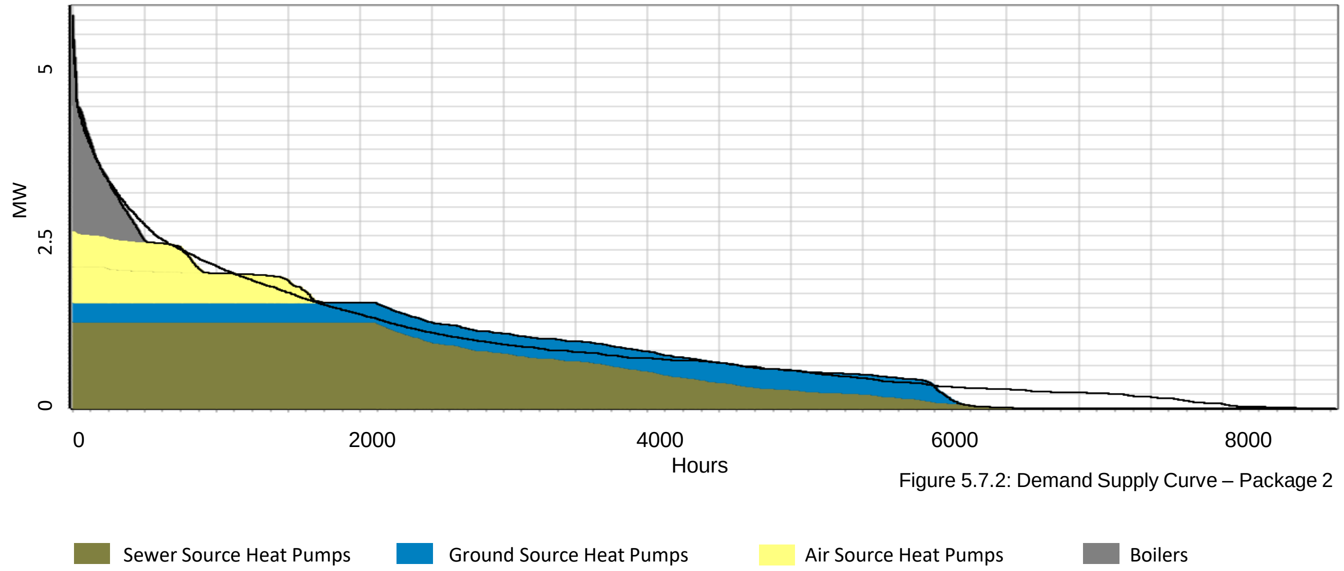

Figure 5.7.2: Demand Supply Curve – Package 2

Supply Options
5.8 Simulation results

Table 5.8.1 shows an annual breakdown of the key plant components for each scenario, and how much heat is supplied by the heat pumps and the collective boilers. It also shows the electricity consumption.

As shown, the contribution of sewer source and ground source heat pumps is similar in different scenarios - this is due to the maximum fixed size.

Air source heat pumps are used as primary source only in the first supply scenario. In the other scenarios they became a secondary or tertiary source, therefore the heat generated by them is lower when other low carbon sources are available.

The ground source heat pump is used as primary source of heat during the period in which the ground water is warmer than the sewer. This prioritisation strategy may change when the metered data becomes available.

For ambient loop, the energy from SSHP and GSHP is not totally generated by them. It is more correct to consider the energy coming directly from the sewer or ground source circuits with the heat pump contributing only in the case where the energy isn't sufficient. This working configuration is apparent in the consumption of electricity - the lowest for both supply scenarios.

The blended COP shows the overall efficiency of the generation systems in the different scenarios. The differences between P1 and P2 scenarios within the same supply scenarios are due to the limited sizes of the most efficient systems (SSHP and GSHP) which supply a higher percentage of the energy in the lower demand scenarios.

Table 5.8.1: Heat Production results at full capacity - 2028

Supply Scenario	Demand Scenario	SSHP (MWh)	GSHP (MWh)	ASHP (MWh)	Boilers (MWh)	Individual systems (MWh)	Electricity Consumption (MWh)	Blended COP
ASHP only	P1			9,650	800	/	3,900	2.7
ASHP only	P2			7023	650	/	2,700	2.8
SSHP + ASHP	P1	5.690		4,060	690	/	3,250	3.2
SSHP + ASHP	P2	5700		1600	350	/	1,900	4.0
SSHP + GSHP + ASHP	P1	4,800	1,490	3,570	570	/	3,100	3.4
SSHP + GSHP + ASHP	P2	4,790	1,350	1,070	470	/	1,990	3.9
SSHP + GSHP + ASHP (amb.)	P1	4,250	1,649	2,200	240	2,040	2,460	4.2
SSHP + GSHP + ASHP (amb.)	P2	3,910	1,630	700	150	1,300	1,790	4.3

Supply Options
5.8 Simulation results

Figure 5.8.1 shows the percentage of the energy generation by different systems in each scenario.

With this visualisation it is easier to understand the different contribution of the technologies in each scenario.

The first supply scenario is the simplest with ASHP contributing for more than 90% of the energy generated.

In case of use of the SSHP, with a fixed maximum size, the different percentage of energy generated in the two demand scenarios is clear, with package 2 reaching 74% of energy generated by this system with a higher COP.

The contribution of the GSHP is below or around 20% in all scenarios in which it is used. This is due to the prioritisation strategy which uses it as primary source in the coldest period of the year. When sewer temperatures are metered and known this percentage may vary and will potentially reduce.

For ambient loop, the energy generated by the individual systems in each apartment will be around 20%. The energy in the ambient loop will not be supplied totally by the sewer and ground because it will not be sufficient (due to the limited flow of the sewer and limited water extraction from the ground) and there are no cooling loads which can generate rejected heat. Therefore the contribution of centralised heat pumps and boilers will be required.

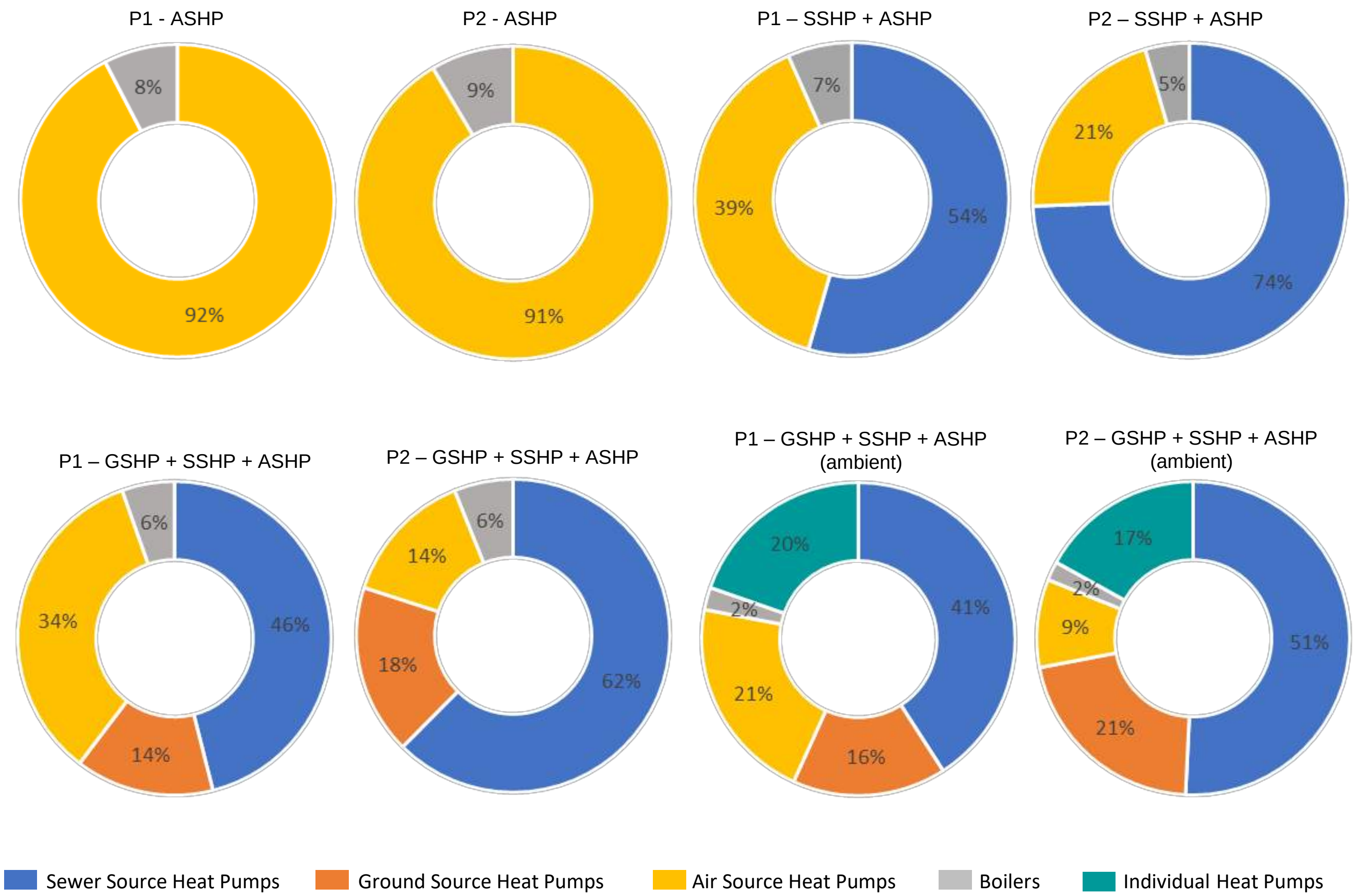

Figure 5.8.1: Energy production percentages at full capacity - 2030

Supply Options
5.9 Plant layout

Figure 5.9.1 shows the suggested layout for the main energy centre plant required in the Package 1 scenario with SSHP and ASHP.

Plant sizes have been based on selections made by reputable manufacturers and piping and access requirements have been considered.

The energy centre location varied during the study and the final location, under Brandon Walk, emerged only during the last phase of the study. Therefore further investigation will need to be undertaken about the exact location and integration with the existing structures, as well as for the space requirements.

Table 5.9.1: Energy Centres plant area

Supply scenario	Demand Scenario	Area m²
ASHP only	P1	500
ASHP only	P2	360
SSHP + ASHP	P1	500
SSHP + ASHP	P2	360
SSHP + GSHP + ASHP	P1	500
SSHP + GSHP + ASHP	P2	360
SSHP + GSHP + ASHP (amb.)	P1	400
SSHP + GSHP + ASHP (amb.)	P2	320

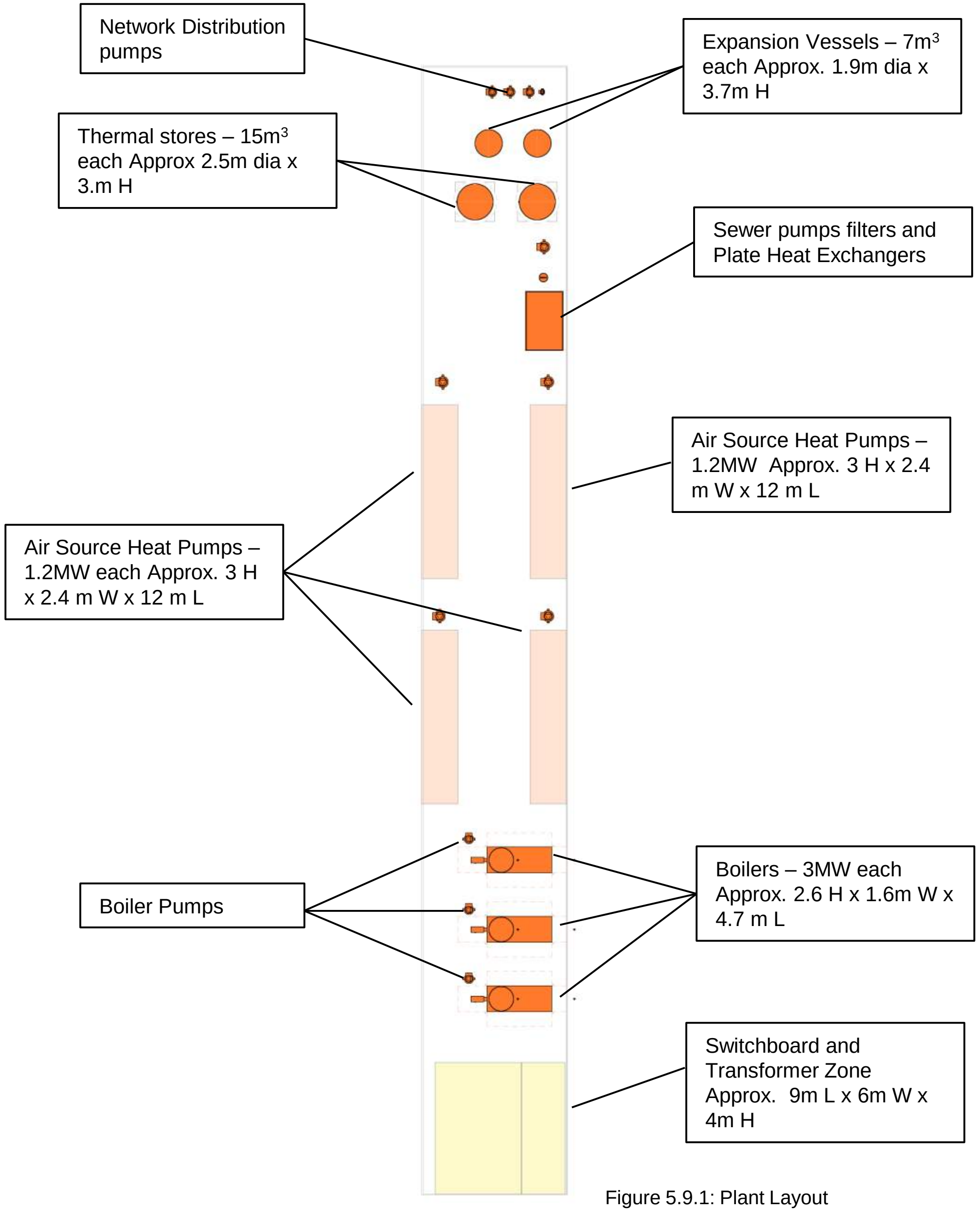

Figure 5.9.1: Plant Layout

Supply Options
5.10 Risk Register

Table 5.10.1: Risk Register

Title	Risk	Mitigation	Level pre-mitigation	Level post-mitigation
S1 – Securing Energy supply SSHP	SSHP heat availability – Flow rate and temperatures of the sewer are vital for the efficiency of the system and the heat offtake. Reduced flow rate can mean too high unit cost for heat from the SSHP.	Contact with Thames Water and SSHP manufacturer have been developed. During the next phase of the project flow rate and temperature will be monitored.		
S2 – Securing Energy supply GSHP	GSHP heat availability – No aquifer water for the heat pump, in case of insufficient abstraction water for the ground source heat pump the system can't be used.	The desktop analysis and the contact with nearby GSHP systems owner have identified the opportunity of a sufficient water abstraction rate. The abstraction rate test is expensive and is suggested only in case other low carbon heat source are proven unavailable.		
S3 – Securing Energy supply ASHP	No space for ASHP external units.	Due to the change of location of the energy centre in the final stages of the project it was not possible to check the available space for the external units of the heat pump at the rooftop or in the Grenfell Walks. It is suggested to check it during the next phases.		
S4 – Electrical connection costs	Should the electrical connections to the site require substantial network reinforcement works the costs could escalate into the £million range; this could affect the business case substantially.	Quotation has been requested from UKPN.		
S5 – Phased Plant Installation	Phasing the plant as concept, main components changes or need of additional space can cause problem in the operation.	The plant will not be phased, in some scenarios additional ASHP and boilers will be installed due to the increasing demand. This integration will be planned from the beginning and the adequate space and plant connection allowances will be left during the initial construction.		
S6 – Securing Energy Centre location	The identified location for the energy centre (under Barandon Walk) has been identified only in the late stages of the project. It needs to be checked the availability of the space and the interferences with other activities.	The location is RBKC owned and was suggested by RBKC. There is a need to check the interference with other refurbishment activities and other technical issues, like connection to the sewer etc. not checked during this study since the energy centre location has been changed after the site visit.		

Supply Options
5.11 Conclusions and Next Steps

Different low carbon solutions for the supply of heat are available at Lancaster West. Some technologies are not linked to the location as ASHP and electric boilers, but others such as sewer and ground source heat pumps relate their size and efficiency to the local conditions.

Various manufacturers and experts have been contacted for the possible supply plant configurations and efficiency and four main supply scenarios have been developed.

ASHPs are the most reliable low carbon source, as they can be installed easily and they can be used as primary or secondary source of heat. Due to the use of air as a source of heat the seasonal COP of this technology is the lowest, with consequent higher energy use and carbon emissions. It is suggested this be used as a primary source only in the case where other low carbon technologies are not available.

SSHPs represent a good solution for Lancaster West for low carbon heat supply. The sewer passing in the proximity of the energy centre in an RBKC owned land represents a relatively easy source of heat and no technical issues that can stop the project have been identified.

The SSHP size is limited by the sewer flow rate (which need further investigation) and the heat available at Lancaster West will not be sufficient for supplying all the demand. It is then suggested to use this technology in conjunction with other low carbon solutions such as ASHPs.

As next steps for the project, it is suggested that a specific feasibility test be undertaken which has a cost in the order of £20,000

GSHPs are a viable solution for Lancaster West, but the heat available is limited by local conditions. This technology also shows advantages in cases of balanced heating and cooling loads during the year, however these are not present at the site. It is therefore suggested to take the GSHP as a third option and prioritise the SSHP.

The water extraction rates can only be checked via abstraction tests needed in any open loop system. Tests are expensive (around £150,000) but the costs are mainly for excavation which will be actual costs of the system in case of decision to go ahead.

As next steps for the project it is suggested to undertake a specific geotechnics investigation with a numerical model of the site and water abstraction tests for the identified wells, but only in the case where the Sewer Source Heat Pump will reveal to be a non viable solution.

The ambient loop solution is the plant configuration which needs less energy to generate the heat, but unfortunately this solution benefits a lot from balanced heating and cooling loads which are not present on site, and has high capex due to the need of communal and individual heat pumps. Regardless, this solution has been analysed in the techno-economic model.

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Chapter 6 – Techno-economic analysis

Techno-economic analysis
6.1 Introduction

This section introduces various aspects of a Lancaster West DH scheme.

Context

As mentioned in the introduction section, the study area comprises of a large proportion of residential properties, a leisure centre and an academy. The residential properties are managed by RBKC and largely comprise of social housing. Stakeholders that currently occupy these residential properties are either tenants, leaseholders or freeholders. Tenanted and leased properties cover over 95% of the residential properties (tenants cover over 65%).

Heating System

Currently, RBKC is investigating various retrofitting plans for the estate with aim of reaching net zero carbon by 2030. Decarbonising the current heating demand (currently gas fired) is therefore essential.

The council is responsible for the technical assessment, procurement, installation and testing of the heating systems. For leasehold properties, they are able to recover approximately half of the costs per flat from residents.

The council is also responsible for all ongoing operation and maintenance. It is understood that they recover some of the related fuel and maintenance costs from tenants and leaseholders through a mix of monthly heating and service charges.

For the purposes of this study, it is assumed that the role of the council will remain unchanged whether the new system is a district, communal or individual systems.

Funding

The council has allocated approximately £54m to the estate's refurbishment budget. It is understood that this budget includes refurbishment of the heating system but that the amount available may not be sufficient to cover all costs associated with decarbonisation. As such additional top up funding from HNIP may be required.

The council are likely to keep the ownership of the project and contract out any operations and maintenance works. The project ownership held by the council will help RBKC dictate the heat tariffs charged to various stakeholders. This is important as it allows the council to tackle energy poverty.

Cost Recovery

As the council is responsible for providing the heating system for almost all of the estate it cannot pass the capital costs to its tenants. It can only charge a £/kWhth cost on the heat consumed.

As the council cannot charge tenants with a connection and fixed charge, it is unrealistic to expect that the scheme will provide a positive NPV and IRR but these results need to be contextualised.

The DH analysis therefore compares various low carbon DH schemes against two alternative no DH low carbon scenarios. The aim is that the study can help provide the council comparisons of all solutions and can help inform them of the best cost effective solution which also helps them get closer to their net zero ambition.

Techno-economic analysis
6.2 Scenarios

The table on the right presents the scenarios considered in the feasibility study.

Scenarios from 9 to 12 have been included as non heat network scenarios. Individual ASHP solutions will be required to be adopted in place of district heating for the estate to be in line with their 2030 carbon neutral ambition. A large proportion of the costs associated with individual ASHP solutions will be provided by the council. As previously mentioned, it is their responsibility to fully or partially refurbish (including the heating system) a large proportion of the domestic properties. All costs associated with everyday energy consumption will be directly paid by all entities to their respective energy supplies.

In the district heating scenario the council can earn some revenue from variable charge. It has been assumed that the variable charge is not more than what the entity may pay for heat, if they have individual ASHPs installed. Additionally, the council can make further network and plant efficiency updates or connect more buildings to the DH network as the potential heat demand patterns are better known post retrofitting.

In addition to the table on the right, an alternative scenario was run assuming the potential of electricity from PV panels on all flat rooftops in the estate for scenario 3 and 4. The instantaneous electricity generated from PV would be utilised by district heating before being exported.

Table 6.2.1: District Heating Scenarios

#	Scenario	Description
1	ASHP fed DH network – Package 1	The main source of heat is the ASHP at the energy centre for if the estate adopts package 1 retrofits.
2	ASHP fed DH network – Package 2	The main source of heat is the ASHP at the energy centre if the estate chooses package 2 retrofits
3	SSHP + ASHP fed DH network – Package 1	Heat is supplied by SSHP and ASHP at the energy centre for if the estate adopts package 1 retrofits.
4	SSHP + ASHP fed DH network – Package 2	Heat is supplied by SSHP and ASHP at the energy centre if the estate chooses package 2 retrofits.
5	GSHP + SSHP + ASHP fed DH network – Package 1	Heat is supplied by GSHP, SSHP and ASHP at the energy centre if the estate adopts package 1 retrofits.
6	GSHP + SSHP + ASHP fed DH network – Package 2	Heat is supplied by GSHP, SSHP and ASHP at the energy centre if the estate chooses package 2 retrofits.
7	GSHP + SSHP + ASHP fed ambient DH network – Package 1	Heat is supplied by GSHP, SSHP and ASHP at ambient temperatures from the energy centre for if the estate adopts package 1 retrofits. Additional WSHP is required at each entity to step up the temperatures.
8	GSHP + SSHP + ASHP fed ambient DH network – Package 2	Heat is supplied by GSHP, SSHP and ASHP at ambient temperatures from the energy centre for if the estate adopts package 2 retrofits. Additional WSHP is required at each entity to step up the temperatures.
9	Individual solution – Package 1	It is assumed that the council installs individual ASHPs in each property post package 1 retrofits. Freeholders, leisure centre and the academy are responsible to install their own ASHPs.
10	Individual solution – Package 2	It is assumed that the council installs individual ASHPs in each property post package 3 retrofits. Freeholders, leisure centre and the academy are responsible to install their own ASHPs.
11	Mixed solution – Package 1	It is assumed that all properties in LW1 and LW3 heat network move to low carbon heat. Other properties will move to an individual ASHP solution.
12	Mixed solution – Package 2	It is assumed that all properties in LW1 and LW3 heat network move to low carbon heat. Other properties will move to an individual ASHP solution.

Techno-economic analysis
6.3 Counterfactual and charges

Previous sections in this chapter provided some introductory understanding of the project and charges applied.

This section presents the techno-economic modelling assumptions, the methodology used for the modelling and the results for the scenarios analysed is more detail.

Counterfactual

As a starting point for the analysis we developed a counterfactual scenario for the heat loads that will be supplied by the network. The counterfactual is defined as the most probable scenario in the absence of a district heating scheme. The stakeholder engagement and the site visits also supported the development of the counterfactual.

Lancaster West's ambition to be net zero by 2030 strongly influenced the counterfactual scenario considered. All entities within the Lancaster West estate were assumed to adopt an individual ASHP solution. An electricity linked solution ensures that heat decarbonises proportional to an already decarbonising electrical network.

In the case of the Aldridge Academy and the Kensington leisure centre, heating would be supplied by the existing systems (gas fired boilers and CHP) until the end of their lifetime. It is then assumed that they would move to a ASHP solution.

The costs and carbon implications of this counterfactual are evaluated for comparison.

The carbon emissions are used as a comparator to define the carbon emission reductions operated by the district heating scheme.

The counterfactual costs are used to calculate the connection charges and the heat tariffs (fixed and variable).

Connection Charges

The connection charges are calculated by considering the counterfactual replacement cost for the existing system, or the avoided installation costs of a new system (individual heat pumps in this scenario).

In the context of Lancaster West estate, RBKC is responsible for providing the heating systems for tenants. For leaseholders, RBKC estimates that they would contribute to approximately 55% of the refurbishment costs. The freeholders will be expected to pay all costs.

The leisure centre comes under the RBKC ownership but comes under a different budget. It is expected to pay for its connection charges. The Aldridge academy has limited links to RBKC and will pay for its own connection charges.

The initial stages of the project will be cost intensive for the council.

Heat tariffs

Heat tariffs generally comprise a fixed and variable element. The fixed element reflects the fixed operating costs of the system (e.g. operations and maintenance, plus an amount towards plant replacement costs) while the variable element reflects the cost of fuel.

As outlined in Section 6.1, in the case of LWE it is understood that under current arrangement, tenants pay the variable element only, with RBKC responsible for all costs of operation and maintenance. For the purposes of this study, it is assumed that this arrangement will continue in any future scenario.

Fixed heat charges

It is assumed that all O&M costs are covered by the council's Planned Maintenance budget and that this would be the case under any future heating scenario.

