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THAMESMEAD & BELVEDERE

HEAT NETWORK FEASIBILITY STUDY: WORK PACKAGE 1



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EXECUTIVE SUMMARY

This report presents the findings from the first stage ("Work Package 1") of a detailed techno-economic feasibility study for a new District Energy (DE) network linked to the Cory Energy-from-Waste plant and delivering heat to the Thamesmead & Belvedere area of Bexley.

The requirements at this stage were to undertake a review and update of previous energy mapping and masterplanning work in relation to a heat network opportunity, and to derive initial findings in relation to technical and economic feasibility for such a project.

As part of this initial feasibility work, information was gathered from the following key project stakeholders:

- London Borough of Bexley
- Cory
- Royal Borough of Greenwich
- Peabody Housing Association
- Orbit Homes

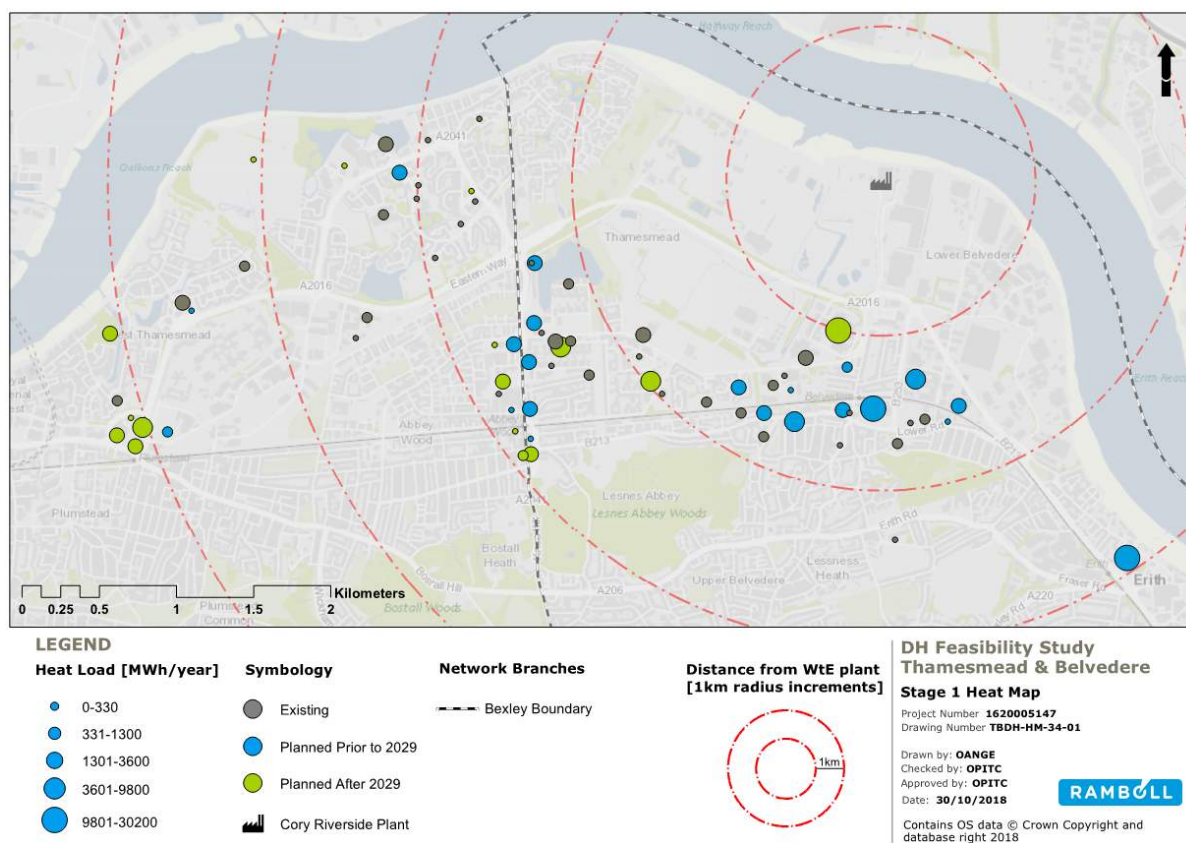


Figure 1: Results from updated heat mapping work

The key findings from Work Package 1 are as follows:

1. The total level of annual heat consumption derived for all identified loads for connection to a heat network can be met via the proposed volume of heat offtake from the Cory EfW plant.

2. Load clusters representing the greatest heat density exist within a radial band of 1 – 3 km from the Cory plant and comprise developments in the Belvedere, Thamesmead South and Abbey Wood areas, for which planned phasing/build-out also occurs earliest.
3. Planned development in the Erith area represents a further potentially significant cluster within this band, though further granularity is required to enable full analysis.
4. Initial economic assessment indicates that implementation and operation of an initial “Core scheme” heat network could achieve IRRs in the region of 4.5 – 8% and positive NPVs, whilst delivering competitively priced heat to connected customers.