To reflect this in the modelling of the DH scenarios, the O&M costs have been offset by an equal and opposite amount of revenue i.e. it is assumed that the heat network project will not bear the costs of O&M, as these will be borne by another cost centre within the council. It is important for the council to be aware of this assumption and for the heat networks team to engage with the council maintenance department over O&M cost budgeting.

Variable heat charge

The variable heat charge used in the techno-economic model has been calculated based on the counterfactual variable costs (individual ASHP solution). In the individual ASHP scenario the ASHP user is assumed to pay the electric supplier directly without any subsidies from the council.

It has been made sure that costs associated with variable heat charge do not exceed the costs associated with cost an entity would anyways be paying an electricity supplier.

Heat trust calculator

The heat calculator only considers domestic properties on gas fired heating, while the demand scenarios in Lancaster West are more complex, including non domestic loads and electric systems.

We then preferred to develop our counterfactual costs according to the methodology explained in the previous points.

A comparison was conducted for an existing residential development against Arup estimates. It was found that the Arup counterfactual costs were cheaper than the estimate stated by the heat calculator, as Arup cost estimate is ~85% of the heat trust calculator cost estimate.

Techno-economic analysis
6.3 Counterfactual and charges

Table 6.3.1 details the values used in the techno-economic model. They are presented in ranges as they have been calculated for each heat load individually. All values are presented in more detail within Appendix E.

Fuel prices

The gas and electricity prices used for this assessment took into account the future projections up to 2035 from Annex M Price growth assumption published by BEIS, the prices were then assumed to stay at the same level until the end of the project's lifetime. No inflation has been applied to the entire model.

Payments to Thames Water for using the sewer for heat (for SSHP scenarios) has been excluded from the calculations. The topic was discussed with Thames Water and the probability of this happening appears low at the time of this study. In case of charges for heat extraction from the sewer, the impact on the heat supply costs will need to be assessed.

Carbon savings calculations

To compare the predicted carbon emissions from the scheme with a counterfactual for the existing scheme, gas, electricity carbon intensity factors were taken from BEIS and from SAP 10. These values are summarised in Table 6.3.2. For each of the scenarios tested, guidance from HNDU Appendix D was used to calculate carbon savings using each supply technology.

Table 6.3.1: Heat charges

Input	Unit	Equivalent Counterfactual cost	Domestic Properties	Commercial Properties
Connection charge	£/kWth	The avoided costs of counterfactual heating systems	0 - 160	300
Fixed charge heat tariff	£/kWth/year	Costs associated with maintenance and replacement of the counterfactual system at the end of its assumed life	33	18 – 21
Variable rate heat tariff	£/kWhth	Equivalent of the variable charges paid in the counterfactual	0.087	0.051
Total Charge (Fixed + Variable)	£/kWhth	Fixed charge spread across the potential demand + Variable rate (average)	0.096	0.053
Annual / Monthly bill for domestic properties Package 1 scenario	£	Total Energy bill for residents in case of Package 1 demand scenario. Values used as reference to uniform tariffs in the different supply scenarios	760 / 63	/
Annual / Monthly bill for domestic properties Package 2 scenario	£	Total Energy bill for residents in case of Package 2 demand scenario. Values used as reference to uniform tariffs in the different supply scenarios	470 / 39	/

Table 6.3.2: Carbon Values

Input	Unit	HNDU	SAP 10
Gas factor	(gCO_2e/kWh)	184	210
Electricity factor	(gCO_2e/kWh	Marginal factors used	233

Techno-economic analysis
6.4 Summary of Capex

Figure 6.4.1 shows the Capex boundary on the heat network schematic and describes inclusions and exclusion in the capex estimation. The costs excluded are in general the costs that RBKC will face in any case also in a no refurbishment DH scenario.

The table on the next page summarises the key Capex properties of the scenarios for which techno-economic analysis has been performed, including total network length, heat demand, a breakdown of the main costs.

The capital cost per kW can be used as a cost comparison between the networks and also as a general comparator with networks in other context.

The length of all DH only solutions is consistent while the last two scenarios only consist of the approximate lengths of the LW1 and LW3 heat network.

In the specific case of Lancaster West, ambient heating systems are most expensive per kW of plant, this is mainly due to the capital associated with having an ambient GSHP, SSHP and ASHP system and a temperature step up WSHP system. In comparison a GSHP, SSHP and ASHP only heat network solutions is approximately £850-£1,400 £/kW cheaper.

The total capital cost is the cheapest for a ASHP heat network solution. The individual ASHP solution has the smallest £/kW as it is required to meet a much higher peak demand (approximately 20%-50% more than ASHP heat network solution).

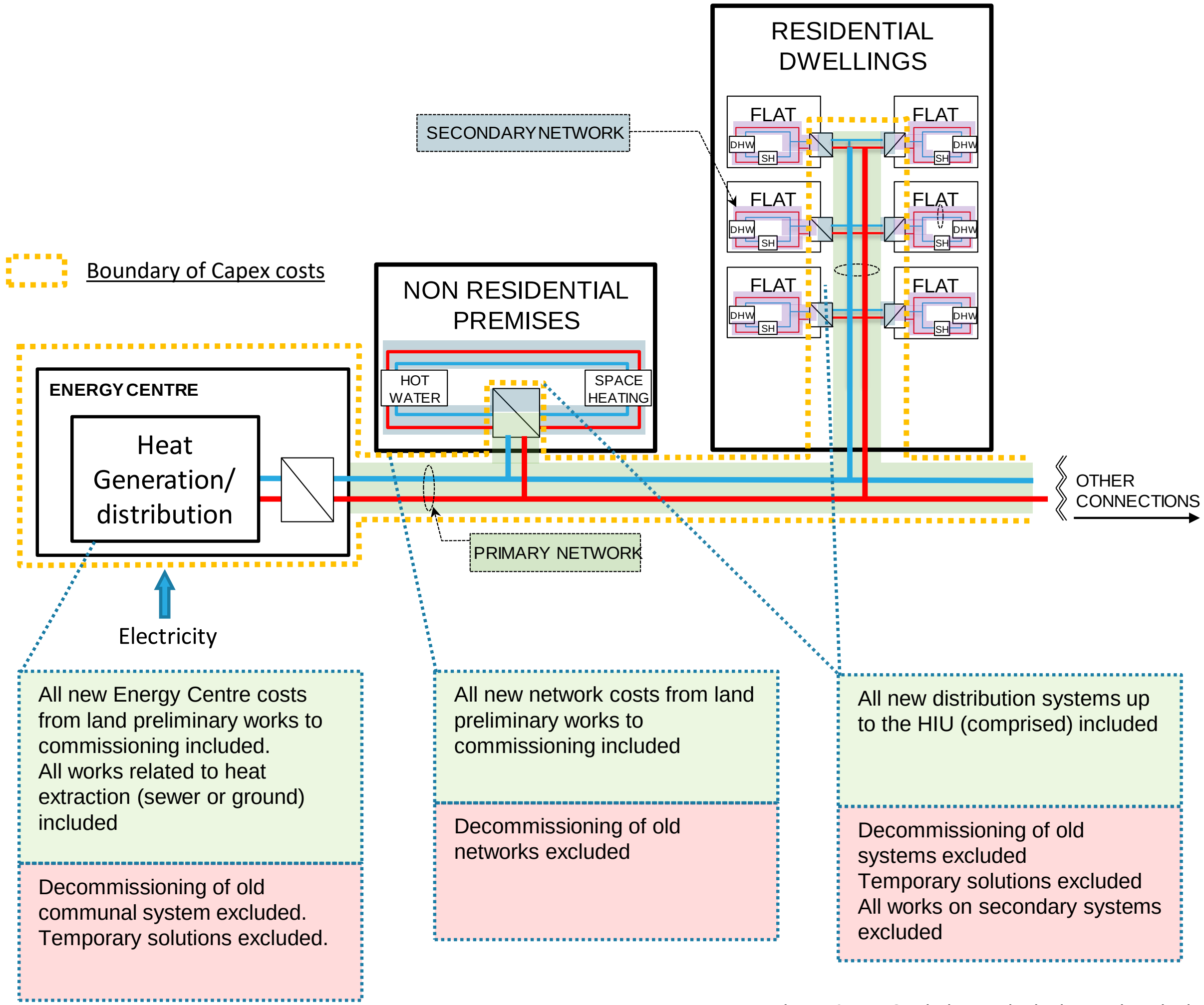

Figure 6.4.1: Capital costs inclusion and exclusions

Techno-economic analysis
6.4 Summary of Capex

Table 6.4.1: Summary of Capex

	P1 - ASHP	P2 - ASHP	P1 - S+ASHP	P2 - S+ASHP	P1 - S+G+ASHP	P2 - S+G+ASHP	P1 - amb S+G+ASHP	P2 - amb S+G+ASHP	P1 - all individual ASHP counterfactual	P2 - all individual ASHP counterfactual	P1 - mixed counterfactual	P2 - mixed counterfactual
Total length (m)	2,270	2,270	2,270	2,270	2,270	2,270	2,270	2,270	-	-	1,290	1,290
Total heat demand (MWh/year)	8,820	6,480	8,820	6,480	8,820	6,480	8,820	6,480	8,820	6,480	8,820	6,480
Peak heat demand (MW)	9	6	9	6	9	6	9	6	11	7	9	6
Capital cost breakdown												
Total Plant Capital Cost - including ancillaries- (£)	2,509,000	1,342,000	4,500,000	3,424,000	4,863,000	3,636,000	11,099,000	9,716,000	8,294,000	5,746,000	5,930,000	4,684,000
Energy Centre Capital Cost - including fit-out- (£)	3,289,000	1,946,000	3,289,000	1,946,000	3,289,000	1,946,000	2,666,000	1,854,000	3,146,000	1,902,000	2,383,000	1,337,000
Total Connection Cost (£)	2,064,000	2,064,000	2,064,000	2,064,000	2,064,000	2,064,000	1,366,000	1,324,000	274,000	274,000	1,615,000	1,615,000
Network Pipe Costs (£)	2,128,000	1,997,000	2,128,000	1,997,000	2,128,000	1,997,000	2,481,000	2,326,000	0	0	974,000	910,000
Project Costs (£)	3,146,000	2,315,000	3,774,000	2,970,000	3,888,000	3,037,000	5,547,000	4,794,000	3,690,000	2,495,000	3,434,000	2,692,000
Optimism bias costs (£)	1,415,000	1,054,000	1,713,000	1,366,000	1,768,000	1,398,000	2,576,000	2,187,000	1,757,000	1,188,000	1,574,000	1,245,000
Total Capital Costs (£)	14,549,000	10,717,000	17,467,000	13,767,000	17,998,000	14,078,000	25,734,000	22,201,000	17,161,000	11,606,000	15,910,000	12,484,000
Capital Cost per kW (£/kW)	1,620	1,790	1,940	2,300	2,000	2,350	2,860	3,700	1,560	1,560	1,660	1,770

Techno-economic analysis
6.5 Capex Categories

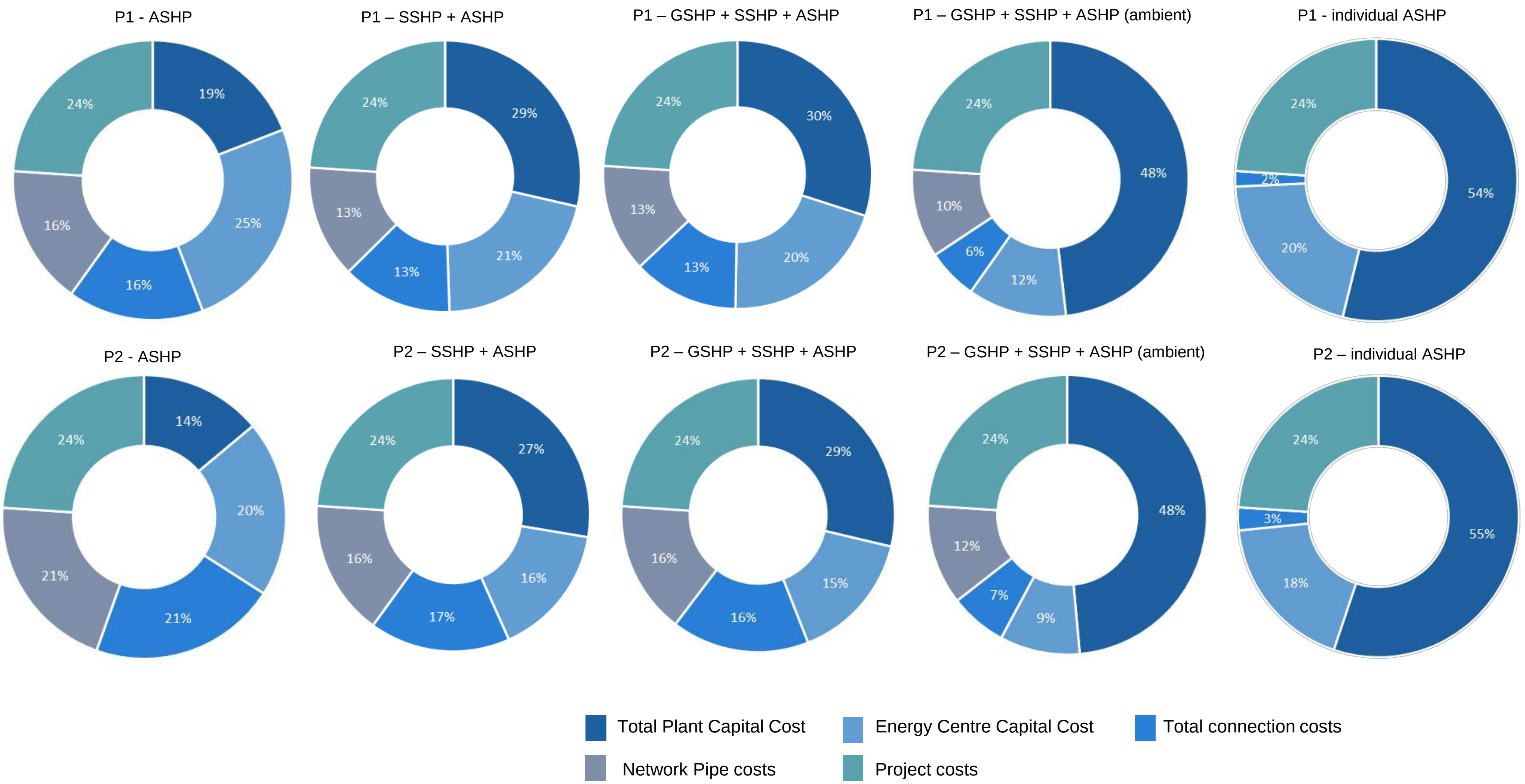

Figure 6.5.1: Split of capital costs

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Techno-economic analysis
6.5 Capex Categories (continued)

The adjacent graph and the graph on the previous page show the breakdown of capital costs for the scenarios analysed.

Here it is easier to see how the plant costs contribute to the overall capital costs. As expected, capital costs grow with the addition of more plant equipment. This considerably grows for the ambient GSHP + SSHP + ASHP system. This is because this system requires an addition of a WSHP system at each entity to step up the temperature.

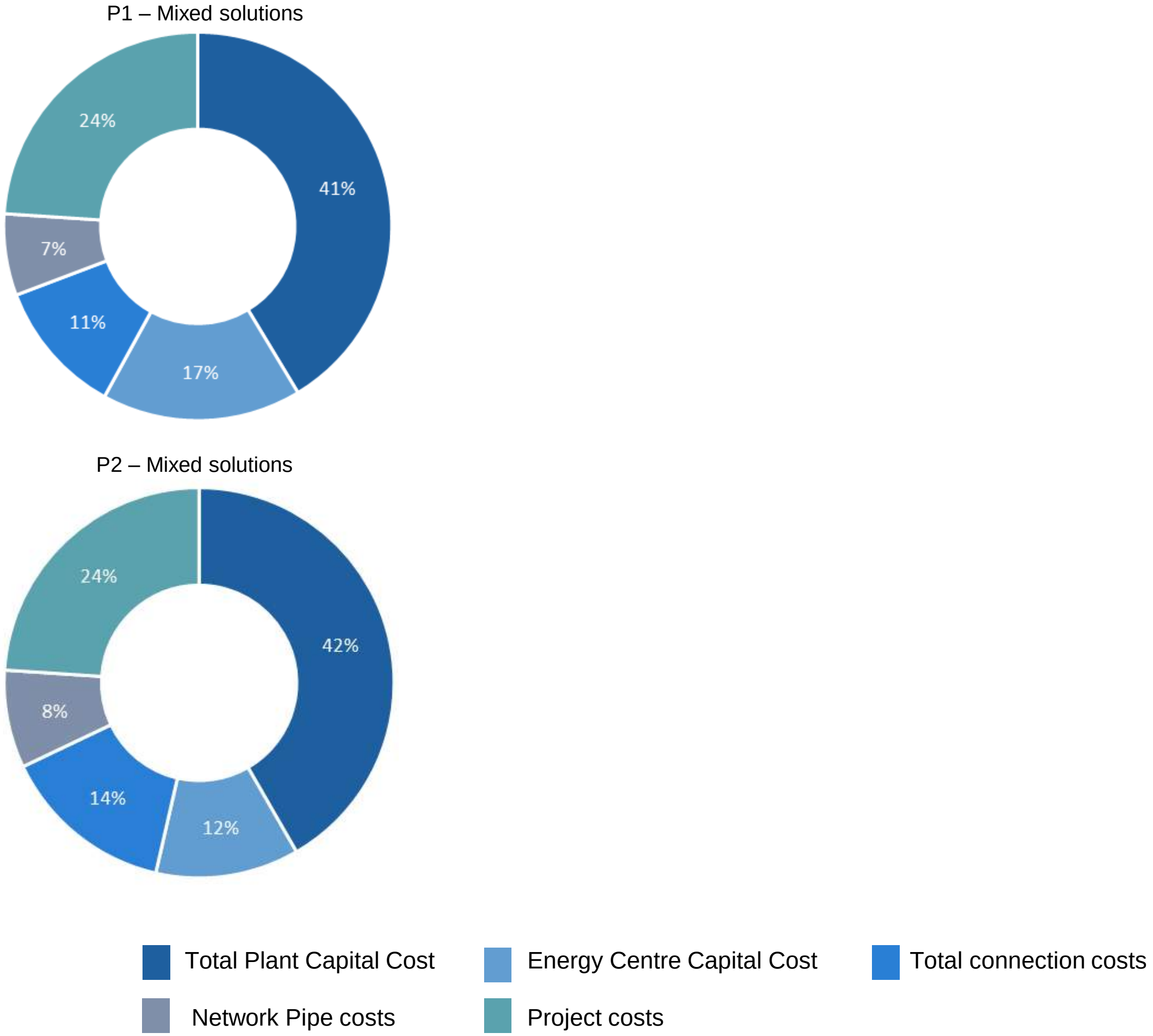

Figure 6.5.2: Split of capital costs

Techno-economic analysis

6.6 Economic analysis

The techno-economic modelling has revealed the following clear conclusions about the proposed network scenarios analysed. (NOTE: The NPC and NPV columns are presented due to the special nature of this scheme.)

- As stated before, the economic results are based on the assumption that the residents are charged to align annual bills calculated for the individual heat pump scenario, which is supposed to be the maximum the council can charge to remain competitive with individual solutions. RBKC can then decide to reduce the heat bills to protect people from fuel poverty. Clearly this will reduce returns to the council.
- None of the scenarios considered show a positive NPV or IRR. This is due to a combination of factors, driven largely by the fact that the network is in a social housing setting with RBKC being responsible for refurbishment and O&M of heating systems for its tenants. As such, the cost recovery mechanisms that are generally available to scheme operators are not available here.
- Individual ASHP scenario shows the worst NPV result for package 1. The NPV and NPC are the same as revenues are not generated.
- Ambient heat network systems show the worst NPV for package 2. This is as the Capex for the ambient heat is far greater than the revenue.
- ASHP heat networks followed by SSHP+ASHP heat networks show the best NPV results. The true potential of the SSHP as a heat source is currently only partially known. It is advised that the sewage is monitored to understand sewage flow rates, depth and temperature. A small increase in temperature and/or flow rate can make the SSHP+ASHP network as competitive as the ASHP heat network, if not better.

Table 6.6.1: Key outputs

Scenario No.	Scenario	CAPEX (£m)	40yr NPV (£m)	40yr NPC (£m)	IRR (%) 25yr	IRR (%) 30yr	IRR (%) 40yr	Gap funding (40yr) (£m) To achieve IRR of 3.5%	LCOH (£/kWhth)	Commodity Costs (£) (el cost / kWhth)
1	P1 - ASHP	14.5	- 10.1	25.1	-12.7%	-6.4%	-3.8%	10.1	0.149	0.0422
2	P2 - ASHP	10.7	- 8.0	18.6	-16.1%	-7.8%	-5.9%	8.0	0.150	0.0400
3	P1 – SSHP + ASHP	17.5	- 12.0	27.0	-11.6%	-6.0%	-3.3%	12.0	0.160	0.0355
4	P2 – SSHP + ASHP	13.8	- 9.8	20.4	-13.6%	-6.8%	-4.3%	9.8	0.165	0.0290
5	P1 – SSHP + GSHP + ASHP	18.0	- 12.3	27.4	-11.6%	-6.0%	-3.3%	12.3	0.162	0.0340
6	P2 – SSHP + GSHP +A SHP	14.1	- 10.2	20.8	-14.2%	-7.0%	-4.5%	10.2	0.168	0.0296
7	P1 - amb SSHP + GSHP + ASHP	25.7	- 19.7	34.8	-13.9%	-7.0%	-3.3%	19.7	0.240	0.0472
8	P2 - amb SSHP + GSHP + ASHP	22.2	- 19.6	30.2	< - 20%	-9.8%	-5.3%	19.6	0.273	0.0438
9	P1 - all individual ASHP - no DH	17.2	- 22.2	22.2	N.A	N.A	N.A	22.2	0.236	0.0918
10	P2 - all individual ASHP - no DH	11.6	- 15.1	15.1	N.A	N.A	N.A	15.1	0.228	0.0889
11	P1 - mixed - no DH	15.9	- 12.9	22.9	< -20%	-10.0%	-5.6%	12.9	0.190	0.0617
12	P2 - mixed - no DH	12.5	- 11.2	17.5	< -20%	-13.8%	-9.1%	11.2	0.200	0.0545

The last two columns of the table represent the levelised costs of heat (LCOH) and the commodity costs for the heat generation.

- The LCOH is a parameter used to compare different heat generation scenarios it includes all capital costs and operational costs (also what paid by residents in case of individual solutions). It is clear that the individual solution represents the most expensive heat generation solution and ASHP and SSHP solution are have lower costs.
- Commodity costs for the heat generation represent the costs for the electricity paid for the heat generation. This in case RBKC decides to charge the tenants only by passing these generation costs. As shown the DH solutions have better values than individual ones, due to the higher efficiency of the systems and to the different electricity costs applied to residential properties and to RBKC for the centralised heat generation.

Techno-economic analysis
6.7 Carbon performances

Table 6.7.1 shows the lifetime carbon savings for the different network scenarios analysed. Both HNDU and SAP10 carbon emission factors have been used for this assessment. It has been measured against a counterfactual where it has been assumed that entities themselves will change to electric heating technologies as the current heating system is getting old. It is assumed that 50% of all entities move to electricity by 2027 and 100% by 2030.

The carbon performance of the different options needs to be understood in the context of today's policy environment. The SAP 10 values are representative of the 3-year average carbon factors published in 2019, with the same value used throughout the lifetime of the project. On the other hand, the HNDU factors change to reflect changes in grid composition, for example; the increased contribution of renewable energy. However, they are not as up to date as SAP 10 and are not used in planning policy.

The carbon savings are proportional to the heat supplied and the percentage of heat supplied by efficient low carbon heat technologies. For example, scenario 7 has the best carbon savings as it utilises high COP heat technologies such as GSHP and SSHP at the energy centre and WSHP at each entity for package 1 (high heat demand scenario).

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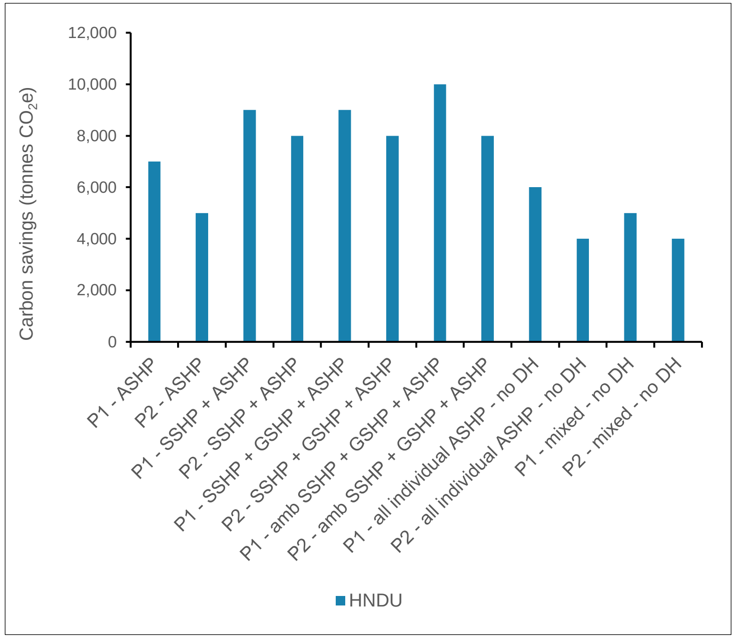

Figure 6.7.1: Carbon Savings Performances – only HNDU

Table 6.7.1: Carbon Performances

Scenario No.	Scenario	HNDU lifetime carbon savings	SAP 10 lifetime carbon savings
		HNDU (tCO_2e) 40 year	SAP 10 (tCO_2e) 40 year
1	P1 - ASHP	7,000	17,000
2	P2 - ASHP	5,000	14,000
3	P1 – SSHP + ASHP	9,000	23,000
4	P2 – SSHP + ASHP	8,000	21,000
5	P1 – SSHP + GSHP + ASHP	9,000	24,000
6	P2 – SSHP + GSHP +A SHP	8,000	21,000
7	P1 - amb SSHP + GSHP + ASHP	10,000	29,000
8	P2 - amb SSHP + GSHP + ASHP	8,000	21,000
9	P1 - all individual ASHP - no DH	6,000	14,000
10	P2 - all individual ASHP - no DH	4,000	10,000
11	P1 - mixed - no DH	5,000	14,000
12	P2 - mixed - no DH	4,000	12,000

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Techno-economic analysis
6.8 Sensitivities

This section outlines the sensitivity analysis of SSHP + ASHP package 1 heat network. All sensitivities for the other scenarios are shown in Appendix F. Given the special nature of the project sensitivities help highlight risks associated with a change in key parameters.

The following sensitivities are shown in the adjacent figures:

- CAPEX variation +/- 30% - The NPV and IRR increases and decreases as the CAPEX is decreased or increased. The CAPEX would be required to reduce significantly (much lower than -30%) in order for the scheme to attain a positive NPV. The reduction of CAPEX provides one of the biggest change in the business case amongst all sensitivities tested.
- Commodity costs +/- 30%. The commodity costs would need to reduce significantly for the network to attain a positive NPV.
- Variable Tariff & Charge +/-30%. The variable element of energy sales tariffs concomitant with the variable element of energy price purchased. The variable heat tariff would need increase significantly for the network to attain a positive NPV.
- Reducing the variable element of the heat tariff compared with the counterfactual (from a 5% reduction to a 20% reduction) - The NPV continues to drop as the difference between the heat tariff and the counterfactual increases.

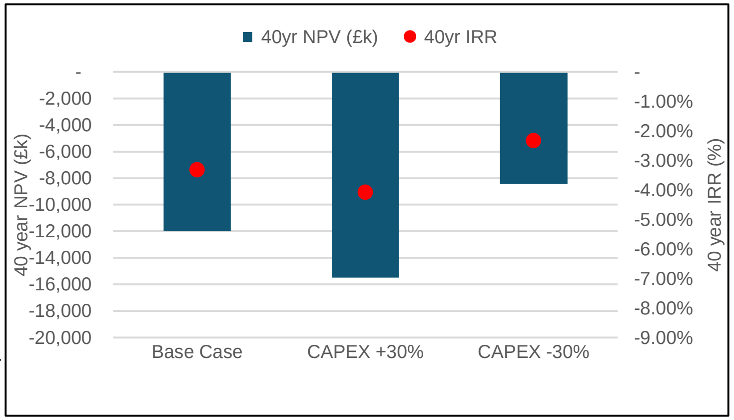


Figure 6.8.1: Capex Sensitivity

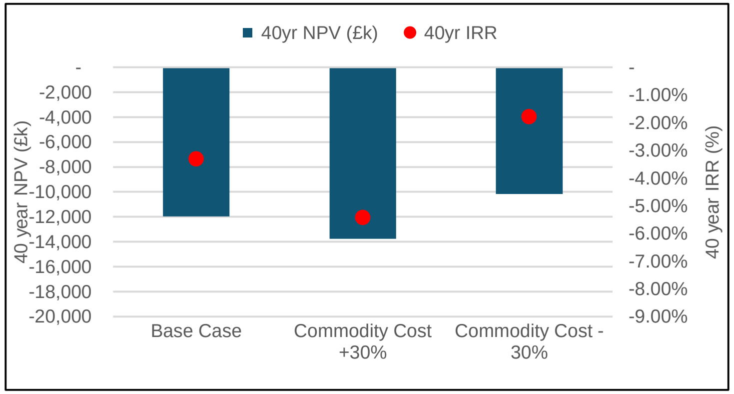


Figure 6.8.2: Commodity Costs Sensitivity

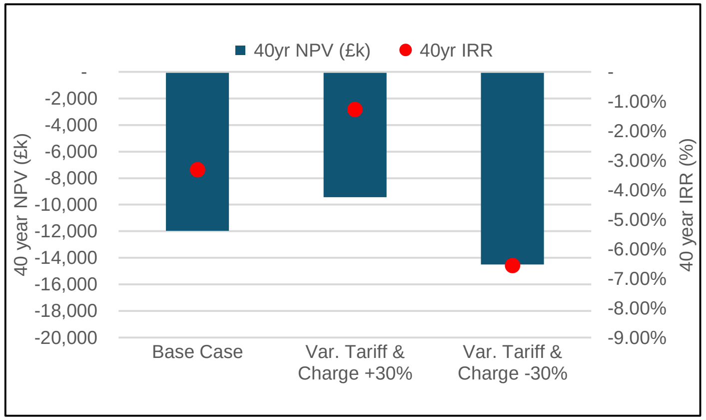


Figure 6.8.3: Variable tariff Sensitivity

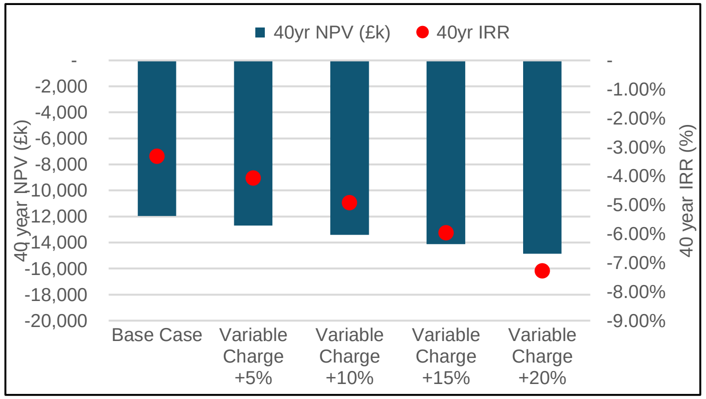


Figure 6.8.4: Variable Charge Sensitivity

Techno-economic analysis
6.8 Sensitivities

The following sensitivities are shown in the adjacent figures:

- Changes in the energy demand (between -30% to + 50%) – The IRR of the network remains negative if the energy demand is increased by 50%.
- Network losses (between +10% to +40%) – As expected the increase of network losses adversely impacts the already negative NPV and IRR. For the 40% scenario, IRR is too poor to compute a percentage.
- The sensitivities assessed will have an impact not only on the financial output of the schemes but also on the carbon emissions. The impacts have been calculated using both HNDU and SAP10 emission factors and are shown in the adjacent graphs. The sensitivities are as follows:
- Changes in the energy demand (between -30% to +50%) – The network show a positive carbon savings values for all the demand and technology variations.
- Network losses (between +10% to +40%) – 15% losses is already included in the energy modelling, the further increase of them worsen the carbon performances but the network still present positive values also in the worse case analysed.

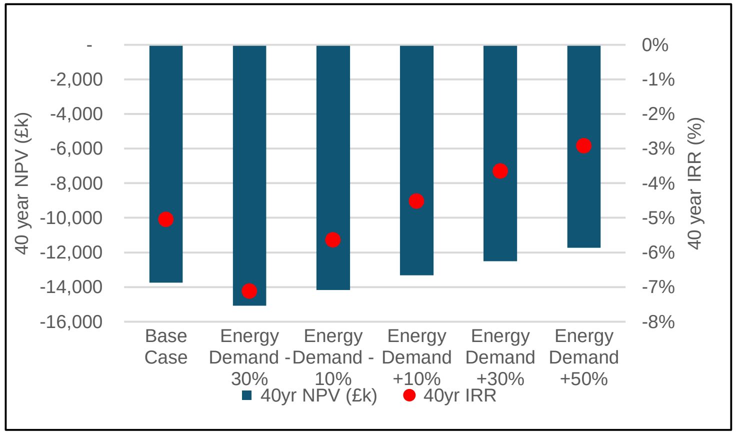


Figure 6.8.5: Energy Demand Sensitivity

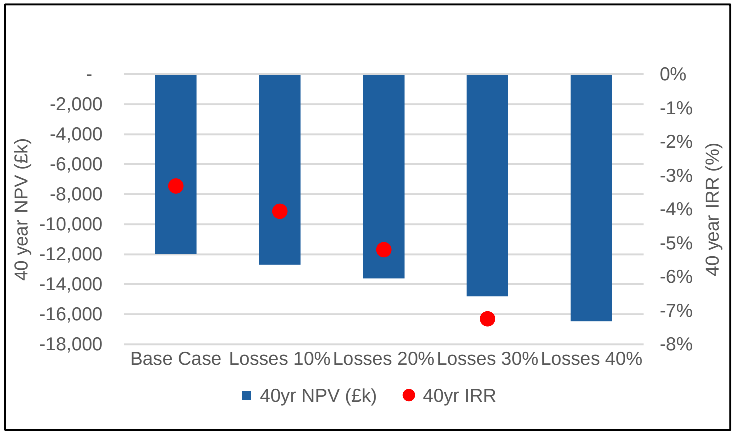


Figure 6.8.7: Heat losses Sensitivity

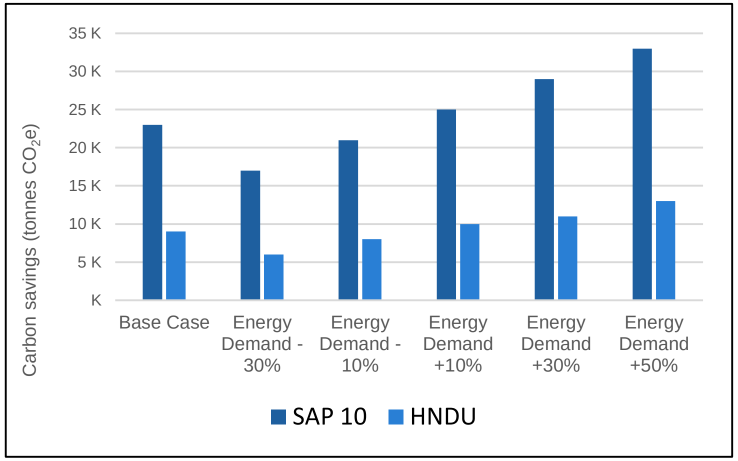


Figure 6.8.9: Energy Demand Sensitivity

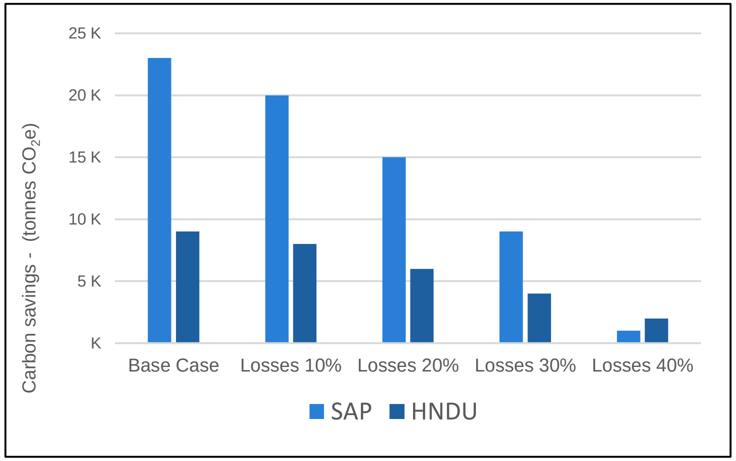


Figure 6.8.10: Heat losses Sensitivity

Techno-economic analysis

6.8 Sensitivities

SSHP Sensitivities

As stated before the true potential of the SSHP as a heat source is currently partially known and conservative figures for flowrate and temperature have been used for the energy simulation.

Two different sensitivity analysis has then been done to check the economic results in case of variation of the COP of the heat pump and of the available flow in the sewer. The sensitivities has been applied to the SSHP+ASHP scenarios.

The COP sensitivities consider a +/-20% variation in the SSHP COP, without any change in the plant sizes.

The sensitivity on the capacity considers a +30% flow, and then heat, available from the sewer with the consequent increase in the SSHP size.

The techno-economic modelling presented the following clear conclusions shown in table 6.8.1:

- The +/-20% variation in the COP shows a variation of around +/-0.4 £m for P1 and +/-0.3 £m for P2 with the consequent variations in the IRR.
- A 20% increase in COP and a +30% increase in size of the SSHP will provide a variation of around -0.3 £m for P1 and -0.2 £m for P2 with the consequent variations in the IRR.
- The NPV remains in any case worse than the ASHP solution, while the commodity costs remains in any case better than the ASHP solution.
- The above is also represented in the LCOH column.
- Variations in the flowrate and temperatures can be bigger than what used for the sensitivities and so the economic implications of it. Is then suggested to measure sewer key parameter during the next phase of the project

Table 6.8.1: Key outputs

Sensitivity	Scenario	CAPEX (£m)	40yr NPV (£m)	40yr NPC (£m)	40yr IRR	Gap funding (40yr) (£m) To achieve IRR of 3.5%	LCOH (£/KWhth)	Commodity Costs (el (£) / kWhth)
-20% COP	P1 – SSHP + ASHP	17.5	- 12.4	27.5	-3.7%	12.4	0.162	0.0379
-20% COP	P2 – SSHP + ASHP	13.8	- 10.2	20.9	-4.9%	10.2	0.168	0.0319
Original	P1 – SSHP + ASHP	17.5	- 12.0	27.1	-3.3%	12.0	0.160	0.0355
Original	P2 – SSHP + ASHP	13.8	- 9.8	20.5	-4.3%	9.8	0.165	0.0290
+20% COP	P1 – SSHP + ASHP	17.5	- 11.6	26.7	-2.9%	11.6	0.157	0.0331
+20% COP	P2 – SSHP + ASHP	13.8	- 9.5	20.1	-3.8%	9.5	0.162	0.0261
+30% Capacity	P1 – SSHP + ASHP	17.6	- 11.7	26.9	-3.0%	11.7	0.158	0.0331
+30% Capacity	P2 – SSHP +ASHP	13.9	- 9.6	20.3	-3.9%	9.6	0.163	0.0262

Techno-economic analysis
6.8 Sensitivities

SSHP Sensitivities – with PV

As stated earlier the council is aiming to be net zero carbon by 2030. Solar PV on all rooftops is currently under investigation, including what the full potential of solar PV on rooftops might be (dependent on the practical space available) and how the energy generated may be consumed, stored or dispatched. The later is dependent on potential retrofits installed, energy demand patterns and understanding the best potential of storage. All of the above is currently unknown. Therefore to assess the impact of onsite PV on a DH network, the following was assumed:

- Roof areas were assumed using google maps. The potential installed PV capacity was calculated to be 778 kWp.
- PV generation profiles were matched with DH demand profiles. Any excess PV electricity produced was assumed to be dispatched to the grid. The revenue generated was derived from export prices under the SEG (Smart Export Guarantee) scheme.

A sensitivity was run on the SSHP + ASHP DH scheme with PV (as stated above) using the technoeconomic model. The conclusions are shown in table 6.8.2:

- The PV scheme increases the CAPEX by ~0.2m.
- The benefit from PV helps improve the NPV by £0.7m and £0.6m, and NPC by £0.3m and £0.2m for package 1 and package 2 respectively.
- The above is also represented in the LCOH and commodity costs column.
- It should be noted that the heat demand profiles do not match the PV generation profiles. Only 12%-17% of the renewable electricity generated is utilised by the DH system. To best understand the full potential of PV, the PV generation profiles should also be assessed with the expected post retrofit electricity demand profiles for the entire site.
- The carbon emissions saved during the lifetime of the project with PV installations amount to approximately 1,098 tonnes and 987 tonnes for package 1 and package 2 respectively (using HNDU carbon intensity figures). This provides approximately 10% more savings than the original scenarios.

Table 6.8.2: Key outputs

Sensitivity	Scenario	CAPEX (£m)	40yr NPV (£m)	40yr NPC (£m)	40yr IRR	Gap funding (40yr) (£m) to achieve IRR of 3.5%	LCOH (£/KWhth)	Commodity Costs (el (£) / kWhth)
Original	P1 – SSHP + ASHP	17.5	- 12.0	27.1	-3.3%	12.0	0.160	0.0355
Original	P2 – SSHP + ASHP	13.8	- 9.8	20.5	-4.3%	9.8	0.165	0.0290
Original with PV	P1 – SSHP + ASHP	17.7	- 11.3	26.8	-2.8%	11.3	0.158	0.0314
Original with PV	P2 – SSHP + ASHP	14.0	- 9.2	20.3	-3.5%	9.2	0.163	0.0239

Techno-economic analysis
6.9 Additional value and Social NPV

The installation of a heat network creates a range of costs and benefits. Some of these are *private costs and benefits*, accruing directly to the heat network operator or to those connected to the network. Others are *social costs and benefits,* affecting the wider community and society as a whole regardless of their involvement in the heat network.

The district heating network represents for Lancaster West an opportunity for the decarbonisation of heat and for the reduction of local emissions. These scenarios are compared against a counterfactual where RBKC replaces existing high carbon systems with lower carbon alternatives (individual ASHPs) as the existing systems reach the end of their useful life.

Social NPV

The Social Net Present Value (Social NPV) looks at the value of a project to society as a whole. It takes into account the full range of costs and benefits, both private and social, associated with a project.

Local authorities may not wish to use the Social NPV as their final investment decision criterion but it can be considered alongside measures of financial viability to provide an indication of the wider social value of a project. The Social NPV can also provide a useful means of objective comparison between different mutually exclusive heat network projects.

The social NPV combines both private and social costs and benefits. As private benefit the impact on heating costs has been considered. This value reflects the savings on the heat prices for the customer.

As social benefit the carbon emissions and the impact on air quality has been included into our analysis. The values for the analysis has been taken from ”Green Book supplementary guidance tables” (BEIS, 2019). Air quality damage figures are calculated using the urban big averages. The value includes the impact of – particulate matter (PM), nitrogen dioxide (NO_2), volatile organic compounds (VOCs), ammonia (NH) and sulphur dioxide (SO). The impact of NO_x is accounted for by converting NO_x to NO_2.

This network lies within the Kensington and Chelsea Air Quality Management Area (AQMA), which has been monitoring and managing high levels of PM_{10} NO_2 since 2000. A network of this nature could have a positive impact on local air quality by reducing reliance on gas boilers, which emit NO_x.

Figure 6.9.1 summarises the results for all the network scenarios. As can be seen, the social NPV is highest for scenario where the heat supply technology is more efficient and the demand is high (i.e. GSHP + SSHP +ASHP ambient for package 1). The social NPV of SSHP + ASHP for package 1 is only ~15% less than the highest value.

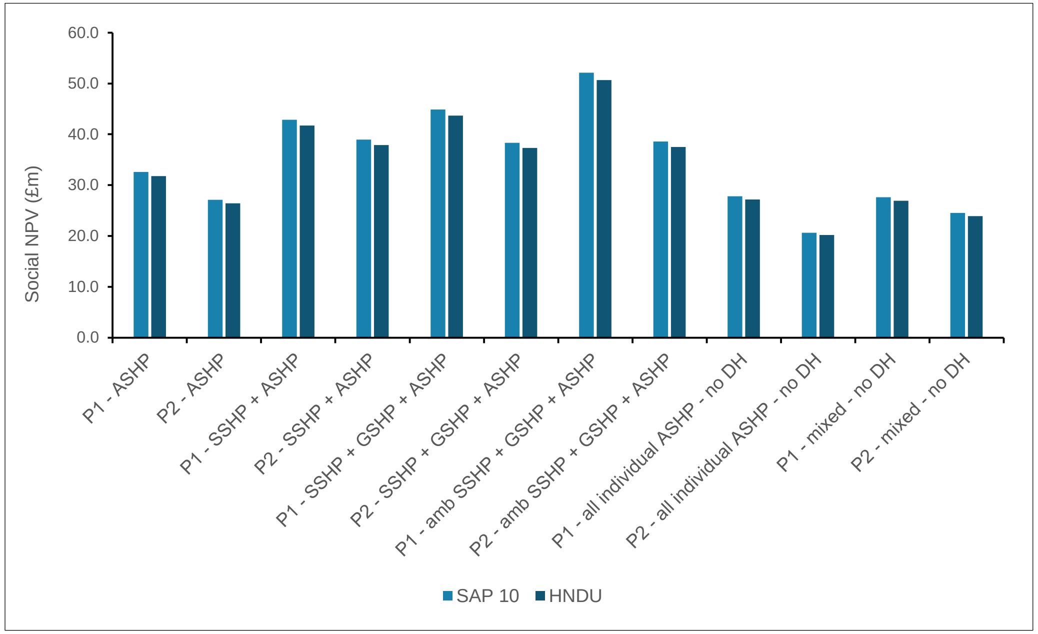


Figure 6.9.1: Social NPV

Techno-economic analysis
6.10 Ensuring readiness for zero carbon pathway

Figure 6.10.1 shows the carbon emission for SSHP+ASHP package 1 systems along with the counterfactual scenario. This is against a counterfactual where it has been assumed that electric heating technologies will be installed over time as existing systems wear out. It is assumed that 50% of all entities move to electricity by 2027 and 100% by 2030.

The carbon emissions are seen to increase in the first few years as developments come online onto the network. The gap between the network emissions and counterfactual is initially due to the counterfactual before 2030 assumes them to be largely stay on the gas grid.

The carbon savings post 2030 happen in the first years, when the electricity network is most carbon intensive and the alternative solution has a higher COP than ASHP only solution (counterfactual).

The graphs run in parallel near 2050 and beyond as by this stage the electricity grid is expected to be almost carbon neutral.

The graphs of the other scenario depend on the heating technology used and the heat demand it supplies.

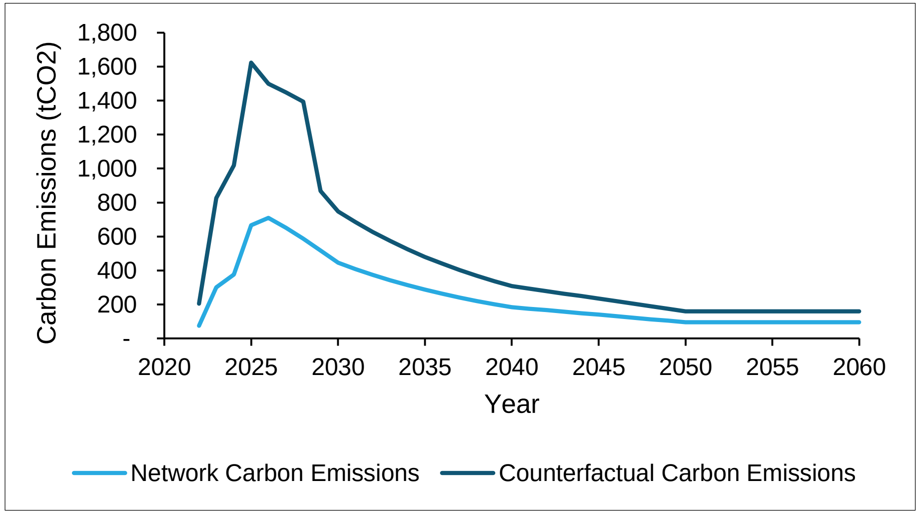


Figure 6.10.1: Carbon Emission comparison for scenario 3 (HNDU carbon intensity figures)

Techno-economic analysis
6.11 Conclusions

The District heating network options for Lancaster West represent an opportunity for the carbon reduction of the heat.

The heat charges considered capture the charges the entities will be expected to pay if they move to individual ASHP solutions. This is however two to three times greater than what entities currently pay for heat in LW1 and LW3. Currently no subsidy has been assumed. The NPV and NPC results will get worse if the council offers to subsidise these bills or reduce them by passing to the residents only the commodity costs for the heat generation as explained in section 6.6.

The financial results show that all scenarios show a negative IRR and NPV. This is as a large proportion of the connection charges are absorbed by the council. The ASHP heat network followed by SSHP + ASHP heat network provide the best results.

The individual solution scenarios compared to the district ones show the highest LCOH and commodity costs for the heat generation.

The true potential of SSHP as a heat source is currently partially known. It is advised that the sewage is monitored to understand sewage flow rates, depth and temperature. A small increase in temperature and/or flow rate can make the SSHP+ASHP network as competitive as the ASHP heat network, if not better, as demonstrated by the COP and available energy sensitivities.

The ambient heat networks require the highest Capex due to the plant equipment required within this scenario (GSHP + SSHP + ASHP at the energy centre and WSHP at each entity). The individual ASHP solutions provide the worst NPV as the council makes no revenue within this scenario but has to absorb a large proportion of costs for tenants and leaseholders.

Chapter 7 – Conclusions and Recommendations

Conclusions and Recommendations

This feasibility study considered the potential for a low carbon heat network in the Lancaster West Estate.

The study considered the network opportunity in relation to:

- Environmental and social performance
- Technical feasibility
- Economic performance
- Commercial delivery.

The conclusions from each of these aspects are summarised below.

Environmental and Social Conclusions

- The district heating networks provide Lancaster West an opportunity to decarbonise heat and to reduce local emissions.
- The analysis indicates that all network scenarios would deliver significant carbon savings.
- The analysis resulted in a range of social NPV values of £20m-£50m over a 40-year time horizon (HNDU factors).
- The heating costs considered capture the charges the entities will be expected to pay if they move to individual ASHP solutions. Despite the lower demand, this is however two to three times greater than what entities currently pay for heat in LW1 and LW3 and can represent a risk of increasing fuel poverty. This is due to fact that all low carbon options are more expensive than gas solutions today in use at Lancaster West. The (potential) advantage of a DH network is that commodity costs might be lower due to better buying power of council and greater efficiencies.
- The district heating scenarios represent a more “protective” environment for the tenants in case they are not able to pay for the heat, since they will deal with the council and not directly with the electricity companies. In addition to that the council has stronger buying power in relation to electricity and should be able to shield tenants from price fluctuations.

Technical Conclusions

Each part of the potential network was assessed for technical feasibility, including:

- Availability of low carbon heat sources .
- Heat network routing
- Connection to heat loads

The assessment did not identify any major risks which would prevent construction and operation of the whole or part of the proposed network, but a variety of risks and uncertainties were identified which could affect the final cost and delivery programme for the network.