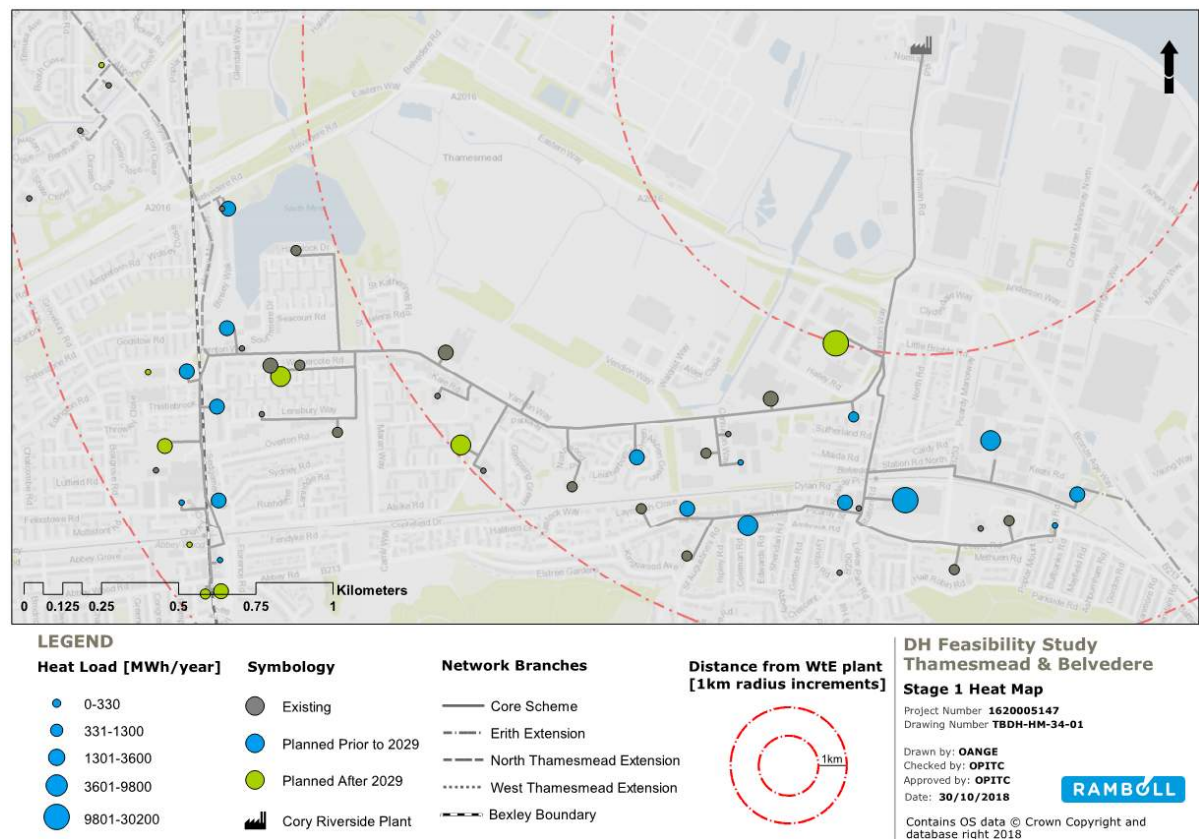


Figure 2: Core scheme heat network route

Based on the findings from Work Package 1, it is recommended that subsequent detailed feasibility work be carried out, as scoped within Work Package 2 of this this, with a focus on the identified initial “Core scheme” opportunity, whilst retaining future-proofing of pipework sizing/capacity to enable network expansion.

1. INTRODUCTION

1.1 Background

Ramboll were appointed by the London Borough of Bexley (LBB) in April 2018, under the Greater London Authority (GLA)'s Decentralised Energy Enabling Project (DEEP), to undertake a detailed techno-economic feasibility study for a new District Energy (DE) network linked to the Cory Energy-from-Waste plant and delivering heat to the Thamesmead & Belvedere area of Bexley.

This DE network was initially proposed within the previous Energy Masterplan (EMP) study, undertaken in 2015, following earlier heat mapping work carried out for LBB by Ramboll in 2011.

This study is being carried out across two discrete Work Packages as follows:

- Work Package 1 (WP1): comprising a review and update of previous energy mapping and masterplanning work.
- Work Package 2 (WP2): comprising a detailed techno-economic feasibility study.

This report summarises the works undertaken and findings of Work Package 1.

1.2 Work Package 1 Scope

The primary scope items for Work Package were defined as follows:

1. Review and update previous energy demand and supply assessment work.
2. Determine appropriate heat supply technologies, identifying:
 - a. initial and future generating options
 - b. potential for private wire
 - c. key risks and constraints.
3. Determine energy distribution options in the short and long term, identifying:
 - a. compatibility with connecting buildings
 - b. feasible routing and size of distribution
 - c. future-proofing requirements
 - d. key risks and constraints.
4. High-level economic assessment of scheme options, including determination of any gap funding requirements and testing of key sensitivities.
5. Confirmation of heating/electrical/cooling options to progress to full techno-economic feasibility and beyond.

This report has been structured in line with these scope items and also to identify the key elements under each which it is recommended be developed in further detail during the subsequent Work Package 2.

2. ENERGY DEMAND ASSESSMENT



The information gathering exercise to inform energy demand assessment work focussed on the following key stakeholders, as defined with LBB prior to project commencement:

- London Borough of Bexley
- Royal Borough of Greenwich
- Peabody Housing Association
- Orbit Homes

2.1 London Borough of Bexley Heat Demand

Early engagement and information gathering took place with representatives of LBB Planning, locating and quantifying the Borough's development sites and predicted capacities. This work identified 3 key areas where large residential developments are currently planned:

1. Belvedere – adjacent to the train station (indicated in green).
2. Thamesmead & Abbey Wood (orange).
3. Erith (blue).

The location of these clusters in the context of the Borough is shown in Figure 3.

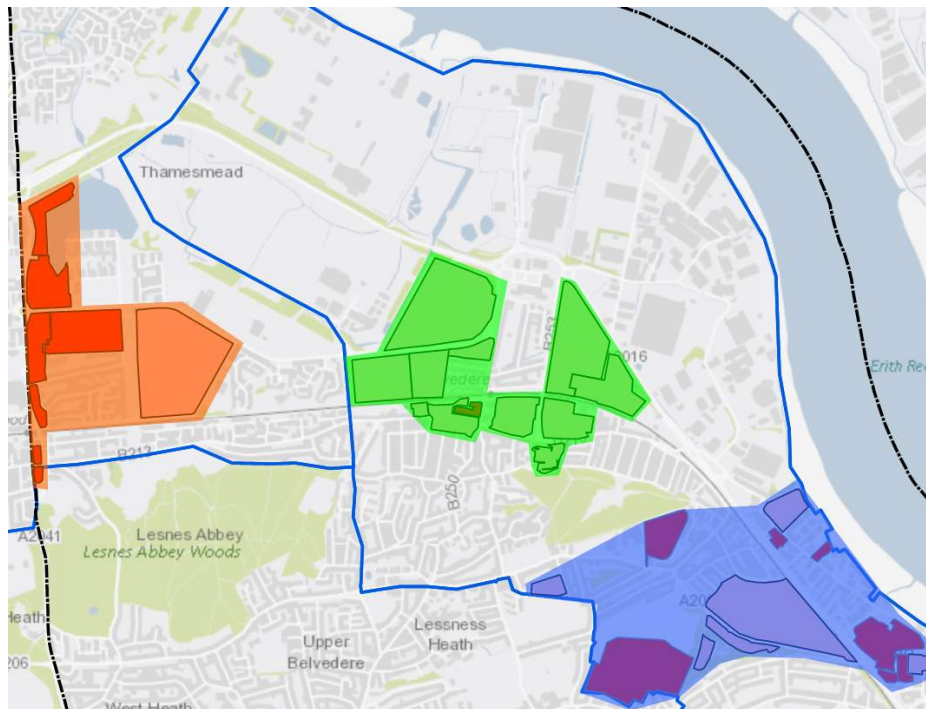


Figure 3: Bexley primary development clusters

The information and data provided by LBB related to a range of possible development capacities, varying primarily according to scale of transport & infrastructure investment.

For the purposes of this study, the “Realistic” scenario was selected for modelling which comprises the building of some 15,200 new homes within the next 20 years, across all areas.

2.1.1 BELVEDERE DEVELOPMENTS

2.1.1.1 Residential Loads

Under the “Realistic” scenario 5,025 residential units could be expected in the wider area of Belvedere, to be built out between 2021 – 2026, with a further 2,500 homes planned between 2030 - 2050.

After further engagement with LBB, the area previously detailed was split into 4 discrete clusters:

- South of the railway, comprising 3,000 new homes to be completed by 2024.
- Northeast of the railway, comprising 1,012 new homes to be completed by 2026.
- Northwest of the railway, also comprising 1,012 new homes to be completed by 2026.
- Development around Hailey Road, comprising 2,500 new homes to be completed by 2050.