The cost model reflects the recommended routing and connection schematics together with provision for risk and optimism bias.

Key technical feasibility considerations include:

- Monitoring the sewer flow rate and temperature
- Developing a plan for the integration of refurbishment works and the replacement of heating systems
- Additional investigations will be needed to confirm the route feasibility.

Economic performance

The economic assessment for all scenarios results in a negative IRR and NPV. This is as a large proportion of the connection costs are absorbed by the council. The ASHP heat network followed by SSHP + ASHP heat network provide the best results.

The economic performance results do not assume any grant contribution to the schemes. RBKC will invest in refurbishing the heating system on the estate and has funding available to do this. The extent to which this funding can cover all aspects of sustainability and decarbonisation is to be confirmed. Nevertheless, additional finance, e.g. through HNIP, is likely to be required.

The true potential of SSHP as a heat source is currently only partially known and it is advised that the sewage network is monitored to understand sewage flow rates, depth and temperature. Future payments to Thames Water for using the sewer for heat (for SSHP scenarios) has been excluded from the calculations. The information was requested but no answer has been received thus far.

Conclusions and Recommendations

Commercial delivery

The commercial delivery of the system differs from other district heating systems. RBKC is the social housing provider and needs to supply tenants with heat. RBKC is today the heat provider for the two communal heating systems and it is expected to be the provider for the future district heating network.

In the case of network expansion outside Lancaster West boundaries, the commercial delivery would change and a promoter needs to be identified and take the project to the next phases.

An operator of the system then need to be identified as for the communal systems in today's scenario.

The operator will need to be protected from project and revenue risks which will all fall on the Council or the promoter responsibility.

Overall conclusions

This feasibility study has identified two feasible heat network schemes which have the potential to deliver significant carbon savings and social benefits.

It is recommended that the SSHP capacity is measured over time and in case of good performance, it is suggested to be chosen as preferred heat source as in scenarios 3 and 4.

In case the SSHP won't be proven as viable or won't perform as needed, the ASHP based supply, as in scenarios 1 and 2, is then suggested to be taken to the next phase.

The use of GSHP won't improve the financial results and will add risk related to the availability of water from the aquifer. It is therefore not suggested as supply solution.

Ambient loops have the potential to be viable where heating and cooling loads are balanced, however this is not the case for Lancaster West.

The next project phase should commence with the key actions identified to address critical project risks.

Next steps

- A feasibility study for the SSHP needs to be done. It will consider the monitored temperatures and flow rates together with civil works needed for the implementation of the system.
- The engagement with Thames Water for the use of the sewer needs to be taken to the next phase and the NDA needs to be signed.
- Internal heating systems for the use of lower temperature supply need to be included in the refurbishment design.
- A final decision on which refurbishment package to chose need to be taken by RBKC.
- A coordinated plan for flat refurbishment and district heating system works needs to be developed. This aspect can be the key for successful refurbishment works. The mitigation of risks related to the overlap of works need a strong coordinated project management and exchange between the different delivery partners.
- The stakeholder engagement needs to be actively sought before and during the next phases. Tenants needs to be made aware of the changes occurring on the heating systems and on the billing strategy.
- Deeper investigation on the routing will need to be undertaken. In particular 3D scans in congested areas and key points identified.

Appendix A – References

ARUP

References

BEIS., 2019. *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal.* [Online] Available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal [Accessed February 2020].

Appendix B – Site walkover photos

Subject	Lancaster West Estate External Route Feasibility Study - Photos Appendix		
Date	31 July 2020	**Job No/Ref**	272173-05

)

Figure 1 - View towards Lancaster Green

Figure 2 – View towards the north-western corner of the Kensington Leisure Centre

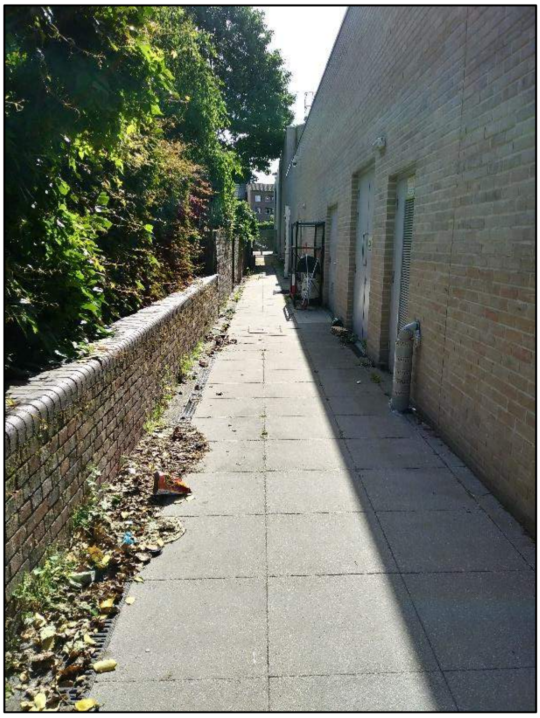


Figure 3 - View looking east of the narrow path, north of the Kensington Leisure Centre

Figure 4 – View looking west of the narrow path, north of the Kensington Leisure Centre

Figure 5 – View of western rear fences to the flats in verity Close

Figure 6 – View of entrance to Verity Close

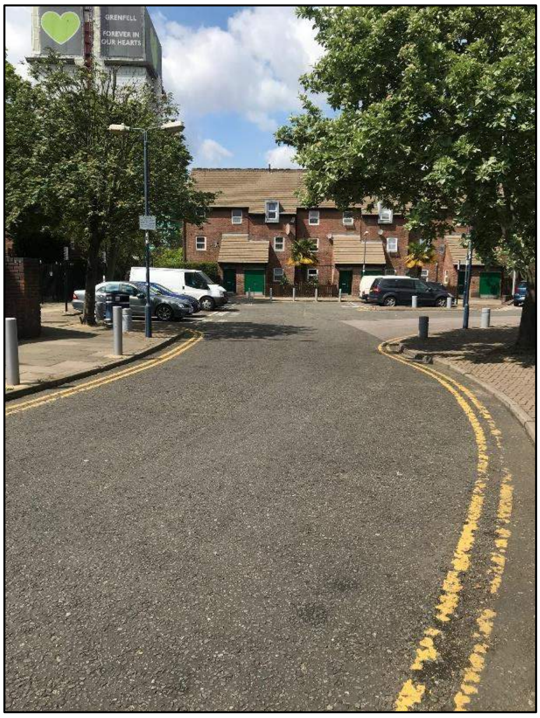


Figure 7 – View of private road in Verity Close

Figure - 8 – View of soft landscaping in public realm (Verity Close)

Figure - 9 - Eastern view of the hard landscaping central to Morland House

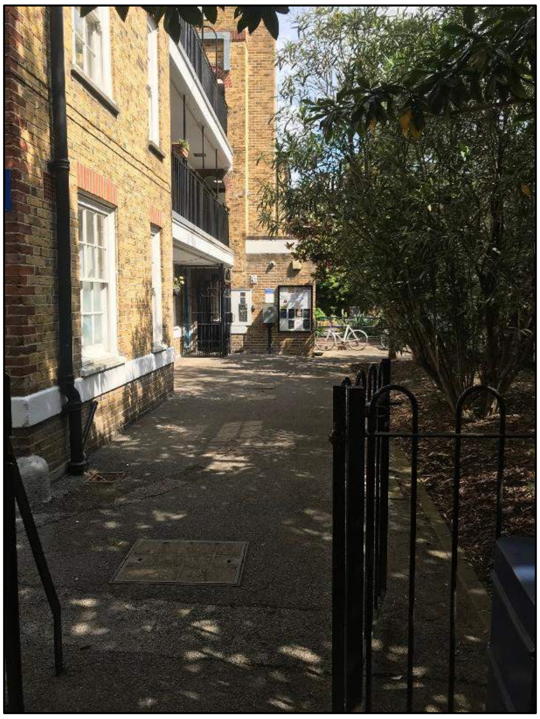


Figure - 10 – Western view of the hard landscaping central to Morland House

Figure 11 – View of landscaping in the centre Morland House

Figure 12 – View facing west on private road north of Lower Clarendon Walk

Figure 13 - Private road west of Talbot Grove House

Figure 14 - Private road north of Upper Clarendon Walk

Figure 15 – Under croft at the north end of Brandon Walk

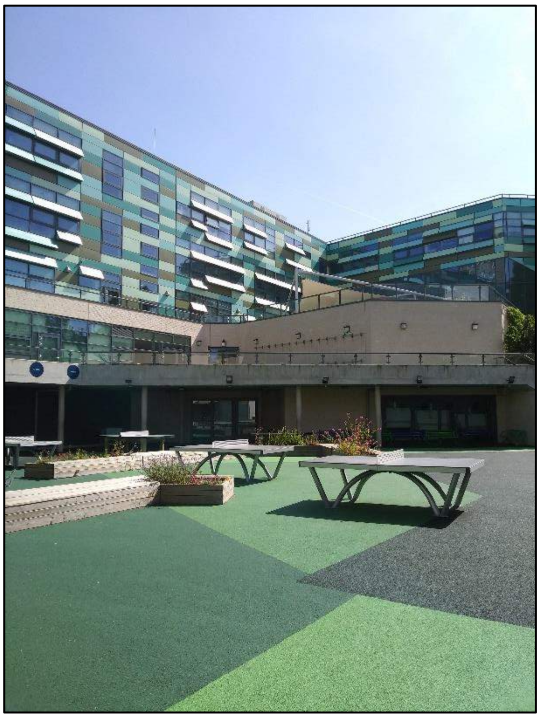


Figure 16 – Kensington Aldridge Academy

Figure 17 – UKPN Substation west of Verity Close

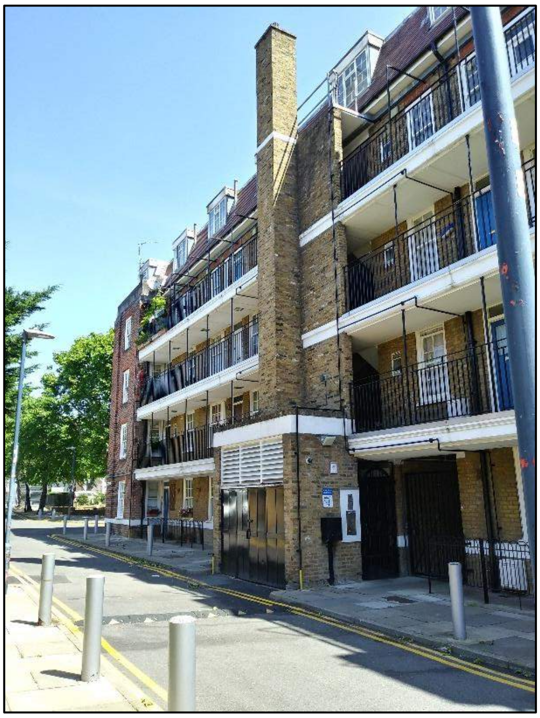


Figure 18 – Talbot Grove House

Figure 19 – Rear of Verity Close (west)

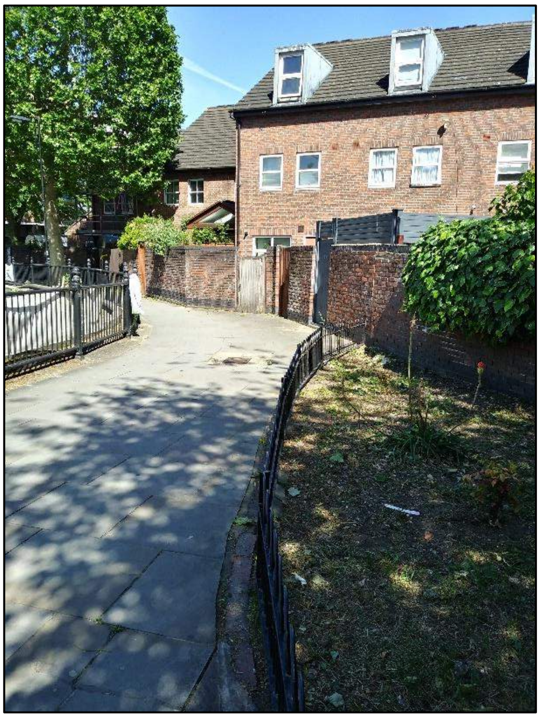
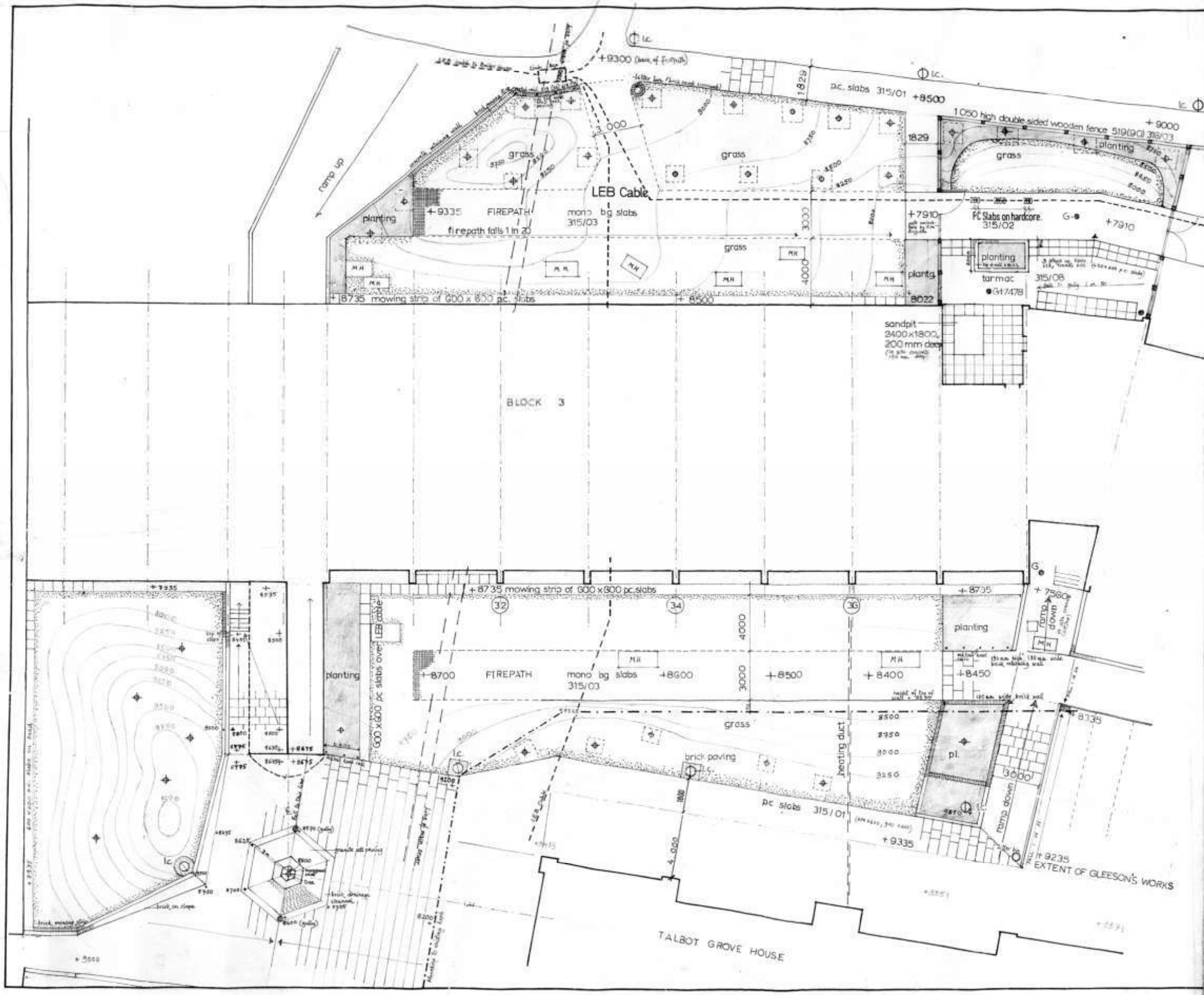


Figure 20 – View of footpath north of Verity Close

Appendix C – Private Utility Records



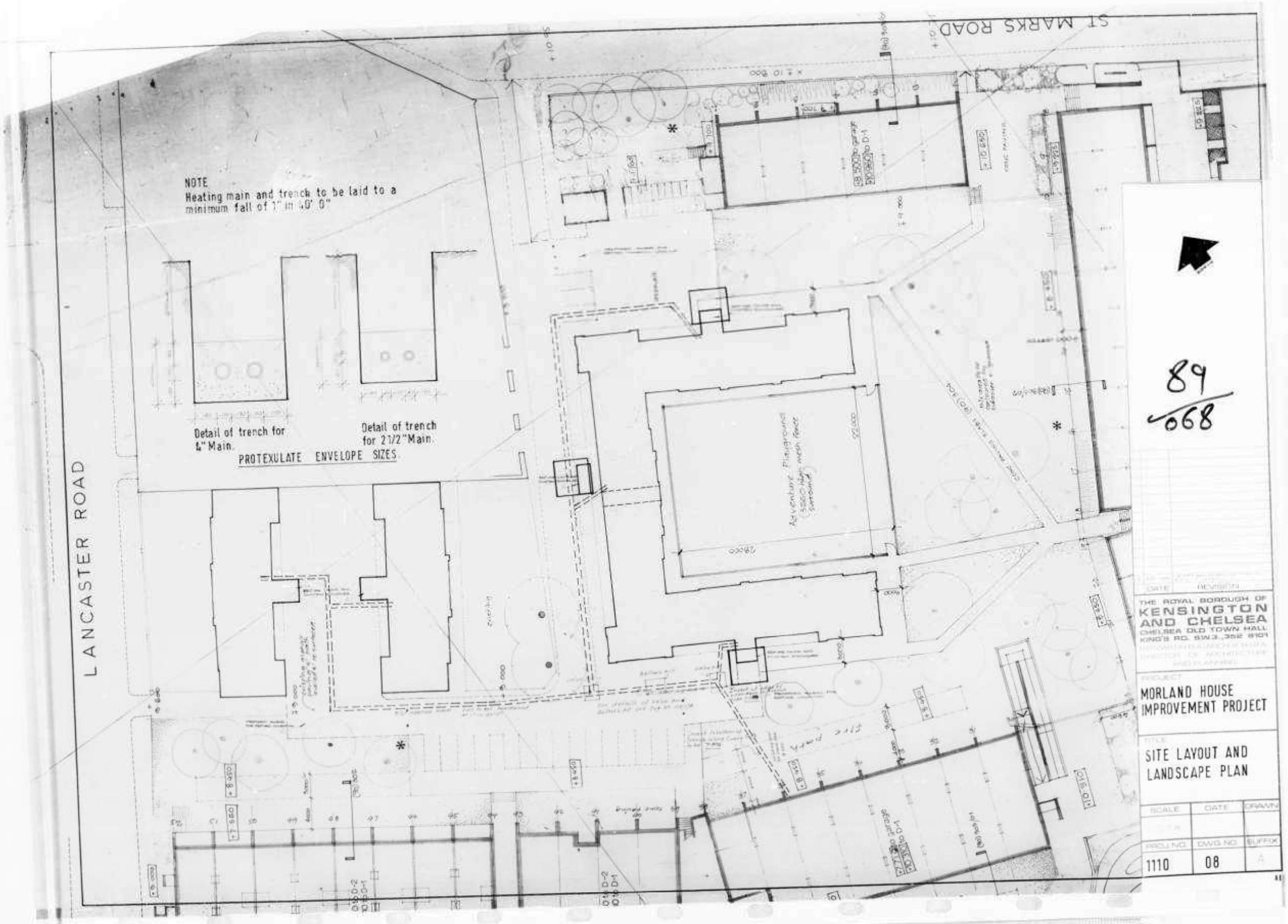
A	Aug '75	LEB Cable added. Retaining wall to childrens home removed. Steps continued. Gulley near Talbot Grove House removed.
B	Oct '75	Site boundary added (chain line). Lighting columns added. Planting areas added.
C	April '78	Revised site boundaries. Revised levels by LEB link box. Levels, paving and contours added between Blocks 2, 3 & 3
	DATE	REVISION

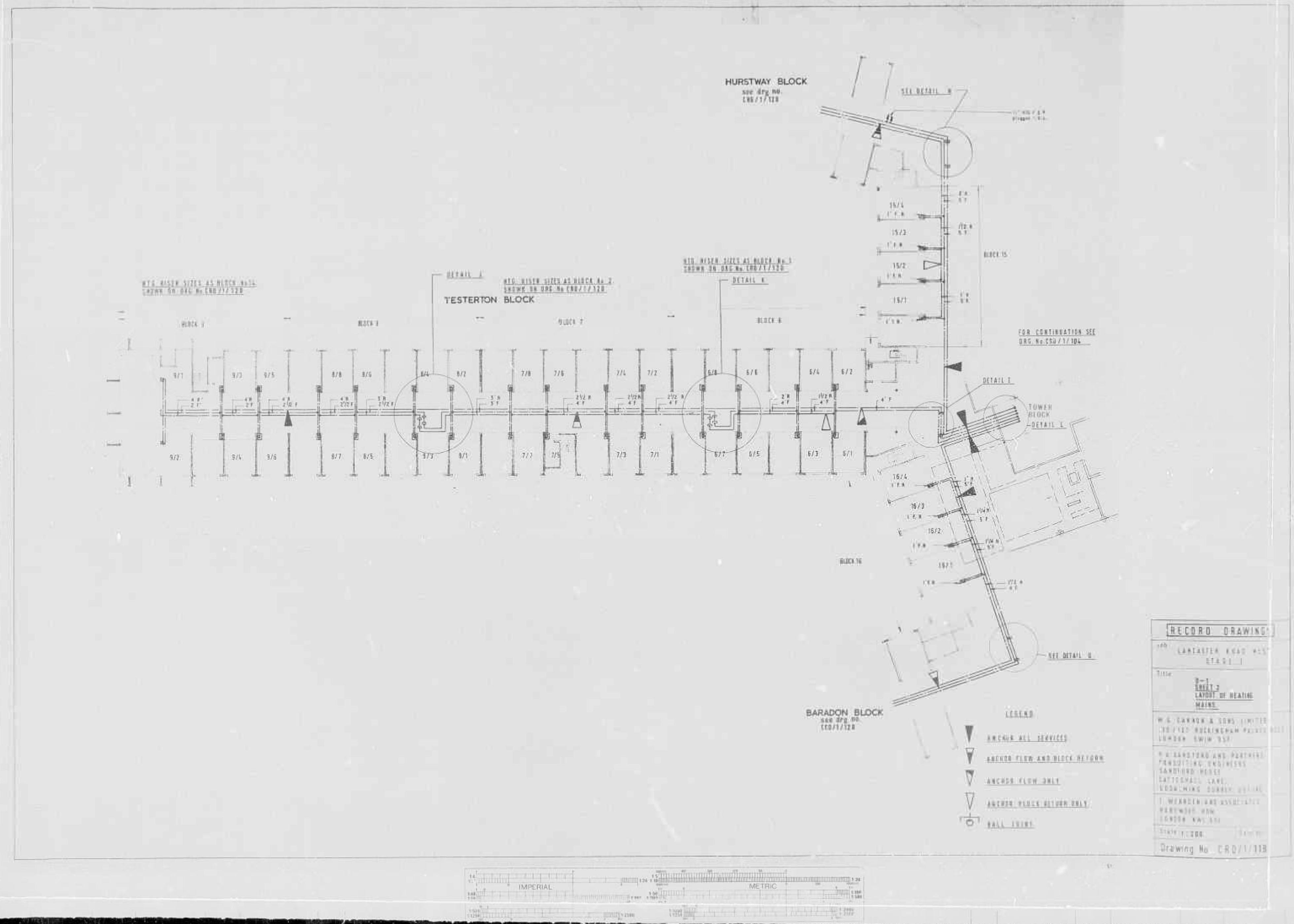
THE ROYAL BOROUGH OF KENSINGTON AND CHELSEA
CHELSEA OLD TOWN HALL
KING'S RD. S.W.3., 352 8101
R.R. MARTIN B.A.(ARCH.) F.R.I.B.A.
DIRECTOR OF ARCHITECTURE AND PLANNING