Figure 4: Potential Development Sites in Opportunity Area - Belvedere

Best practice industry benchmarks were applied in order to all estimation of future heat demand for these new-build residential areas.

This entailed the application of 6.69 MWh/year per residential unit, including domestic hot water and heating. Allowance was also made for secondary heat losses within the building risers.

Table 1: Residential loads in Belvedere

Name	Reference	No. of houses	Heat Demand (MWh/year)
Asda and B and Q Belvedere	B-BEL03	1468	9,822
Gilbert Road Garage Shops and Resi	B-BEL04	197	1,318
Railway Place Shops Belvedere	B-BEL05	234	1,566
Picardy Street	B-BEL06	1101	7,367
Yarnton Way Gasholders Redundant	B-BEL09	347	2,322
Centurion Way Industrial Estate	B-BEL10	538	3,600
Waterfield Close Estate Regeneration	B-BEL11	127	850
Crabtree Manorway South part East	B-BEL12	339	2,268
Crabtree Manorway South part West	B-BEL13	652	4,363
Culling Road	B-BEL14	21	141
Hailey Road (2030-2050)	B-BELL08	2,500	16,728
Total		7,524	50,343

2.1.1.2 Commercial & Retail Loads

Whilst no detail was available at the time of this study breaking out the associated area of new commercial or retail space which will accompany the new residential units, such information was made available by LBB's development partner for the Thamesmead & Abbey Wood area of the Borough, Peabody Housing.

In order to make allowance for such spaces within the Belvedere development clusters, a similar percentage of non-residential space was applied and resulted in an increase in total heat demand of approximately 15% beyond that determined solely for the new residential units.

2.1.1.3 Industrial Loads

2.1.1.3.1 BELVEDERE

The areas to the immediate northeast and northwest of Belvedere station are primarily industrial in nature, comprising around 47 ha between Yarnton Way Employment Area, Hailey Road Business Park and Crabtree Manor Way South Employment Area.

Key industrial activities include storage and distribution, chemical processing, and food production among others. LBB have identified a number of specific sites of significant scale and related energy requirements to be considered for potential connection to a new heat network as set out in Table 2 below.

Table 2: Belvedere Industrial Sites

Heat Load	Floor Area (m ²)	Benchmark (kWh _{th} /m ²)	Heat Demand (MWh/year)
Wurth	7,500	95	713
Allied Hygiene	3,000	95	285
Ferndale Foods	15,500	95	1,473
Total			2,471

2.1.2 THAMESMEAD AND ABBEY WOOD DEVELOPMENTS

2.1.2.1 Thamesmead Peabody Development Areas

Following contact with Peabody Homes, details of intended residential development areas and related quanta was shared for use within this study.

This information set out plans for 3,018 new residential units to be built out across the Thamesmead and Abbey Wood areas of the borough as displayed within Figure 5.

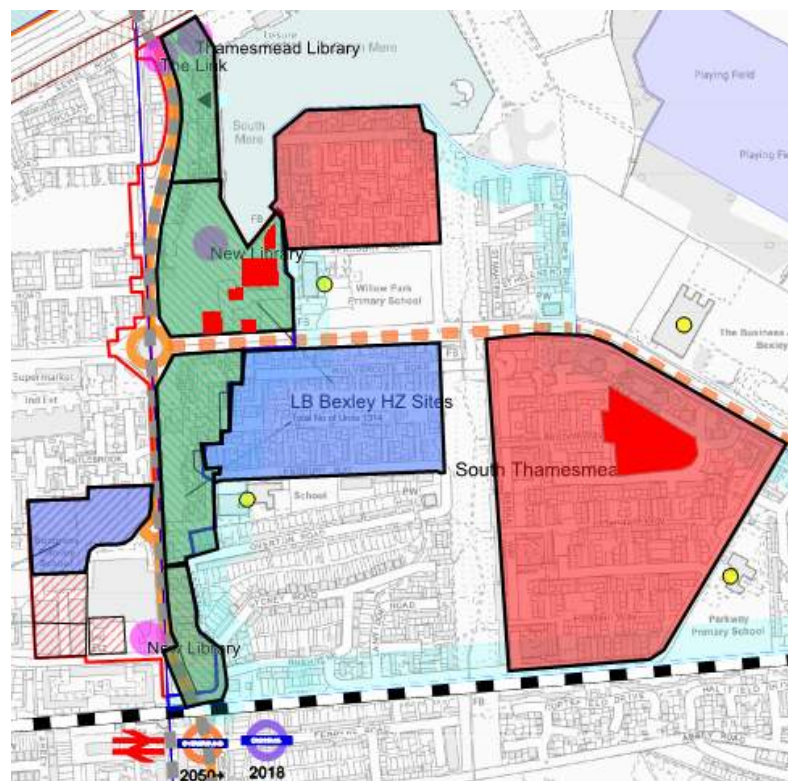


Figure 5: Exert from Peabody Housing Thamesmead & Abbey Wood Development Areas plan

The same benchmarks have been applied and divided per hectare around the development opportunity area. Table 3 summarises the heat loads present.

Table 3: Thamesmead Peabody Development Areas Heat Demand

Name	Residential Flat No.	Commercial Floor Area	Residential Heat Demand	Commercial Heat Demand	Total heat demand
		<i>m²</i>	<i>MWh/year</i>	<i>MWh/year</i>	<i>MWh/year</i>
Binsey Walk	258	1,050	1,495	91	1,587
Coraline Walk	399	3,225	2,313	281	2,593
Southmere Village	384	3,691	2,226	321	2,547
K&L	652	benchmark	3,779	584	4,363
Sedgemere Road	215	3,225	1,246	281	1,527
Abbey Way	40	benchmark	232	36	268
M,N,O,Q,S,T	437	benchmark	2,533	391	2,924
E&F	633	benchmark	3,669	567	4,235
Total	3,018				20,043

2.1.3 YARNTON WAY / ABBEY WOOD TOWER BLOCKS

There are three distinct clusters of residential tower block in the wider Yarnton Way / Abbey Wood area. These comprise 21 towers in total, each housing approximately 50 flats, and have been zoned by location for the purposes of this study.

The Southmere towers are located adjacent to Southmere lake, while Wolvercote Road Area and the Parkview towers can be found south and south east of the lake respectively, as shown in Figure 6.



Figure 6: Tower blocks at Abbey Wood Area¹

The Wolvercote Road Area towers were not included in the study since they are planned to be demolished as part of wider redevelopment works in the area.

The majority of these towers were built in the 1970s and they have currently been taken over by Peabody housing association who are planning a major refurbishment and general improvement of the area as part of the wider Thamesmead redevelopment plan².

Due to lack of existing energy consumption data. Heat loads for the existing towers were derived based on Ramboll's experience of similar building size and age, resulting in an assumption of 201 MWh_{th}/year per tower.

Feasibility of connection to the towers (individual or to a centralised substation) will ultimately be dependent on the heating systems present or planned following refurbishment. Further investigation of this will be carried out during Work Package 2 works.

Table 4: Tower Blocks' Heat Demand

Location	No. of towers	Heat Demand (MWh/year)
Southmere Towers, Southmere Lake	4	805
Parkview Towers, Yarnton Way South	9	1,811
Total	13	2,616

¹ Peabody (2016), *South Thamesmead: The next ten years*, London, pp.2-3, [On Line] Accessed 09/2018
<https://www.thamesmeadnow.org.uk/media/1618/thamesmead-brochure-final-lowres.pdf>

² <https://www.thamesmeadnow.org.uk/the-plan/>

2.1.4 ERITH HEAT DEMAND

2.1.4.1 Residential Loads

The final area considered was Erith, being the furthest south, for which potential development capacity of 4,500 homes has been indicated by LBB.

With development information only available at a high level, it was again necessary to apply best practice benchmarks in order to estimate related energy demands for the Erith area. This approach resulted in a final annual heat load of 30.1 GWh/year by 2026.

Differing from other areas of the Borough, development details for discrete sites in Erith were subject to change at the time of modelling and it was therefore decided not to reflect a breakdown of specific sites within the Erith opportunity area but treat it as a single aggregated load during this initial assessment but to revisit this during Work Package 2.

2.1.5 FURTHER BEXLEY LOADS

2.1.5.1 Existing Non-Residential

In addition to information received and derived for the three key development areas within Bexley, further details of existing loads for potential connections were sought.

Having confirmed the London Heat Map data remains the latest source of borough-wide published heat load information, this data was reviewed and referenced for further non-residential consumers.