PROJECT
LANCASTER ROAD WEST STAGE 3

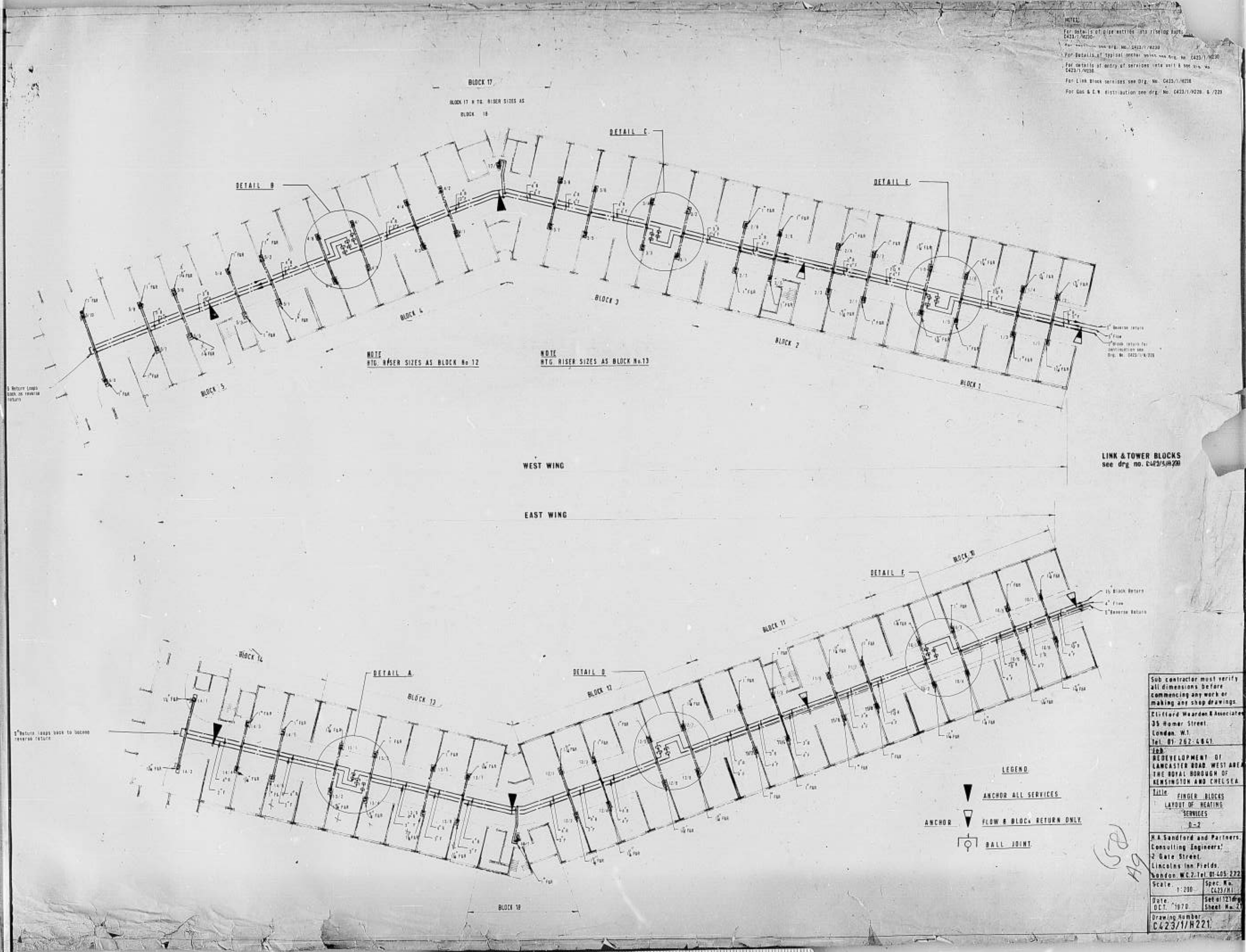
TITLE
EXTERNAL WORKS BLOCK 3

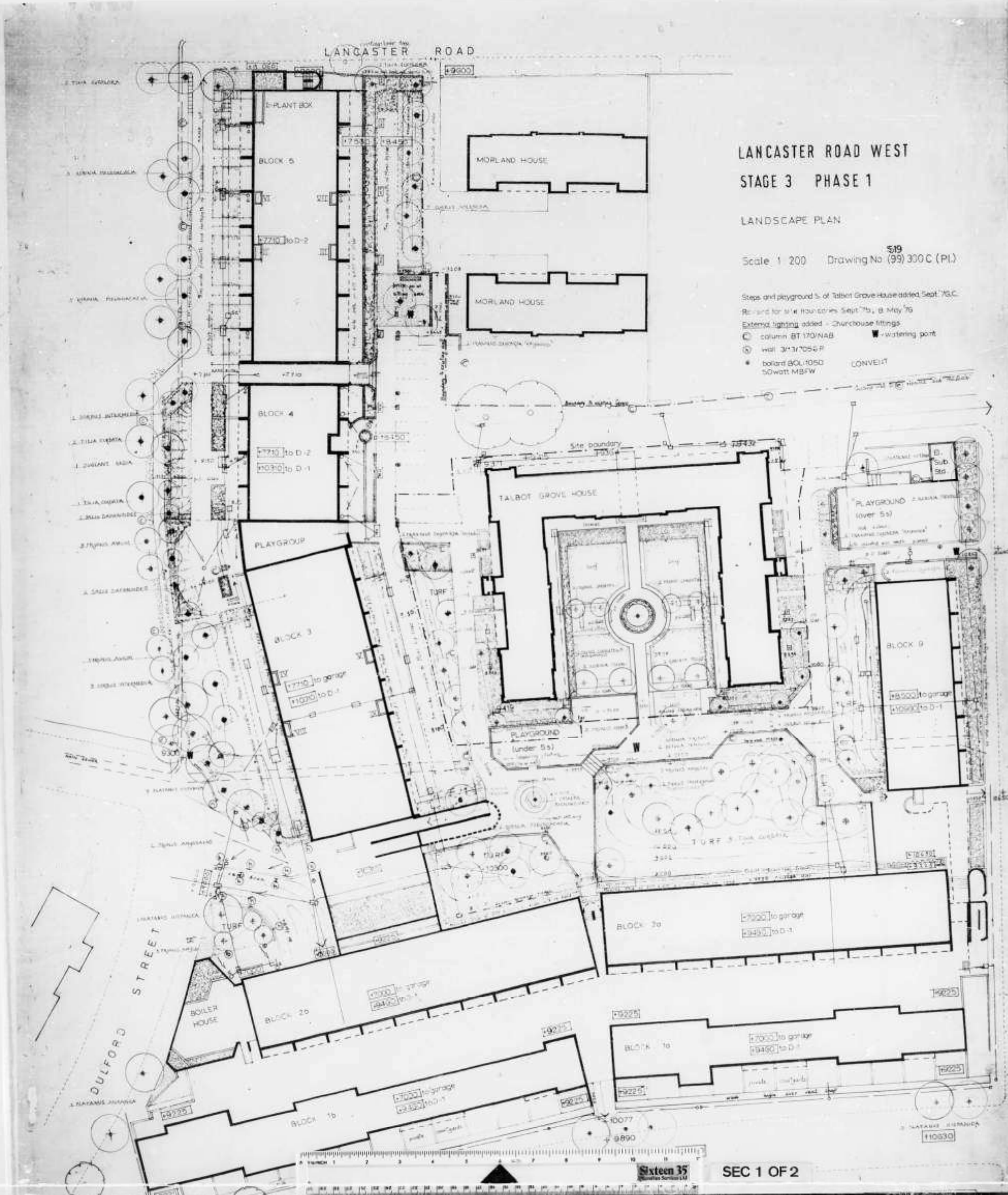
SCALE	DATE	DRAWN
1 to 100	July 75	H.L.P.
PROJ. NO	DWG. NO.	SUFFIX
519	[90]	318c


ST MARKS ROAD
LANCASTER ROAD
NOTE
Heating main and trench to be laid to a minimum fall of 1" in 40' 0"
Detail of trench for 4" Main.
Detail of trench for 2 1/2" Main.
PROTEXULATE ENVELOPE SIZES.
89/068
THE ROYAL BOROUGH OF
KENSINGTON AND CHELSEA
CHELSEA OLD TOWN HALL
KING'S RD. SW3 352 8101
MORLAND HOUSE IMPROVEMENT PROJECT
SITE LAYOUT AND LANDSCAPE PLAN
SCALE
DATE
DRAWN
PROJ NO
DWG NO
SUFFIX
1110
08
DATE
REVISION

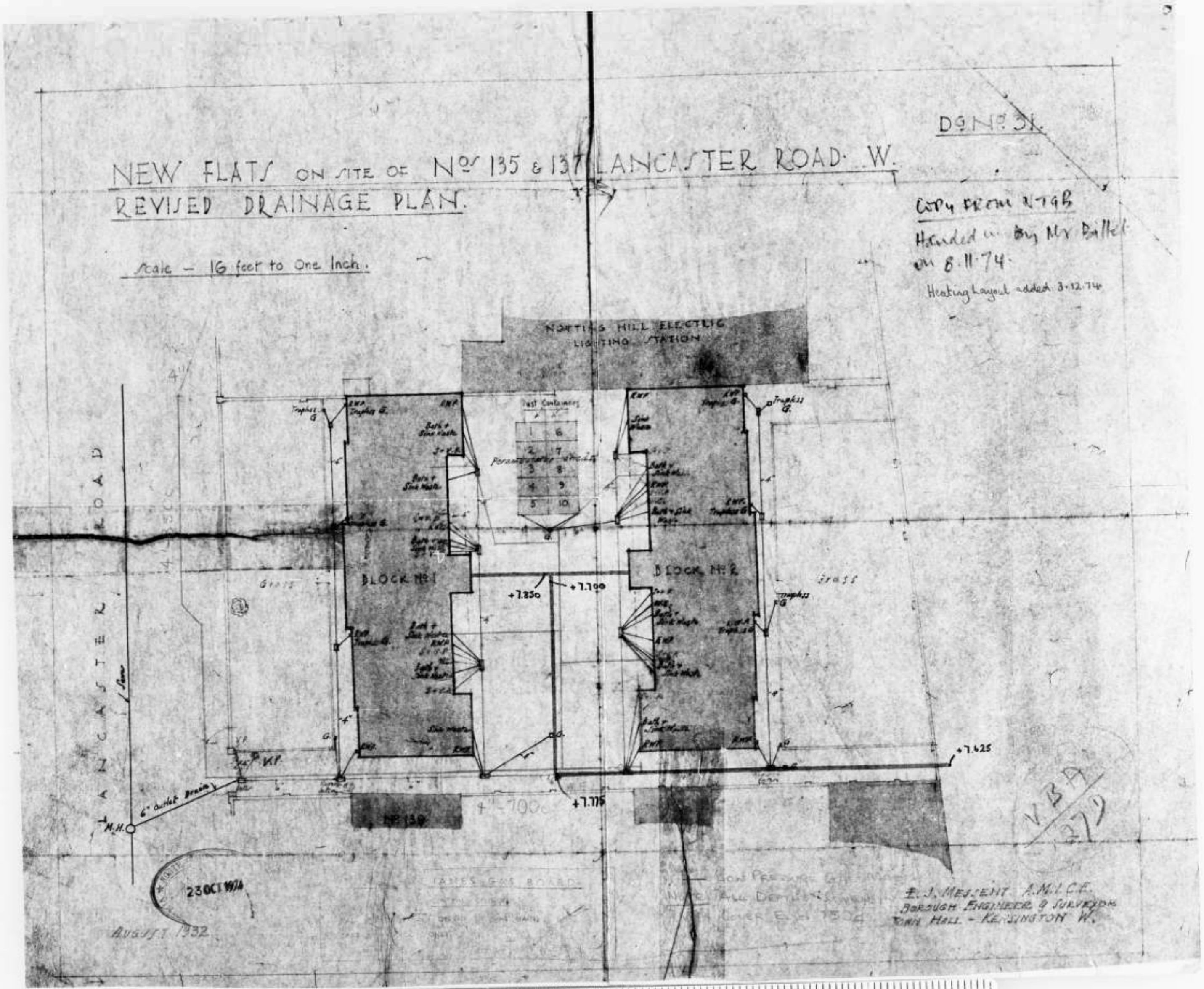


HURSTWAY BLOCK
see drg no.
CRD/1/120
TESTERTON BLOCK
BARADON BLOCK
TOWER BLOCK
DETAIL K
DETAIL J
DETAIL L
SEE DETAIL H
SEE DETAIL G
BLOCK 15
BLOCK 16
LEGEND
ANCHOR ALL SERVICES
ANCHOR FLOW AND BLOCK RETURN
ANCHOR FLOW ONLY
ANCHOR BLOCK RETURN ONLY
BALL JOINT
RECORD DRAWINGS
LANCASTER ROAD
STAGE 1
Title
SHEET 2
LAYOUT OF HEATING
MAINS
W.G. CANNON & SONS LIMITED
LONDON SW1W
CONSULTING ENGINEERS
SANDFORD HOUSE
Scale 1:200
Drawing No. CRD/1/118
IMPERIAL
METRIC


NOTES:
For details of pipe entries into riseing ducts C423/1/H230
For Details of typical anchor points see Drg. No. C423/1/H230
For details of entry of services into unit & see Drg. No. C423/1/H238
For Link Block services see Drg. No. C423/1/H238
For Gas & C.W. distribution see drg. No. C423/1/H228. & /229
BLOCK 17
BLOCK 17 HTG. RISER SIZES AS BLOCK 18
DETAIL C
DETAIL B
DETAIL E
BLOCK 4
BLOCK 3
BLOCK 2
BLOCK 5
BLOCK 1
NOTE
HTG. RISER SIZES AS BLOCK No 12
NOTE
HTG. RISER SIZES AS BLOCK No.13
WEST WING
EAST WING
LINK & TOWER BLOCKS
see drg no. C423/5/H200
DETAIL F
BLOCK 10
BLOCK 11
BLOCK 14
DETAIL A
DETAIL D
BLOCK 13
BLOCK 12
BLOCK 18
LEGEND
ANCHOR ALL SERVICES
ANCHOR
FLOW & BLOCK RETURN ONLY
BALL JOINT
Sub contractor must verify all dimensions before commencing any work or making any shop drawings.
Clifford Wearden & Associates
35 Homer Street.
London. W.1.
Tel. 01-262-4841.
Job.
REDEVELOPMENT OF LANCASTER ROAD WEST AREA
THE ROYAL BOROUGH OF KENSINGTON AND CHELSEA
Title.
FINGER BLOCKS
LAYOUT OF HEATING SERVICES
D-2
H.A.Sandford and Partners.
Consulting Engineers.
2 Gate Street.
Lincolns Inn Fields.
London. W.C.2. Tel. 01-405-2727
Scale. 1:200
Spec. No. C423/H1
Date. OCT. 1970
Set of 121 drgs
Sheet No. 27
Drawing Number
C423/1/H221
58
A9


LANCASTER ROAD WEST
STAGE 3 PHASE 1
LANDSCAPE PLAN
Scale 1 200 Drawing No 519 (99) 300 C (Pl.)
Steps and playground S. of Talbot Grove House added Sept. '76 G.C.
External lighting added - Churchouse fittings
column BT 170/NAB
watering point
bollard BOL 1050 50watt MBFW
CONVENT
LANCASTER ROAD
MORLAND HOUSE
MORLAND HOUSE
BLOCK 5
PLANT BOX
BLOCK 4
PLAYGROUP
BLOCK 3
TALBOT GROVE HOUSE
Site boundary
PLAYGROUND (over 5s)
Sub Sta
BLOCK 9
PLAYGROUND (under 5s)
TURF
BLOCK 2a
BLOCK 2b
BOILER HOUSE
BLOCK 1a
BLOCK 1b
DULFORD STREET

SEC 1 OF 2


DG. Nº 31.
NEW FLATS ON SITE OF Nos 135 & 137 LANCASTER ROAD. W.
REVISED DRAINAGE PLAN.
Scale – 16 feet to One Inch.
Copy from N79B
Handed in by Mr Billet
on 8.11.74.
Heating Layout added 3.12.74
NOTTING HILL ELECTRIC LIGHTING STATION
Dust Containers
Perambulator Stores
BLOCK No 1
BLOCK No 2
Grass
+7.850
+7.790
+7.775
+7.625
LANCASTER ROAD
M.H.
6" outlet drain
No 139
23 OCT 1974
VBA
AUGUST 1932
E. J. MESSENT A.M.I.C.E.
BOROUGH ENGINEER & SURVEYOR
TOWN HALL – KENSINGTON W.

Appendix D – Pinch Point sketches

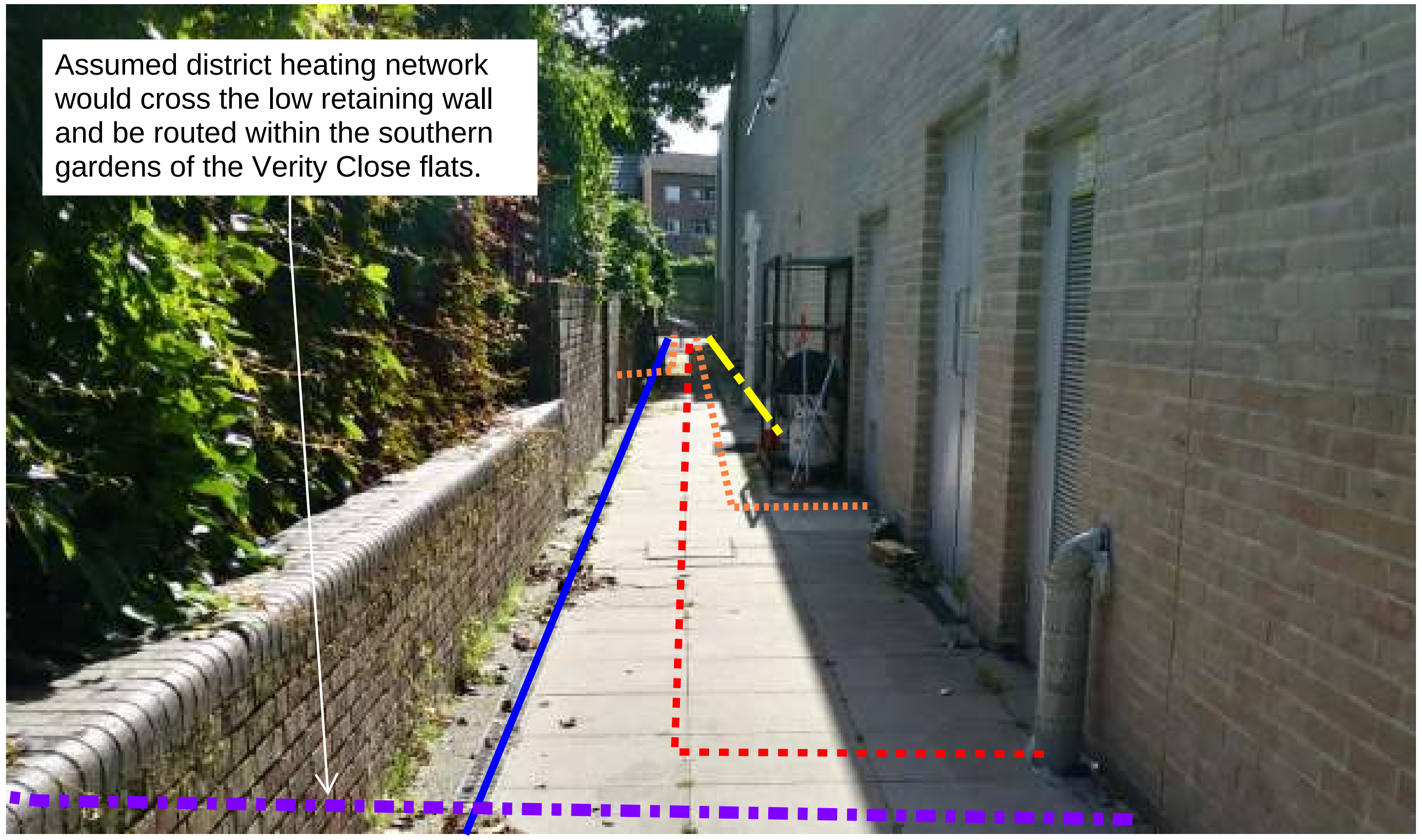


Figure 1: Pinch point A - Path north of the Kensington Leisure Centre

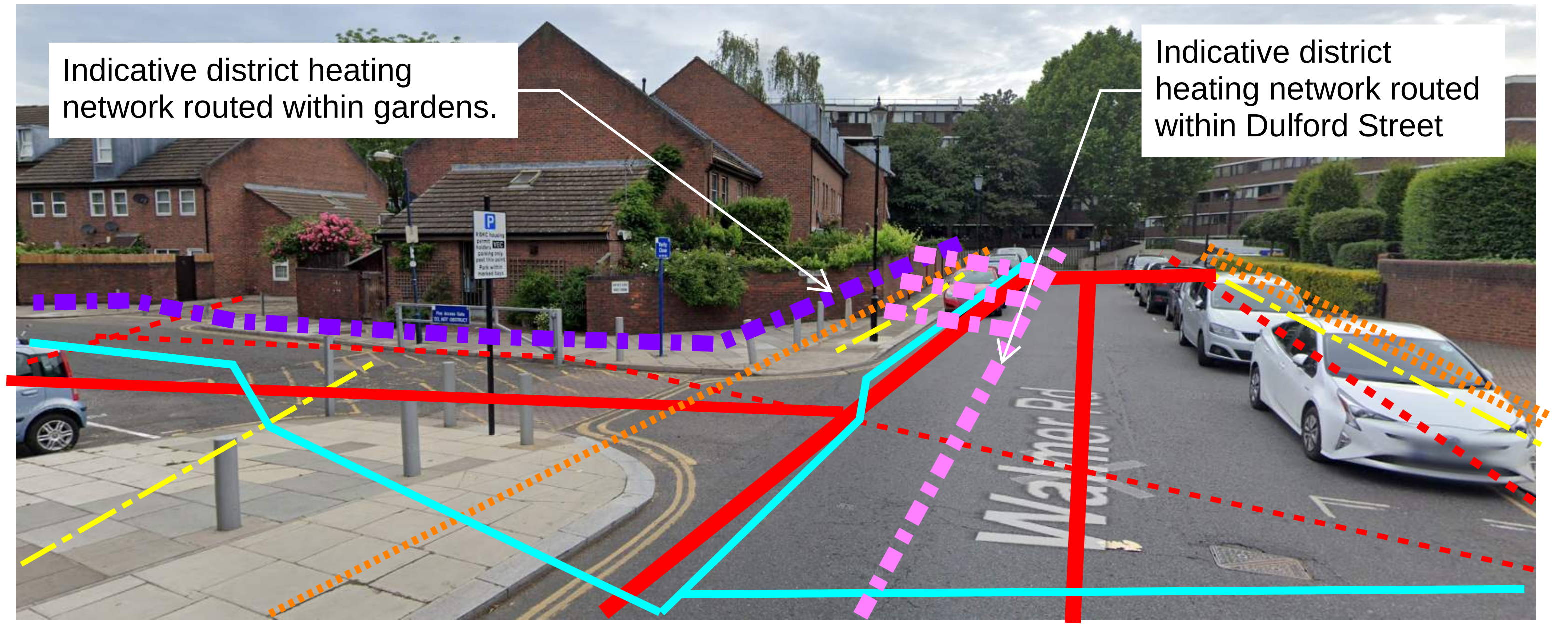


Figure 2: Pinch point B - View north-east on Dulford Street

Note:

This sketch is not to scale and line widths are not accurate utility widths.

Horizontal alignments are not to be considered accurate and are indicative only. A CAD composite is to be obtained in the next design stage which will show these alignments more accurately.

Vertical alignments are unknown.

No vertical or horizontal coordination has been undertaken.

Presence of existing utilities are to be confirmed on site through survey works.

Refer to Groundiwse Report (Ref: 26041FM Rev 4) for further details.

Note, several electrical cables may be represented by each line shown identifying the electrical network.

Legend:

Indicative existing utilities:

UKPN Electrical Network

Assumed private SW Network

Cadent LP Gas network

BT

Thames Water Combined Sewer

Thames Water Potable Water

Indicative proposed utilities:

Proposed district heating pipe route

Alternative district heating network route

Approximate alignments of existing and proposed utilities at pinch points - Sheet 1 of 2

272173-05 Lancaster West Estate

31.07.20 | For Information | MW

SK-CU-001

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Figure 3: Pinch point C - View west of St Marks Road

Figure 4: Pinch point D - View north on Cornwall Crescent

Approximated alignments of existing and proposed utilities at pinch points - Sheet 2 of 2

272173-05 Lancaster West Estate

31.07.20 | For Information | MW

SK-CU-001

ARUP

Note:

This sketch is not to scale and line widths are not accurate utility widths.

Horizontal alignments are not to be considered accurate and are indicative only. A CAD composite is to be obtained in the next design stage which will show these alignments more accurately.

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No vertical or horizontal coordination has been undertaken.

Presence of existing utilities are to be confirmed on site through survey works.

Refer to Groundiwse Report (Ref: 26041FM Rev 4) for further details.

Note, several electrical cables may be represented by each line shown identifying the electrical network.