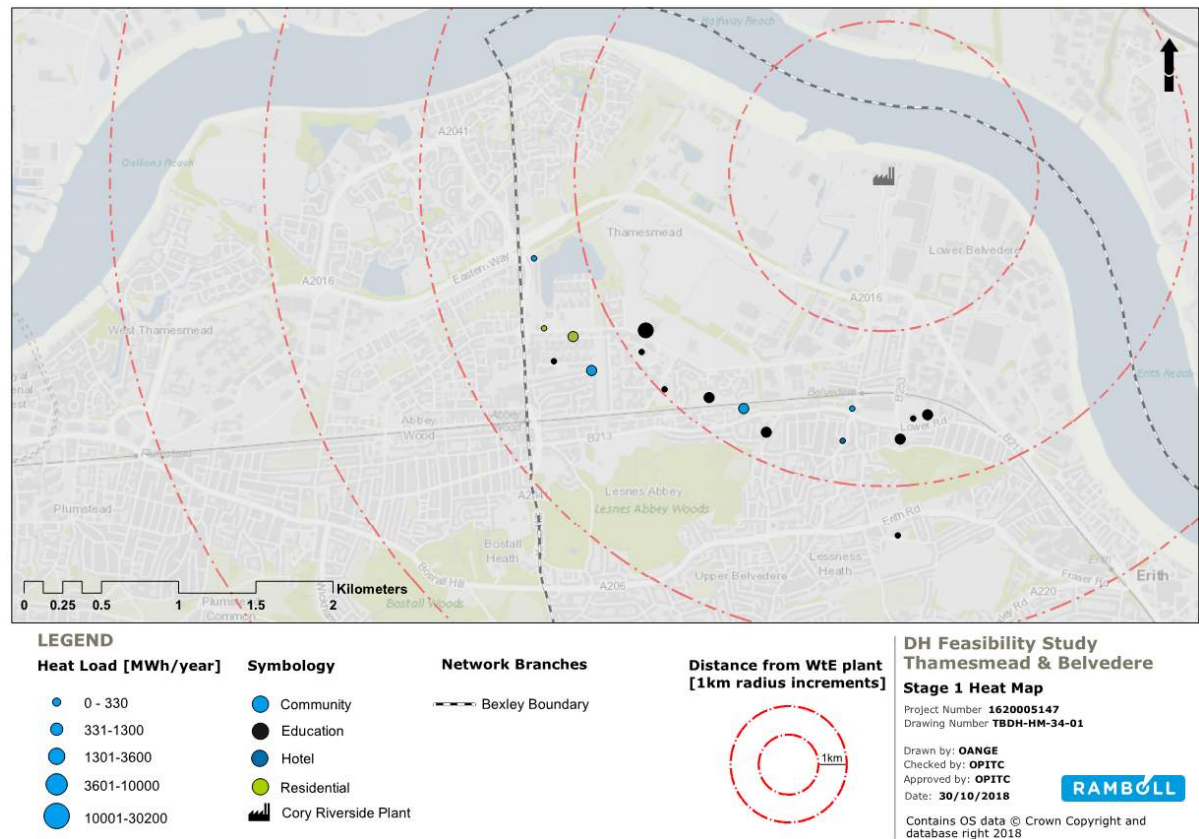


Figure 7: Other Bexley loads

These loads comprise primarily social infrastructure such as schools, community centres and libraries, with the relating heat consumption data summarised within Appendix 1. The scale and status of these loads will be reviewed and, if required, revised during Work Package 2.

2.1.5.2 Existing Industrial

The area immediately east of the Cory EfW plant, along the Thames bank, comprises a range of often large industrial sites within the Burt's Wharf area as indicated in Figure 8.



Figure 8: Burt's Wharf area

Whilst featuring a wide range of tenant types and size, the largest presence within this area comprises storage and distribution centres for foods and logistics suppliers, utilising a mix of related warehouses and open storage yards.

2.1.5.2.1 HEATING DEMANDS

Heating provision for large-volume spaces such as warehouses is most typically via means of warm air convection or radiant panels, rather than the LTHW systems more suited for supply from heat networks.

This assumption will be tested during Work Package 2, through further assessments for selected large sites and energy users.

2.1.5.2.2 COOLING DEMANDS

It is likely that more significant loads are associated with the cooling demands of the largest food storage and distribution centres, including those operated by Asda, Ocado, Tesco and Lidl.

Any alternative provision of cooling sourced from the Cory plant would need to offset the use of existing local electrical chiller plant fed from the Grid, with options including:

1. Use of new heat network link to deliver high-grade heat, for conversion to coolth via new local absorption chilling plant.
2. Direct provision of chilled water via cooling network, fed from centralised conversion of high-grade heat using absorption chilling plant.
3. Provision of Private Wire infrastructure and connection, serving retained electric chillers.

Whilst the offtake of high-grade heat suitable for raising high-temperature hot water to distribute to industrial customers is possible, this would entail separate heat exchanging equipment to that used by the main heat network where main drivers are to minimise distribution temperatures.

Combined with the requirement for local plant (and related space) provision, any use of heat to generate cooling is likely to be more feasible if carried out locally to the Cory plant, with chilled water subsequently distributed to connecting loads/buildings.

However, the lower temperature differential at which cooling networks operate would result in a need for larger diameter pipework for flow and return circuits, when compared to heat distribution.

2.1.5.2.3 PRIVATE WIRE OPTIONS

For the reasons set out, the business case for energy provision to large industrial customers is deemed to be most feasible for direct electrical connections via a "private wire" arrangement, featuring the direct sale of generated electricity to customers.

Such a supply would enable provision of energy to serve both general site/building power demands plus those specific to cooling provision.

In order to minimise both contractual complications, and to mitigate the requirement for any intermediary to be suitably licensed for electrical supply, it is recommended that opportunities for private wire provision are best investigated by Cory direct with would-be customers, independent of supply to a new heat network.

2.2 Greenwich Heat Demand

The Royal Borough of Greenwich (RBG) supplied Ramboll with details of their current masterplanning capacity information for the Thamesmead and Abbey Wood areas of the Borough, being those closest to Bexley.

This information set out capacities set against 3 distinct growth scenarios:

- a) "Baseline Growth".
- b) "Transit Scenario".
- c) "HIGH Growth Scenario".

In order to align with the assumptions made for residential capacity growth within LBB, the median growth figures detailed within the "Transit Scenario" have been applied within this study, with residential developments accordingly split between 3 opportunity areas as follows:

1. Thamesmead West.
2. Thamesmead East.
3. Thamesmead North.

When combined, the residential capacity across these 3 areas totals approximately 4,350 units. The heat demand data for these properties has been calculated based on the number of properties provided by RBG and benchmarks developed from Ramboll's engineering experience.

2.2.1 GREENWICH THAMESMEAD WEST

2.2.1.1 Residential Loads

The largest RBG cluster is Thamesmead West that has a total derived heat load of 14.5GWh/year. A breakdown of the heat loads by area is given in Table 5 and their locations indicated in Figure 9.

Table 5: Greenwich Thamesmead West heat demand characteristics

Site Name	Reference	Area (Ha)	No. of houses	Heat Demand (MWh/year)
Griffin Manor Way HZ West Thamesmead Gateway. Hunter Plastics Ltd and Pettman Crescent	87	6.2	66	442
The Reach	88	0.7	-	-
Thames Reach Local Centre	89	0.9	506	3,386
Broadwater Dock	94	5.7	408	2,730
Plumstead Bus Garage	99	1.9	208	1,392
Woolwich Trade Park	100	1.4	-	-
Pettman Crescent	101	0.6	728	4,871
McDonalds and Plumstead mail delivery office	102	0.5	245	1,639



Figure 9: Greenwich Thamesmead West Opportunity Area

2.2.2 GREENWICH THAMESMEAD EAST

2.2.2.1 Residential Loads

The Thamesmead East cluster represents the second largest derived heat load in RBG, at approximately 7.3 GWh/year, as detailed within Table 6 and Figure 10.

Table 6: Greenwich Thamesmead East heat demand characteristics

Site Name	Reference	Area (Ha)	No. of houses	Heat Demand (MWh/year)
Lidl Abbey Wood	58	6.2	-	-
Harrow Manorway and Eynsham Drive Pet hospital redevelopment	59	0.7	212	1,418
Cross Quarter and Lyndean Industrial Estate	61	0.9	272	1,820
Lyndean Industrial Estate	62	5.7	476	3,185
Abbey Wood Telephone Exchange	68	1.9	-	-
Abbey Wood Post Office and Abbey Wood Community Group	72	1.4	101	676
Abbey Place on Felixstowe Road	106	0.6	36	241



Figure 10: Greenwich Thamesmead East Opportunity Area

2.2.3 GREENWICH THAMESMEAD NORTH

2.2.3.1 Residential Loads

Table 7 presents the heat loads derived for the Thamesmead North development cluster, with their location respective locations shown in Figure 11.

Table 7: Greenwich Thamesmead North heat demand characteristics

Site Name	Reference	Area (Ha)	No. of houses	Heat Demand (MWh/year)
Thames Waterfront	9	30.0	-	-
Thamesmead Town Centre	9a	12.5	-	-
Gallions Reach Health Centre	21	1.4	224	1,499
The Moorings incl. Titmuss Ave Open Space	26	18.3	-	-
The Moorings Community Hub	26A	0.0	-	-



Figure 11: Greenwich Thamesmead North Opportunity Area

Of the clusters defined within RBG, Thamesmead North comprises the smallest combined heat load at 1.5 GWh/year.

The entire heat demand arises from Gallions Reach Health Centre since no other connections are considered when applying RBG's "Transit" scenario. The alternative "High Growth" scenario includes 9,017 additional homes to be developed across the Thames Waterfront and Thamesmead Town Centre areas.

Whilst not considered within this stage of assessment, further guidance will be sought from RBG during Work package 2 as to the likelihood for some or all of this additional capacity to come forward, given the significance of its scale and related heat load.