Legend:

Indicative existing utilities:

UKPN Electrical Network

Assumed private SW Network

Cadent LP Gas network

BT

Thames Water Combined Sewer

Thames Water Storm Relief Sewer

Thames Water Potable Water

BSkyB

Zayo

Vodafone

Virgin Media

Indicative proposed utilities:

Proposed district heating pipe route

Alternative district heating network route

Appendix E – Connection charges

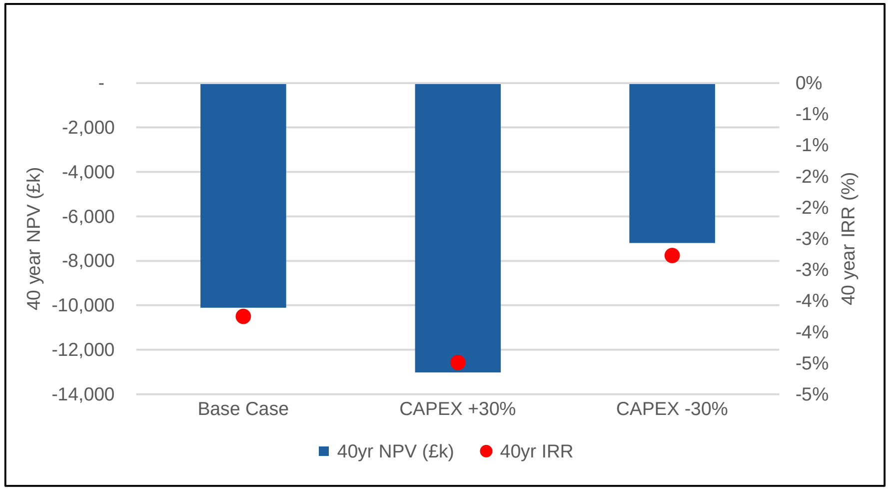
ARUP

Connection charges

Building ID	Name	Package 1 (£/kW)	Package 2 (£/kW)
1	Camborne Mews 1-12	20	28
2	Camborne Mews 13-36	106	157
3	Barandon Walk 301-339 & 401-439	84	152
4	Camelford Court	38	63
5	Camelford Walk	50	91
6	Lower Clarendon Walk 1-8	-	-
7	Clarendon Walk 1-56	48	86
8	Upper Clarendon Walk 1-40	-	-
9	Hurstway Walk 301-339 & 401-439	80	146
10	Morland House 1-17	73	79
11	Morland House 18-34	29	31
12	Talbot Grove House	53	60
13	Talbot Walk	26	71
14	Testerton Walk 301-339 & 401-406	51	80
15	Treadgold House 1-38	-	-
16	Upper Talbot Walk	119	159
17	Verity Close 1-7	-	-
18	Verity Close 8-25	99	140
19	Verity Close 26-43	99	158
20	Verity Close 44-50	-	-
21	Verity Close 51-60	-	-
22	Verity Close 61-68	-	-
23	Kensington Aldridge Academy	300	300
24	Kensington Leisure Centre	300	300

Appendix F – Sensitivities

Appendix F
Sensitivities – Scenario 1



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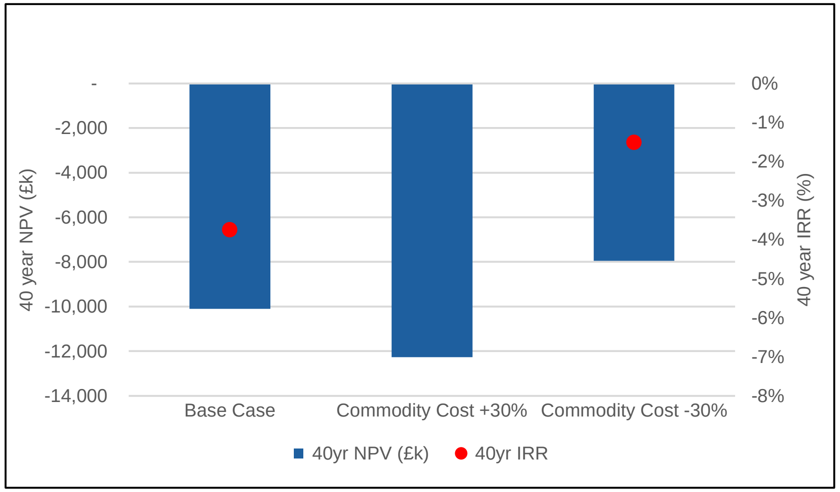
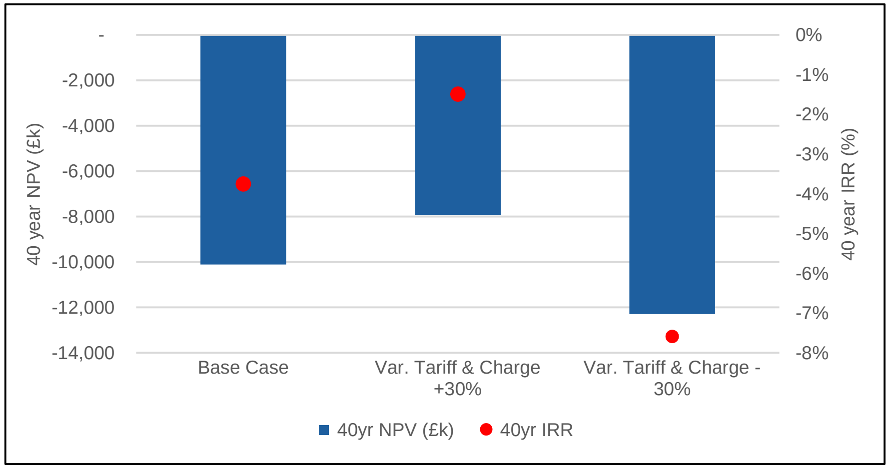
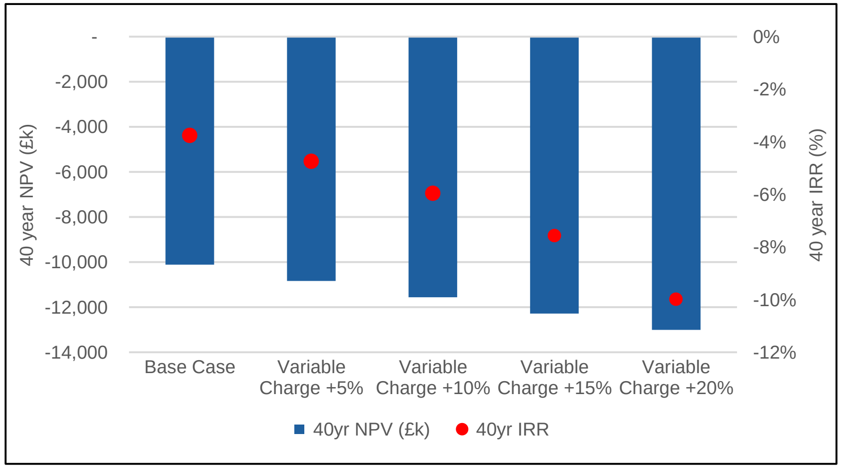


Commodity Costs Sensitivity



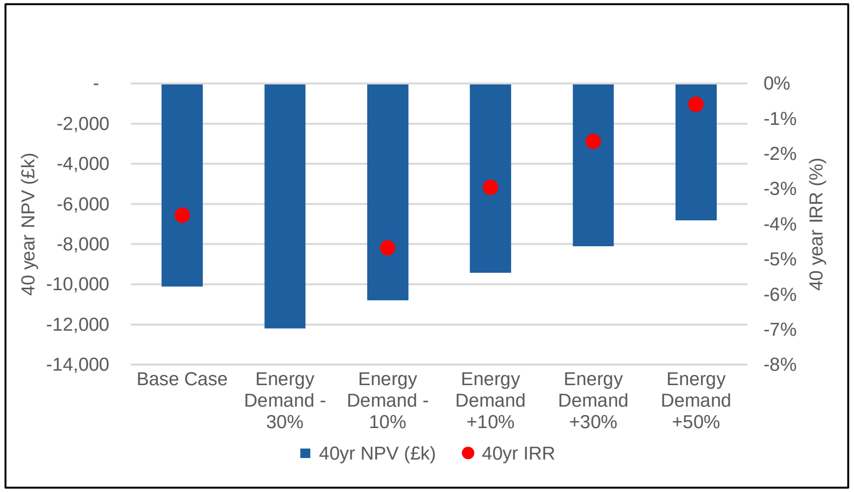
Variable Tariff Sensitivity



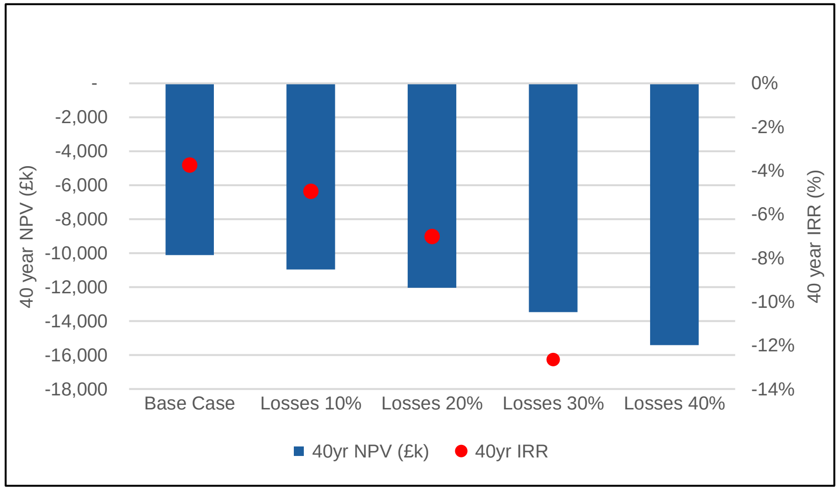
Variable Charge Sensitivity

ARUP

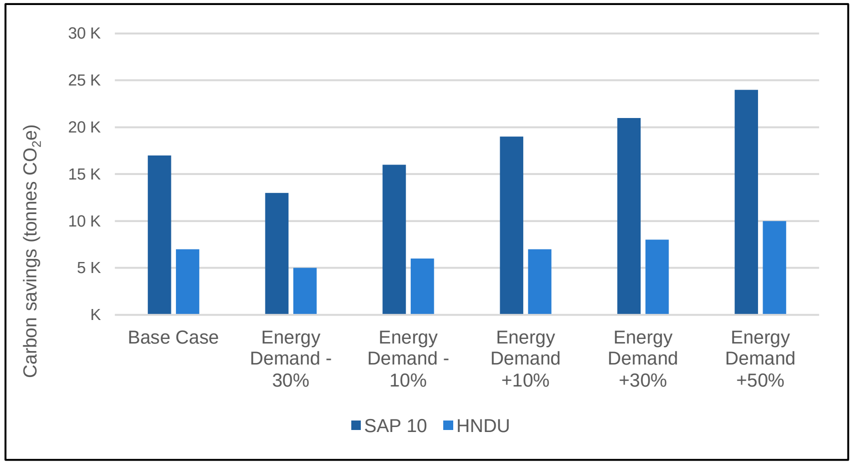
Appendix F
Sensitivities – Scenario 1



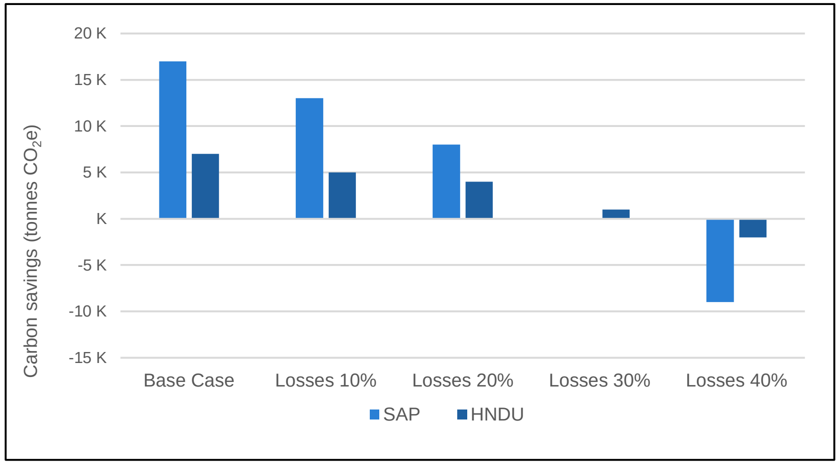
Energy Demand Sensitivity



Heat Losses Sensitivity

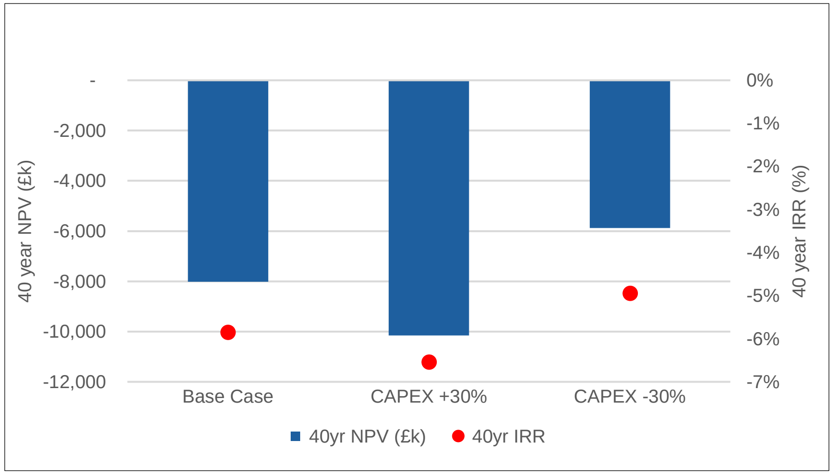


Energy Demand Sensitivity

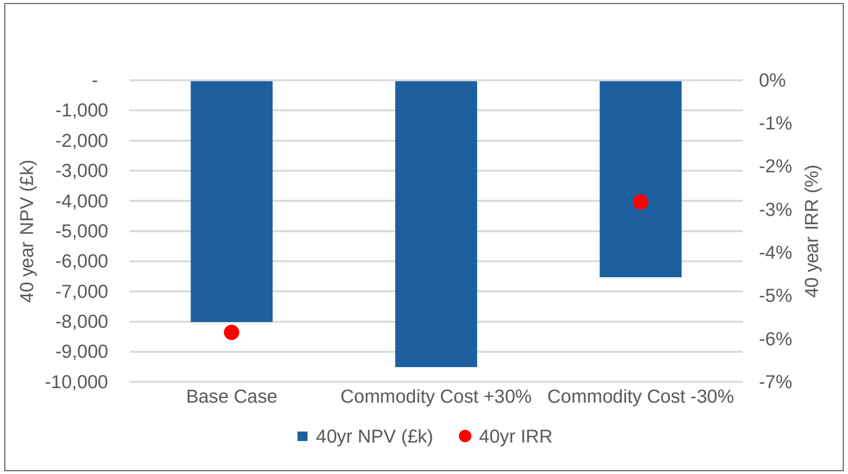


Heat Losses Sensitivity

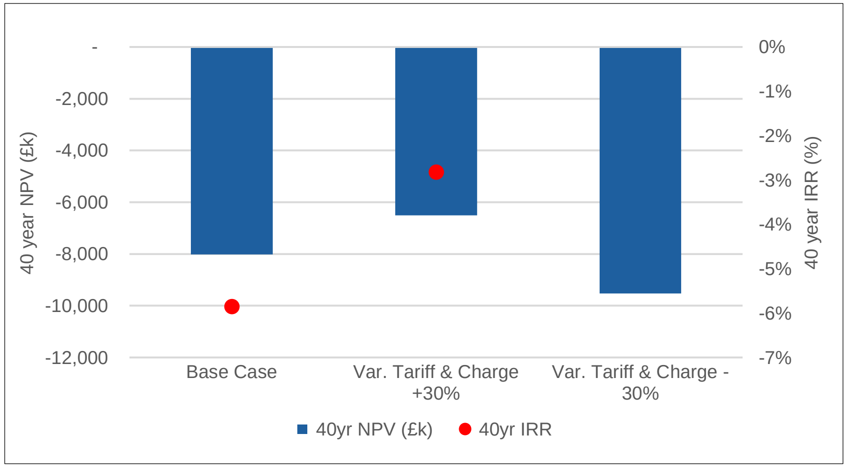
Appendix F
Sensitivities – Scenario 2



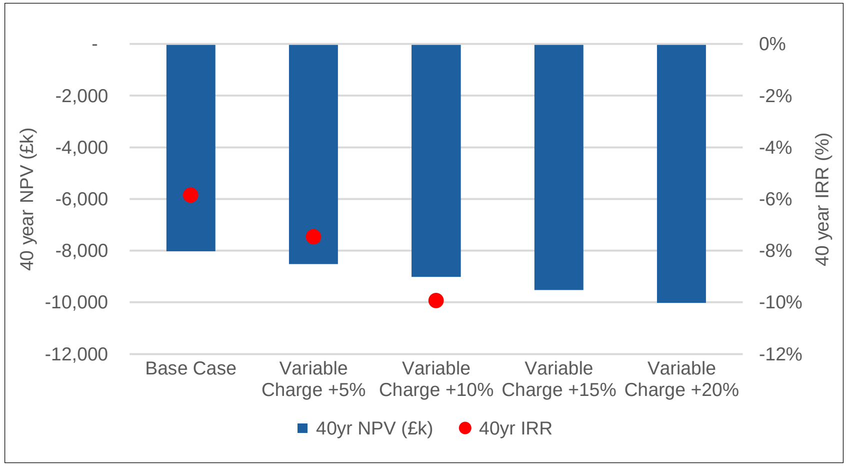
Capex Sensitivity



Commodity Costs Sensitivity



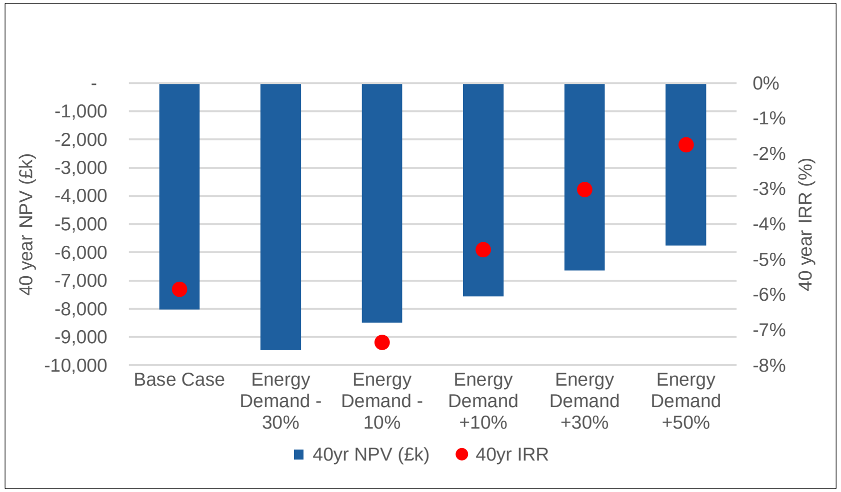
Variable Tariff Sensitivity



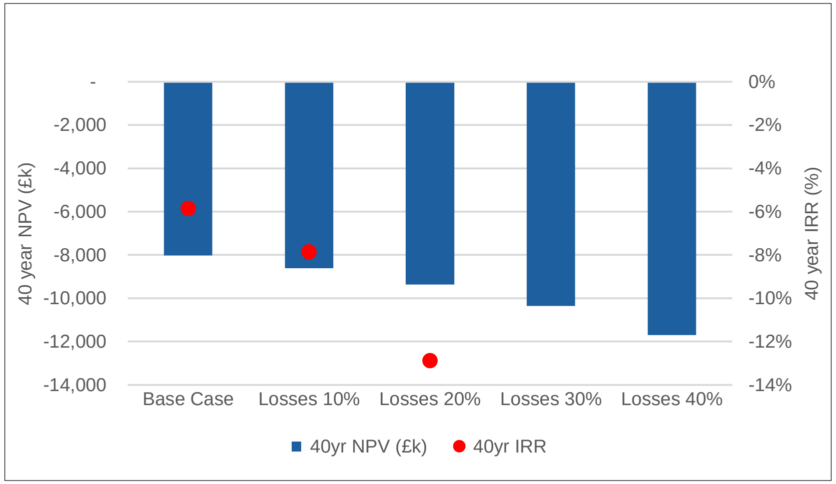
Variable Charge Sensitivity

ARUP

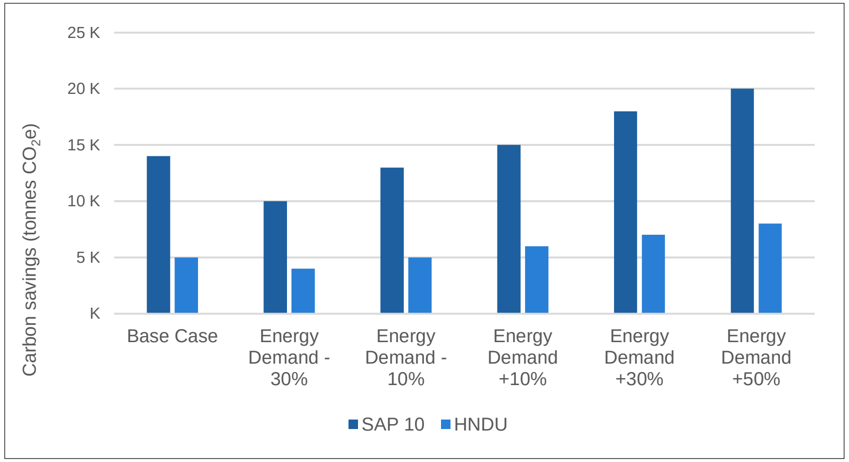
Appendix F
Sensitivities – Scenario 2



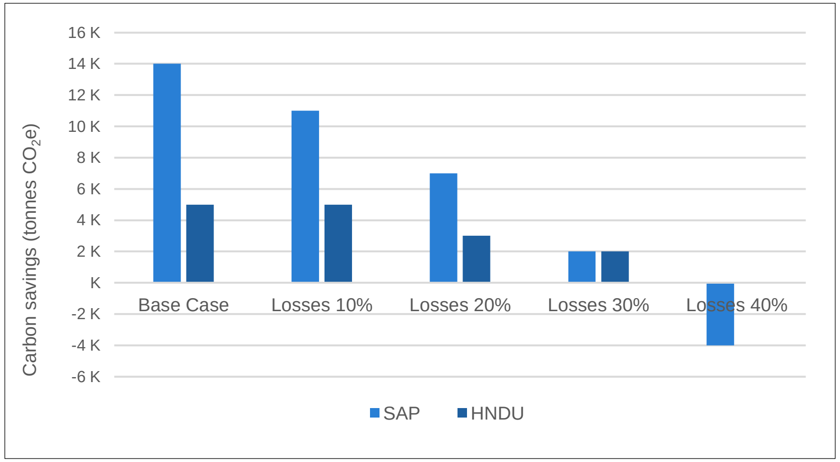
Energy Demand Sensitivity



Heat Losses Sensitivity



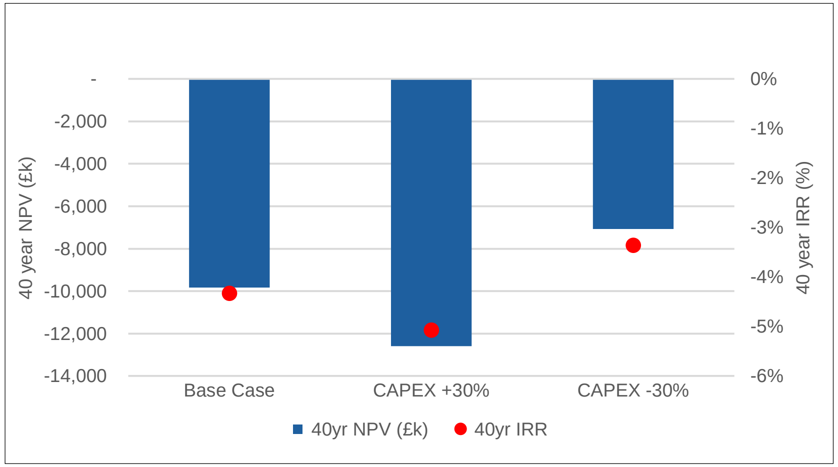
Energy Demand Sensitivity



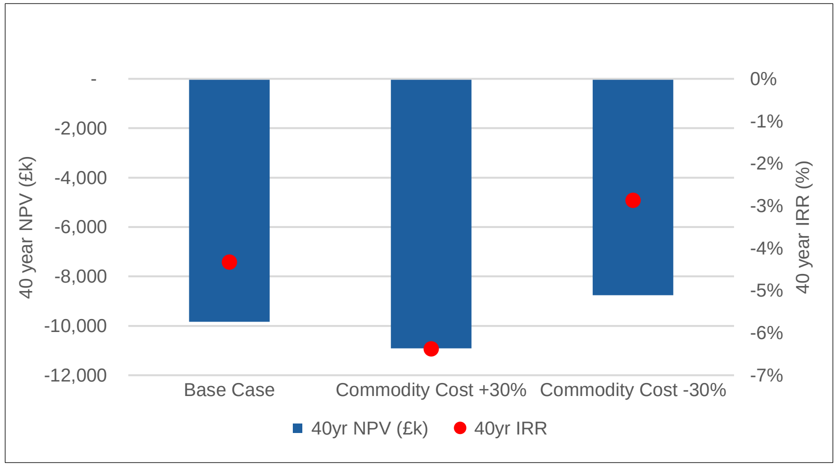
Heat Losses Sensitivity

ARUP

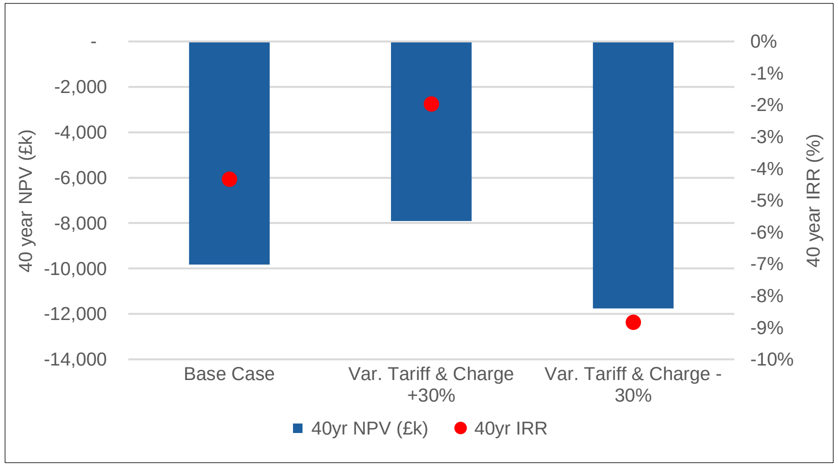
Appendix F
Sensitivities – Scenario 4



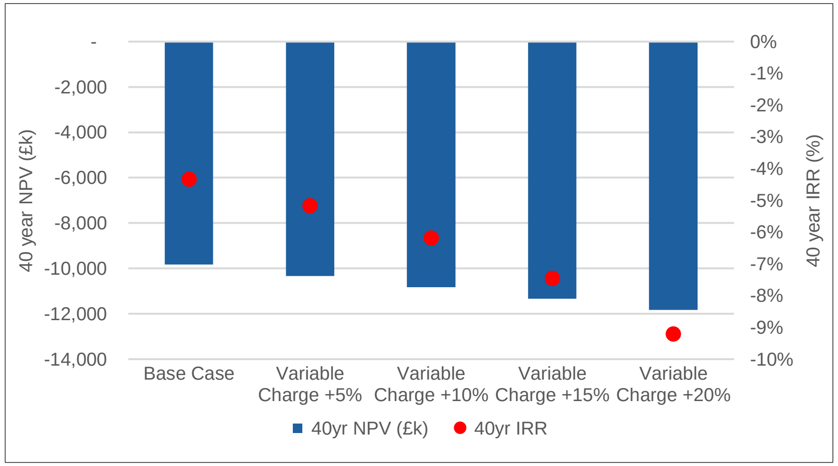
Capex Sensitivity



Commodity Costs Sensitivity



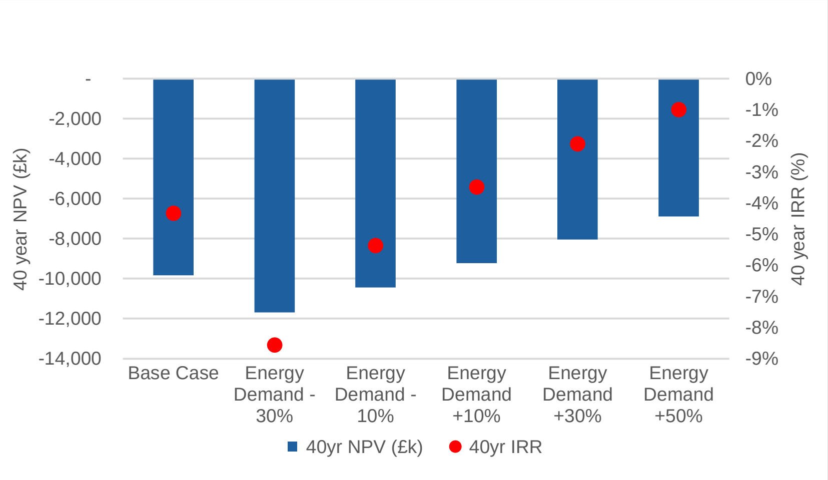
Variable Tariff Sensitivity



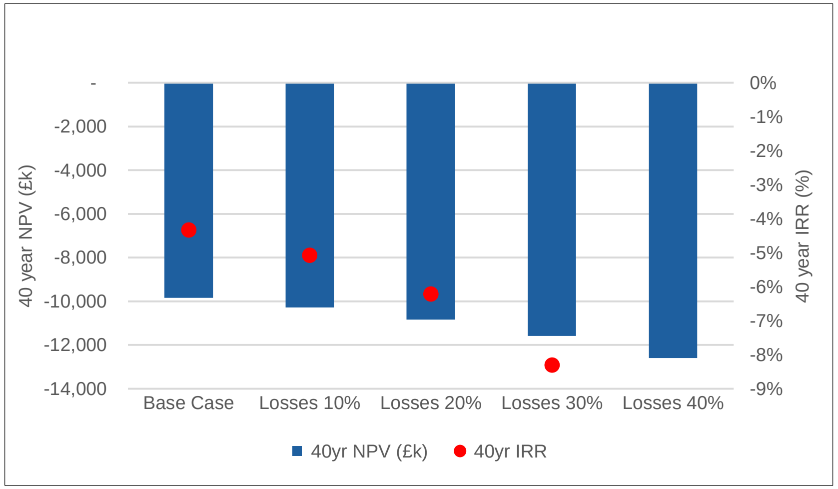
Variable Charge Sensitivity

ARUP

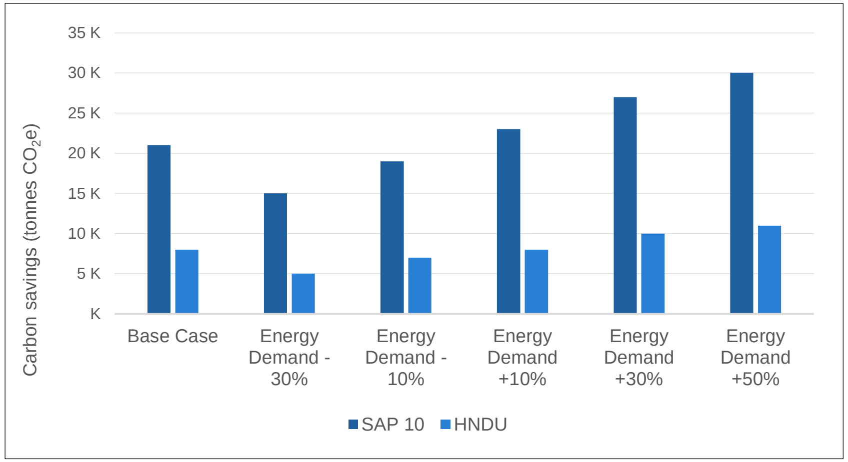
Appendix F
Sensitivities – Scenario 4



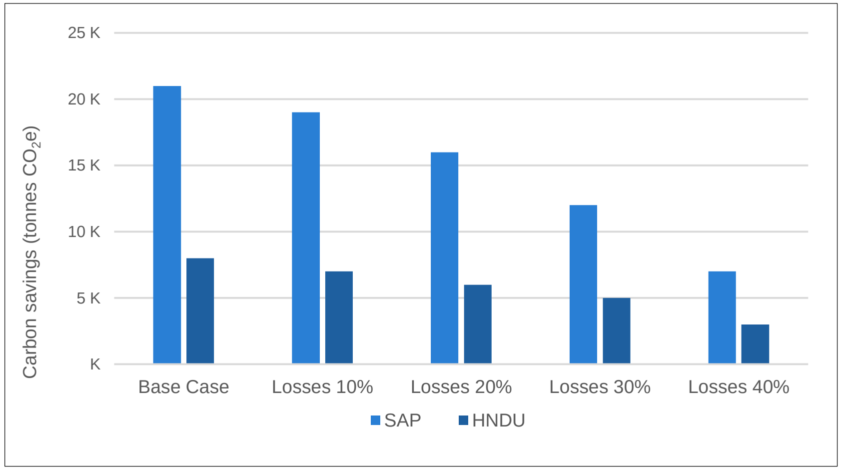
Energy Demand Sensitivity



Heat Losses Sensitivity



Energy Demand Sensitivity



Heat Losses Sensitivity

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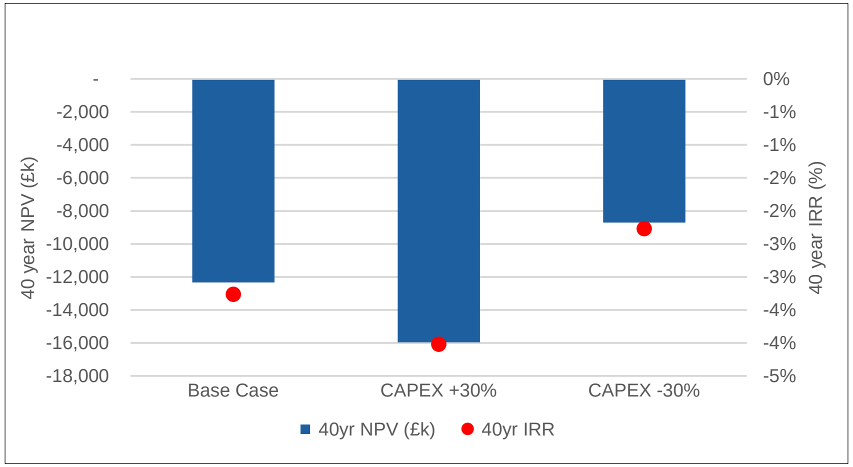
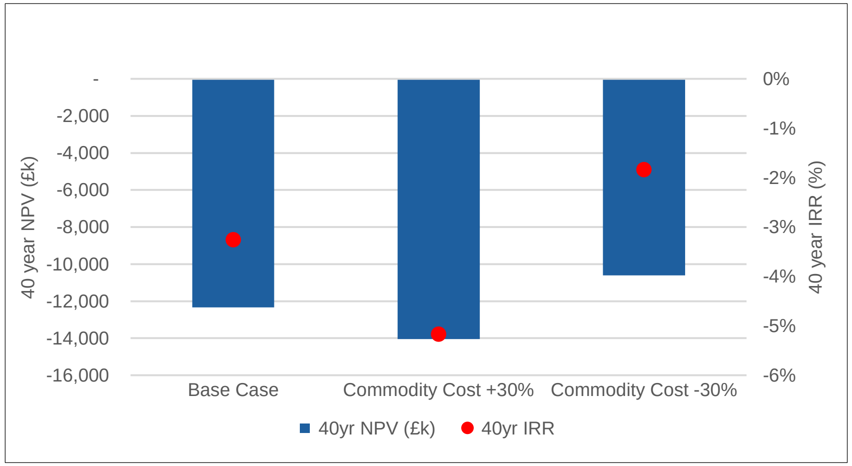
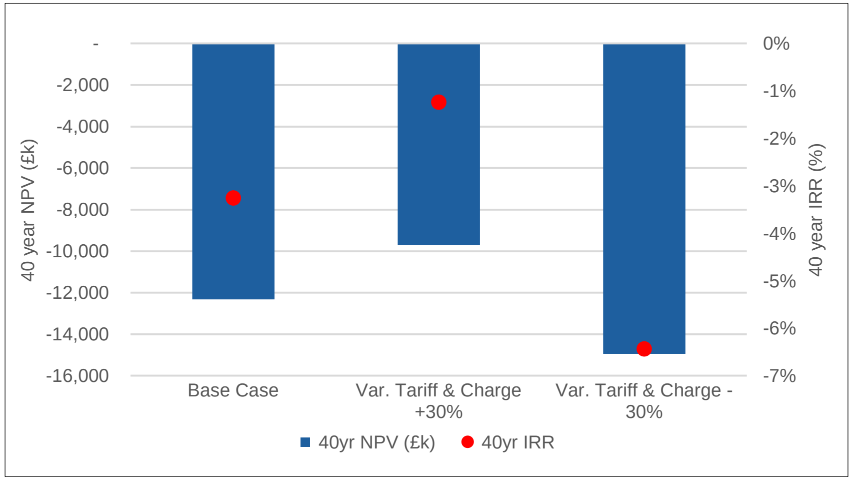
Appendix F
Sensitivities – Scenario 5



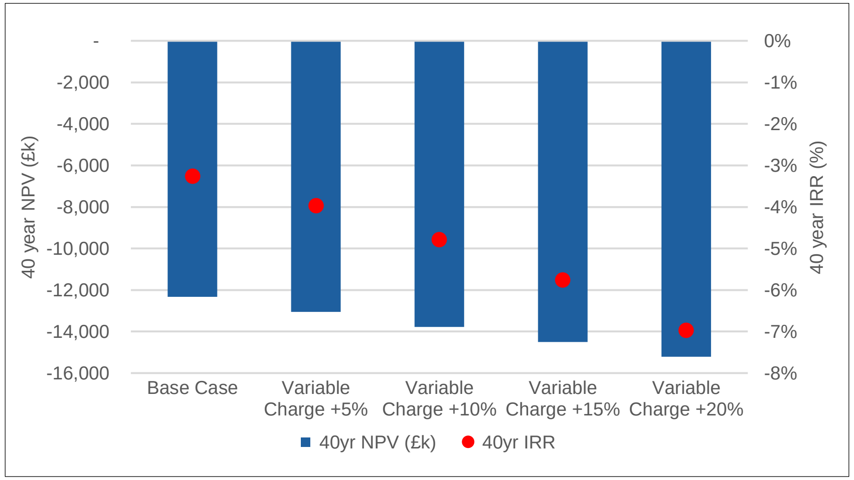
Capex Sensitivity



Commodity Costs Sensitivity

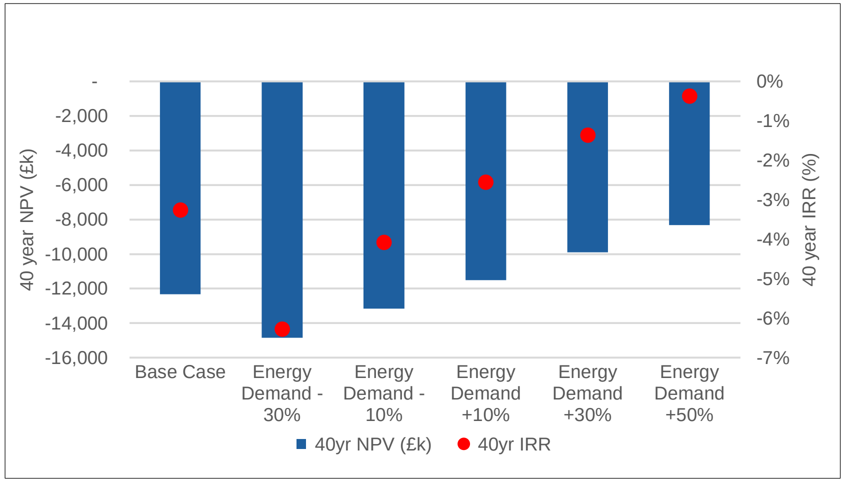


Variable Tariff Sensitivity

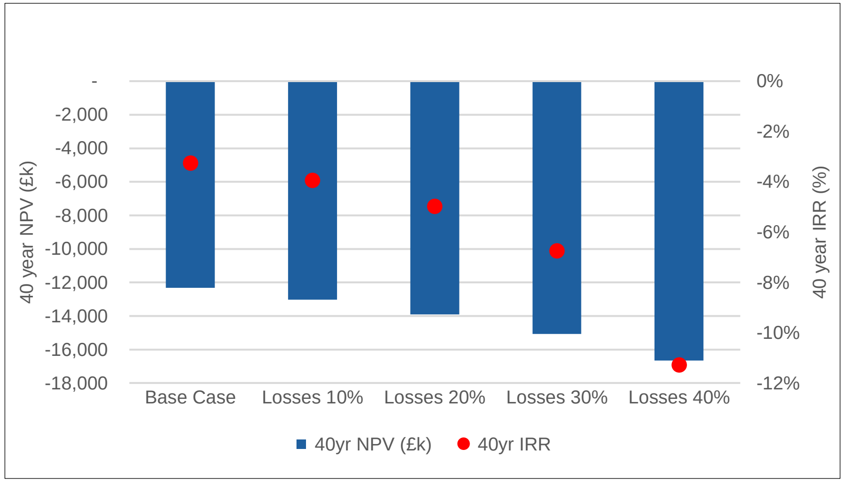


Variable Charge Sensitivity

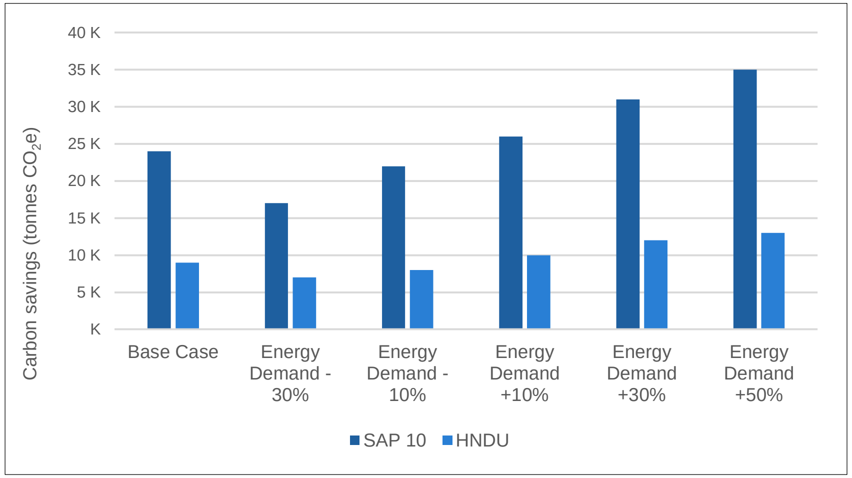
Appendix F
Sensitivities – Scenario 5



Energy Demand Sensitivity



Heat Losses Sensitivity



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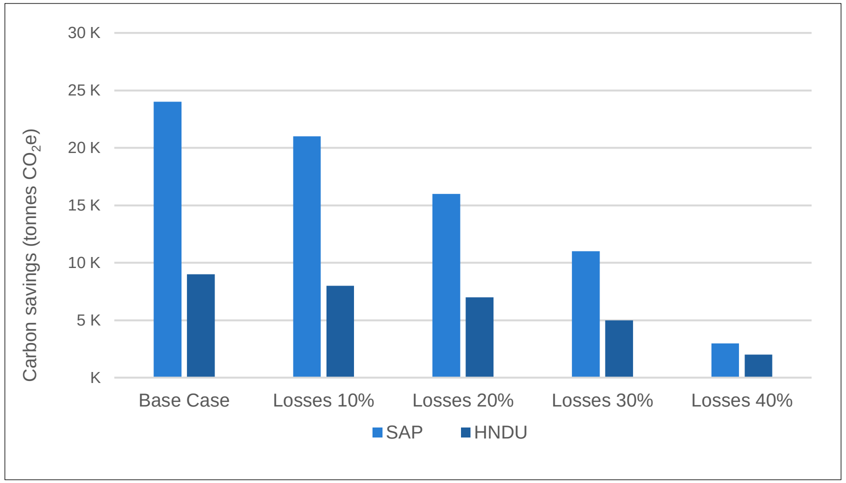

Heat Losses Sensitivity

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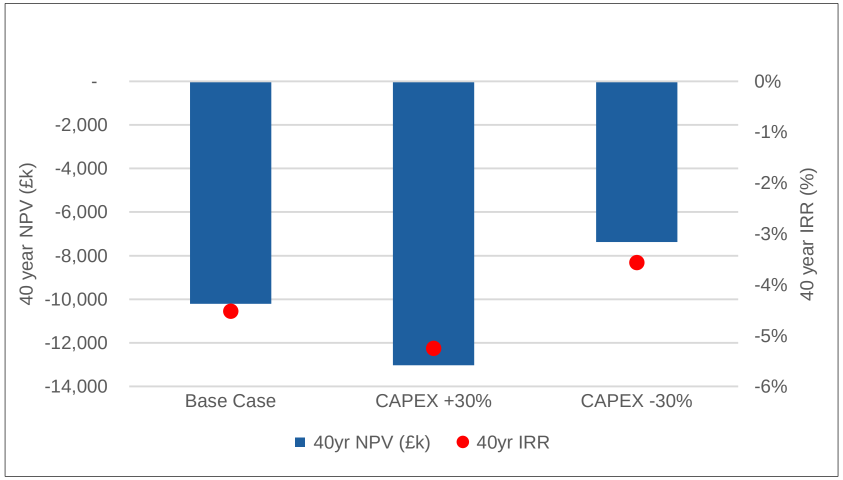
Appendix F
Sensitivities – Scenario 6



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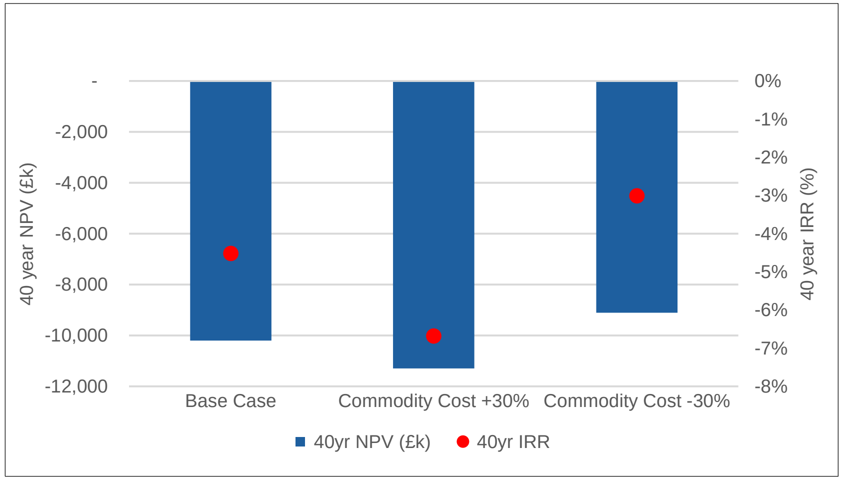
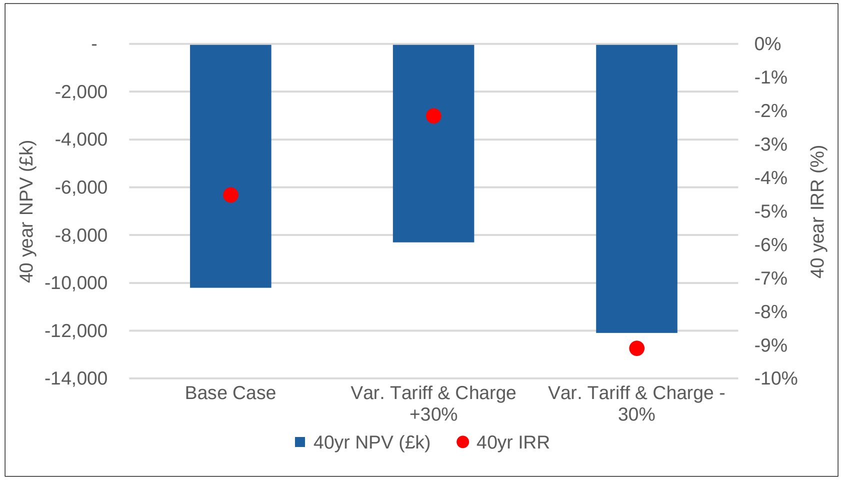
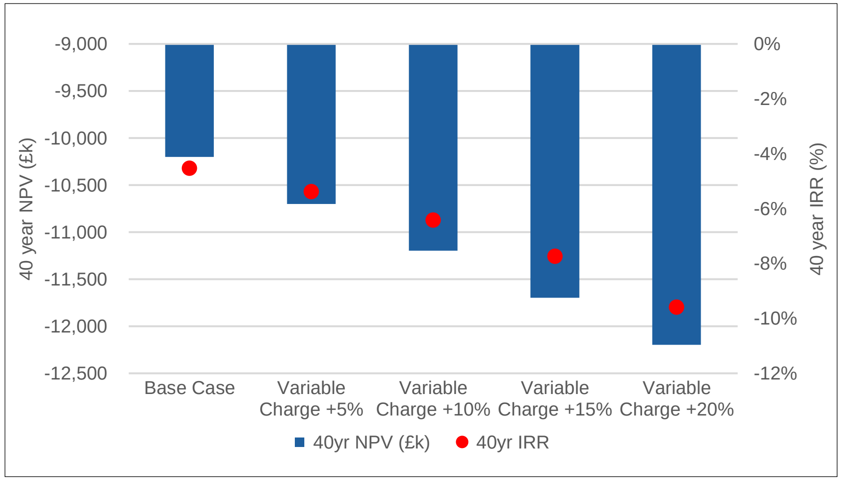


Commodity Costs Sensitivity



Variable Tariff Sensitivity



Variable Charge Sensitivity

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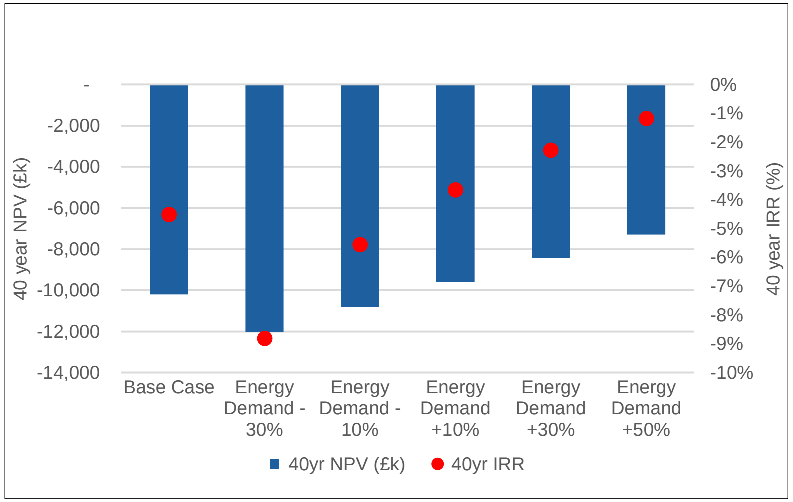
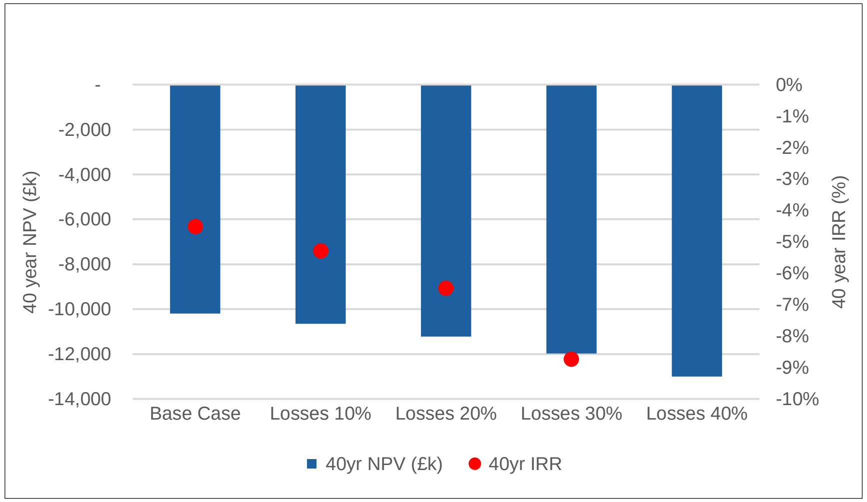
Appendix F

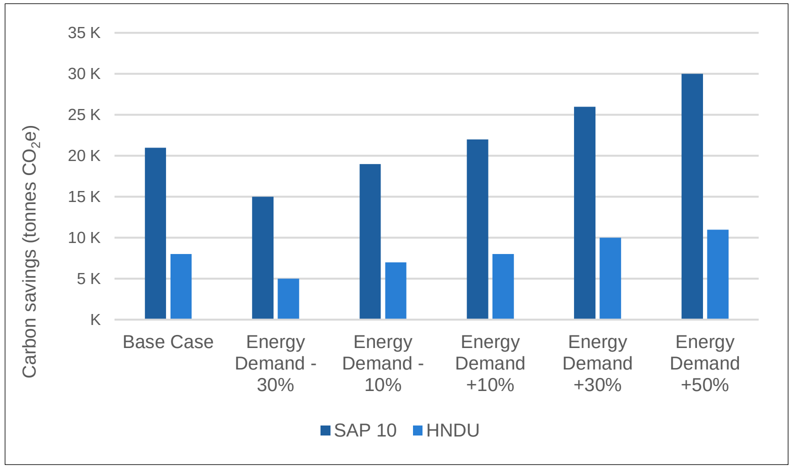
Sensitivities – Scenario 6



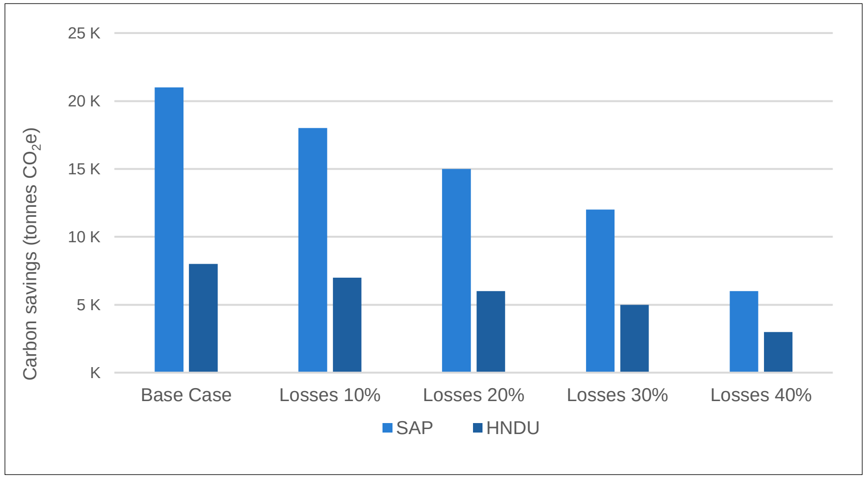
Energy Demand Sensitivity



Heat Losses Sensitivity

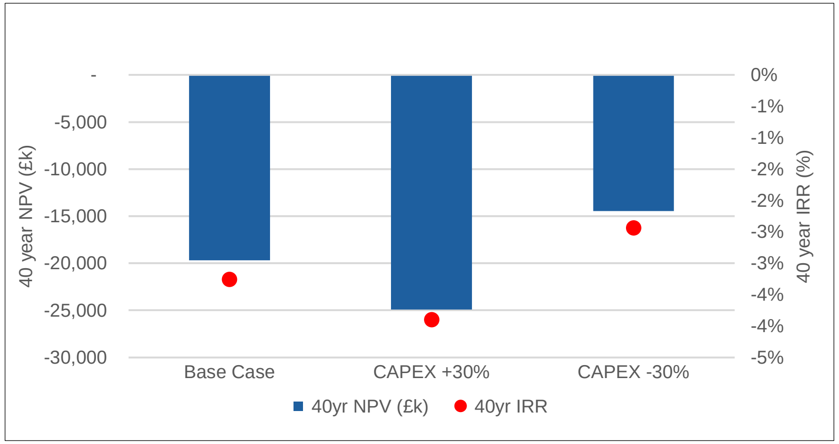


Energy Demand Sensitivity

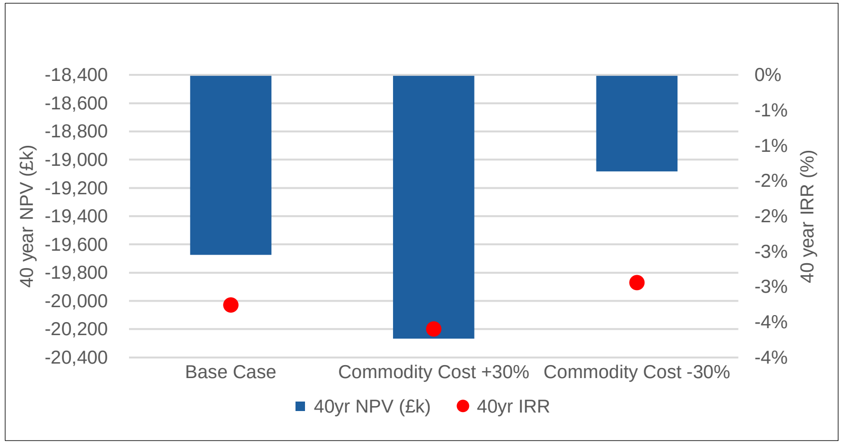


Heat Losses Sensitivity

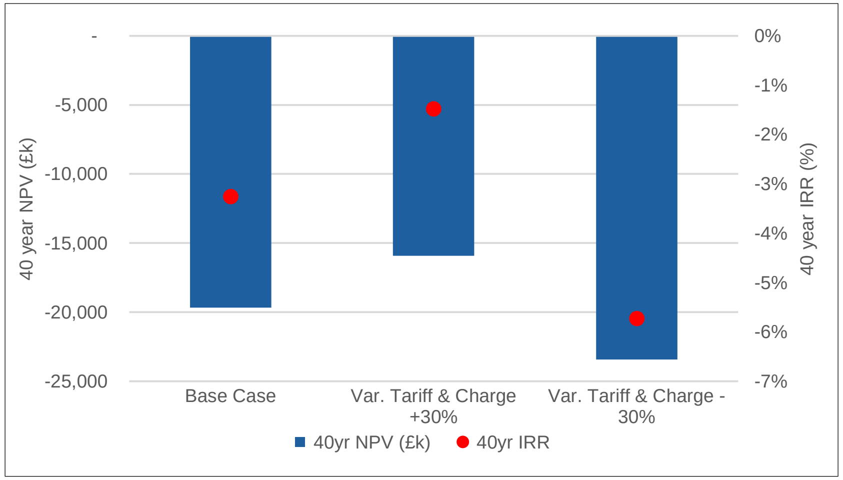
Appendix F
Sensitivities – Scenario 7



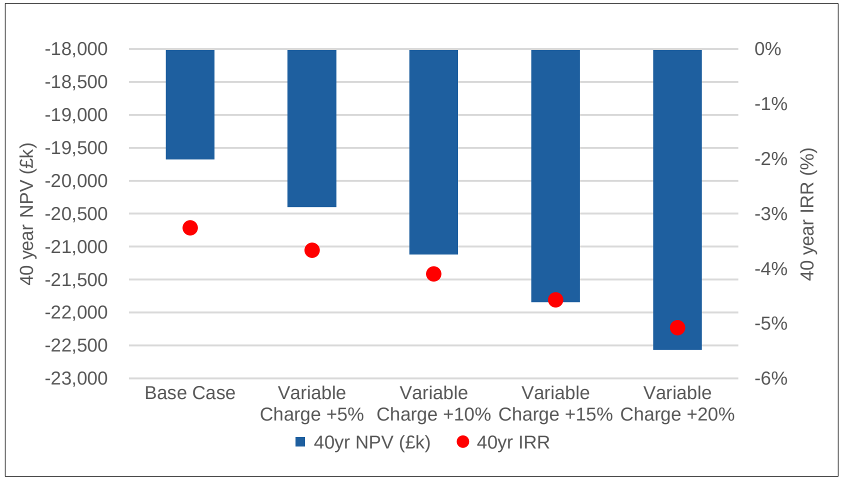
Capex Sensitivity



Commodity Costs Sensitivity

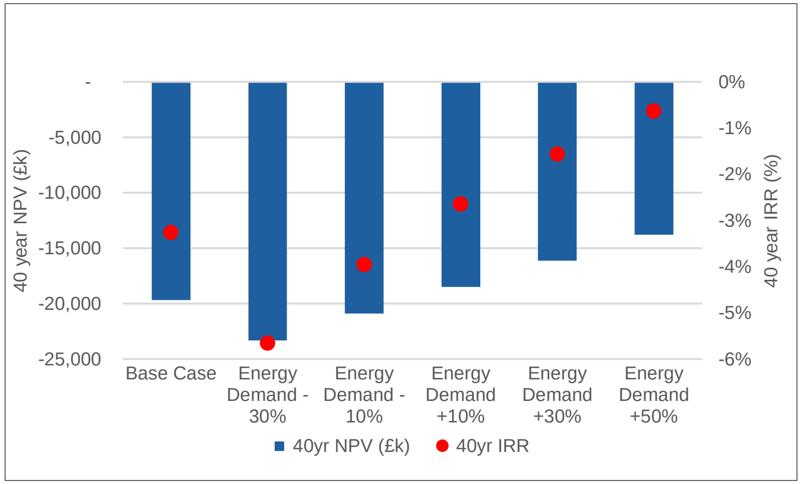


Variable Tariff Sensitivity

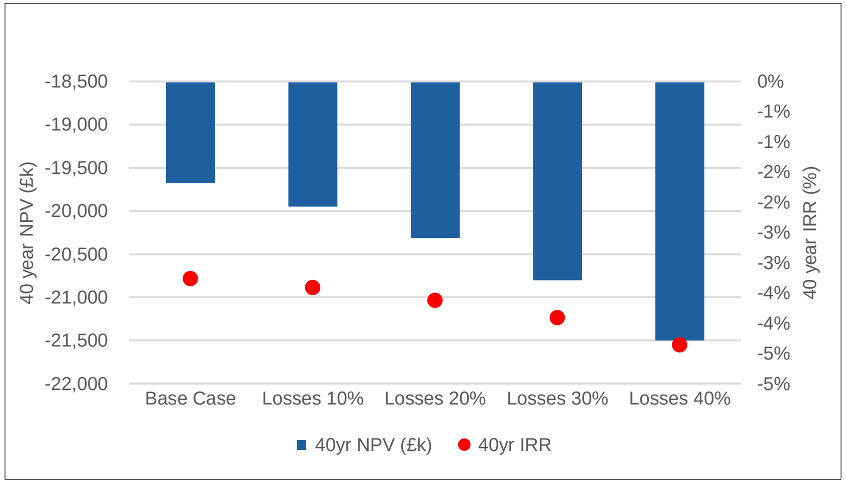


Variable Charge Sensitivity

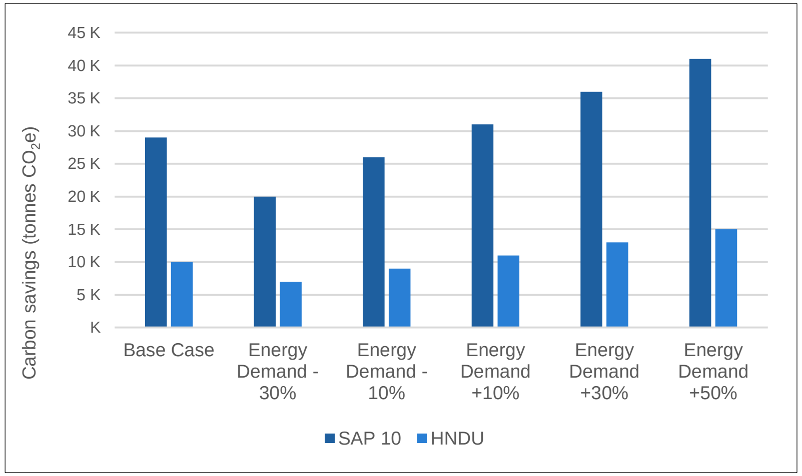
Appendix F
Sensitivities – Scenario 7



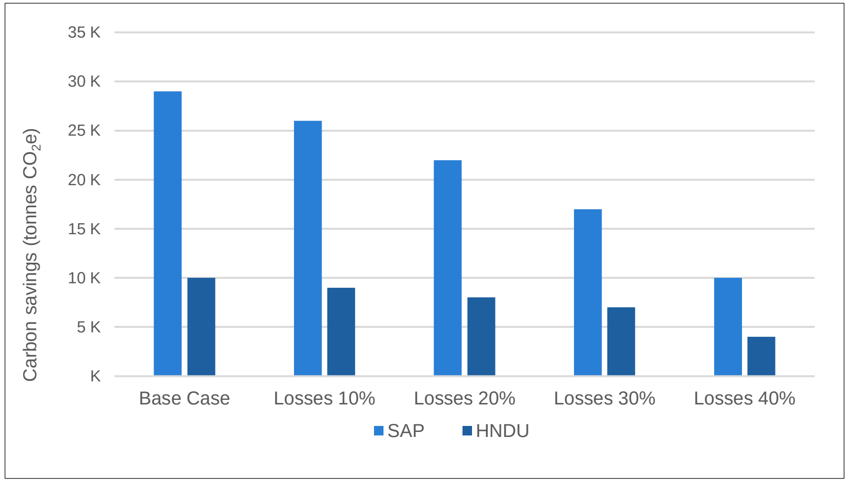
Energy Demand Sensitivity



Heat Losses Sensitivity



Energy Demand Sensitivity



Heat Losses Sensitivity

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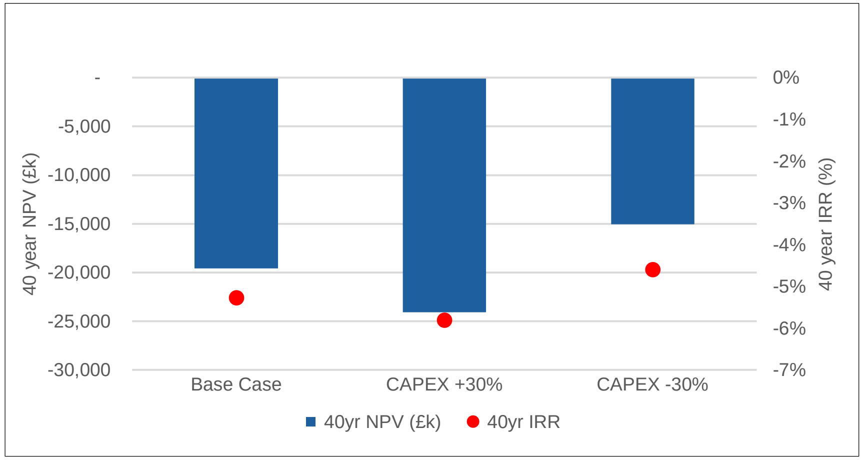
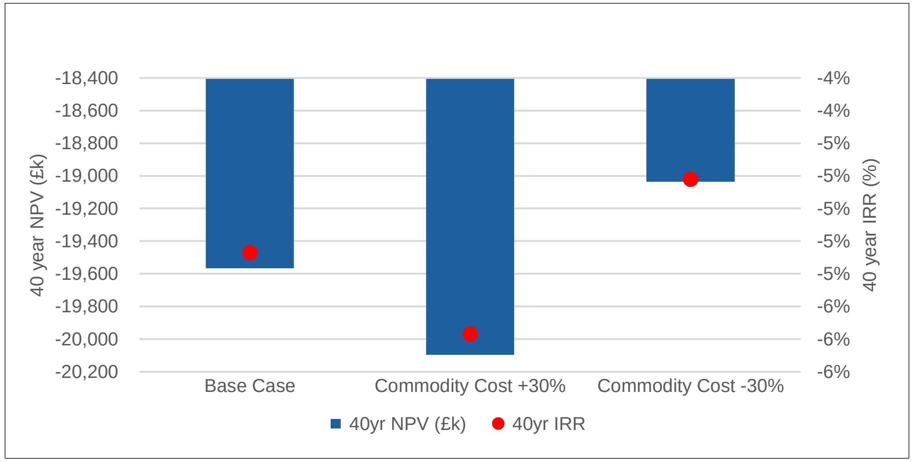
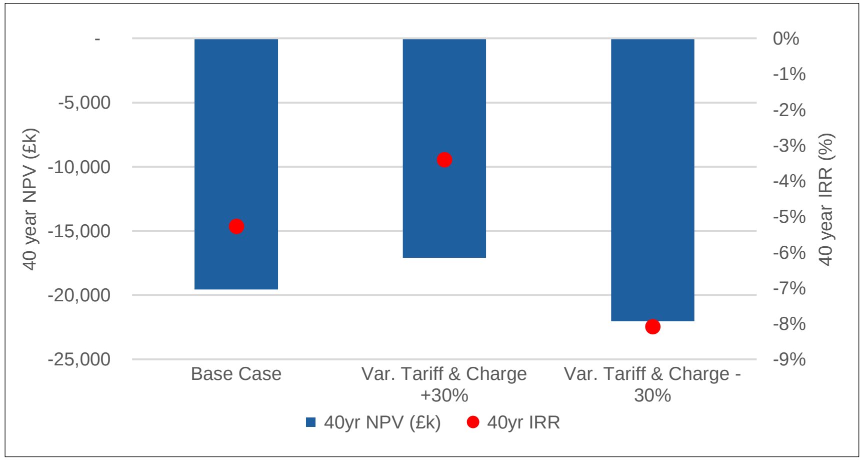
Appendix F
Sensitivities – Scenario 8



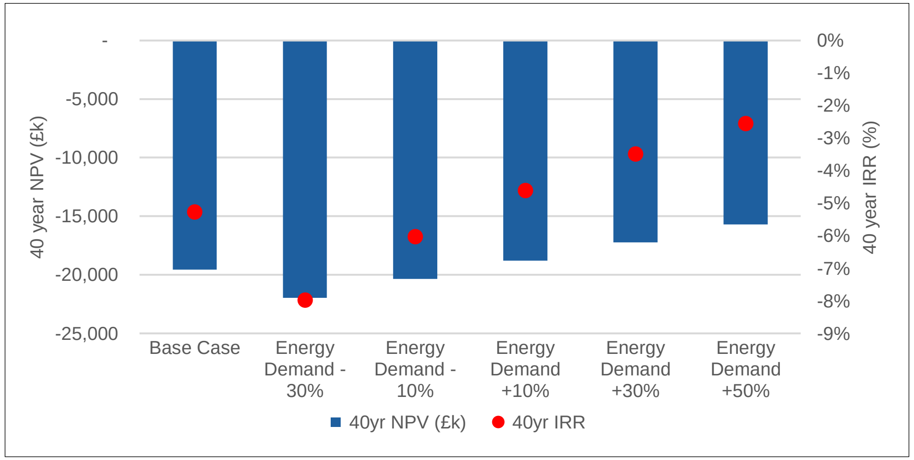
Capex Sensitivity



Commodity Costs Sensitivity



Variable Tariff Sensitivity



Variable Charge Sensitivity

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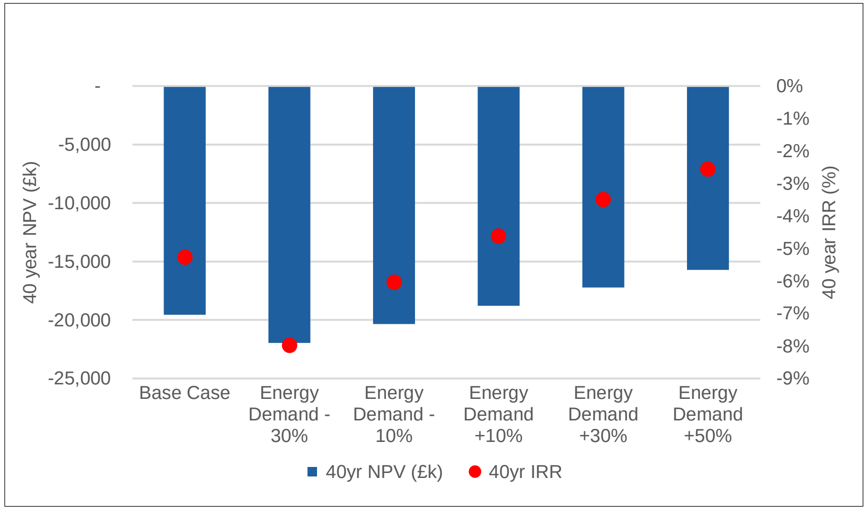
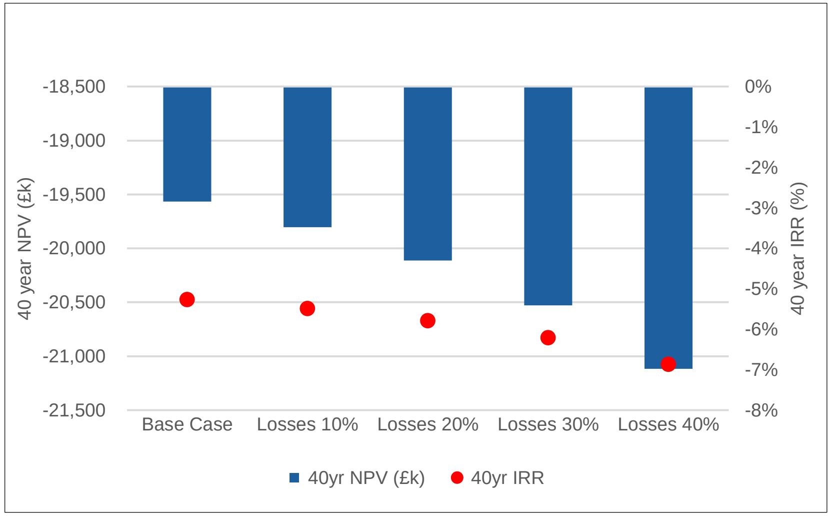
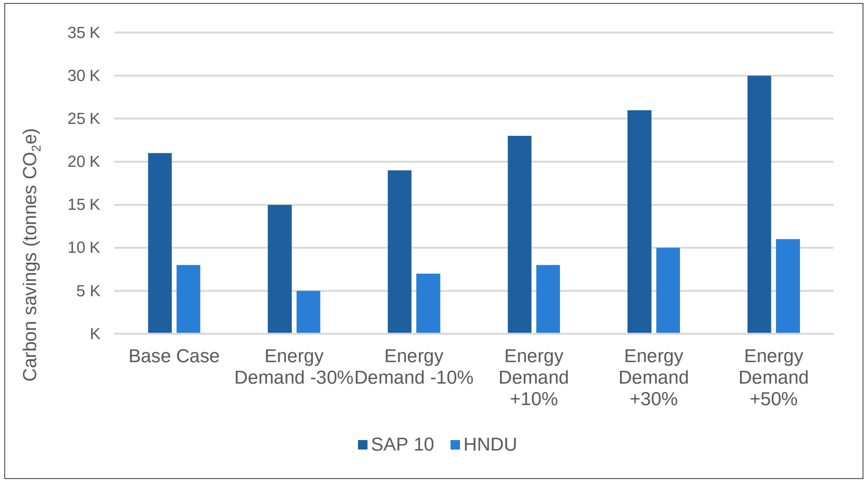
Appendix F
Sensitivities – Scenario 8



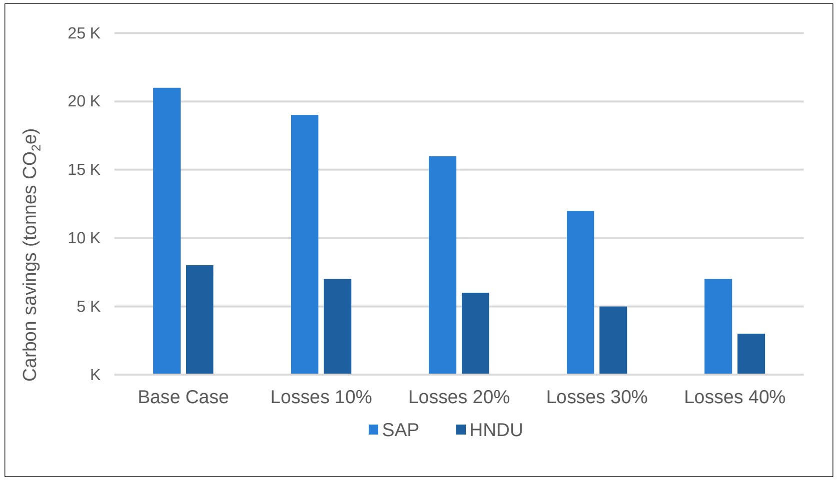
Energy Demand Sensitivity



Heat Losses Sensitivity



Energy Demand Sensitivity



Heat Losses Sensitivity

Appendix G – Fire Engineering review and recommendations

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Fire Engineering review and recommendations

The Arup fire team have carried out an overall review of this feasibility report. A number of general observations have been identified and listed below, which are to be considered from a fire safety perspective. The list may not be exhaustive as it is based on the high level proposals for feasibility. Therefore as the design progresses into a more detailed stage, fire safety aspects will need to be assessed in a greater level of detail.

- The report mentions that insulation measures will be installed as part of the refurbishments. It is understood this is within the envelope of buildings – specification of insulating material(s) would need to meet the latest regulations and guidance regarding combustibility.
- The proposed connection strategy for some of the developments considers routing new pipes in parallel with the existing ones (within basements / risers), to then remove the existing ones once the new system is running. This will need to be planned allowing for suitable fire stopping where pipes cross compartment walls/floors, and reinstating the fire resistance of the walls/floors when the old pipes are removed. Any building / refurbishment works associated with the system installation would need to taken into account any impact on fire safety of the building.
- The proposals consider the need to provide temporary electric boilers within residential units while the refurbishment works take place. The risk of these boilers on fire safety of the building will need to be assessed for this provision and mitigating measures identified, as needed.
- For some of the developments the proposals are to replace tanks, pipes and potentially radiators within the residential units, as well as the connection between the units and landlord risers – all with the buildings in occupation. There will need to be an ongoing fire risk assessment in place for these works, which shall address among other risks, the impact on the residential units' compartmentation, and identify mitigating measures.
- For some developments the proposals are to run distribution pipes over the facades or external stairs and then along the access balconies per level. The report mentions the opportunity to hide or incorporate the external pipes within the facades. The materials of the pipes and thermal lagging need to be selected with consideration of the current combustibility requirements of materials in the envelope of buildings; the pipes then enter the apartments, crossing the external walls, so the risk of ignition of any existing combustible insulation within external cavity walls also needs to be addressed. Required widths and heights of escape routes will need to be considered in the planning of these pipe routes.
- The possibility to provide PV installations over the roof of the Leisure Centre is mentioned. The fire risk of PV panels would need to be assessed for the intended use and existing roof construction, build-up and access/egress routes to determine acceptable configurations of the PV panels, fire-fighting access (e.g. how the fire brigade can isolate the PV panels in the event of a fire) and required fire safety provisions, if any.
- The potential need to provide a temporary electric boiler at the roof of the Kensington Aldridge Academy is mentioned. This temporary installation would require a fire risk assessment considering existing roof construction, build-up and access/egress routes and identifying any required mitigating measure to the risk posed by the temporary boiler.
- The proposals include a new Energy Centre to be located within the northern basemen of Brandon Walk. The design of this new Energy Centre will need to address life safety, including providing suitable means of escape provisions and fire protection measures – note this type of accommodation may need to be designed as a place of special fire risk.