2.2.4 FURTHER GREENWICH AREAS

2.2.4.1 Non-Residential Loads

In addition to defined capacities for new residential development within the Borough, RBG provided a schedule of existing non-residential buildings with potential suitability to connect to a new DH network.

Accompanying heat demand data was sourced and is summarised in Table 8.

Table 8 : Other Greenwich Anchor Loads heat demand characteristics

Name	Building Type	Heat Demand (MWh/year)
Birchmere Centre	Office	654
Bishop John Robinson C.E. School	Education	138
Discovery Primary School	Education	416
Hawksmoor Primary School	Retail	317

Name	Building Type	Heat Demand (MWh/year)
Hawksmoor Youth Club	Community	57
Heronsgate Primary School	Education	442
Linton Mead Primary School	Education	318
Nathan Way Amenity Site	Waste Site	101
St Margaret Clitherow School	Education	163
Thamesmere Leisure Centre	Leisure Centre	2,015
Windrush School	Education	302
Woolwich Polytechnic School	Education	1,236

In total, the identified existing non-residential heat loads considered for connection to the DH network within RBG totals 6 GWh/year.

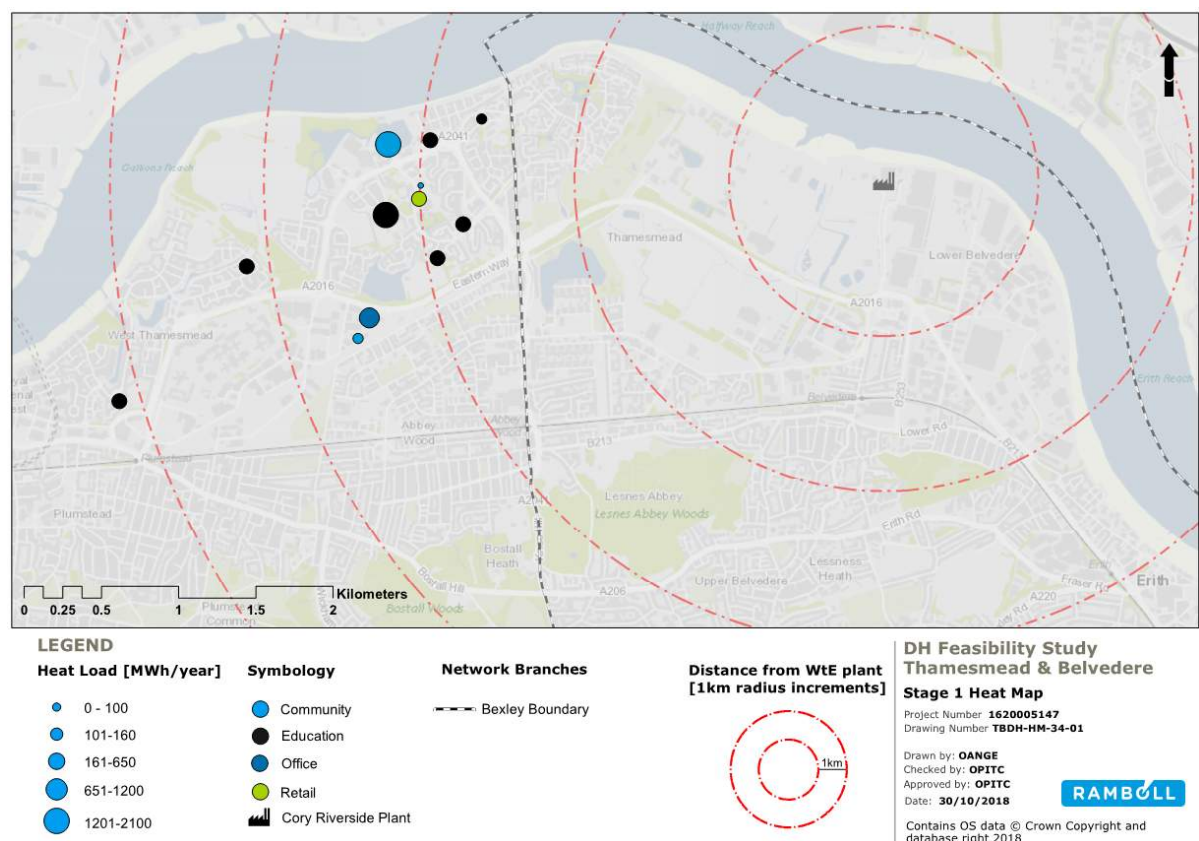


Figure 12: Other Greenwich Loads

Data was gathered for further non-residential loads, however these were ultimately not considered within the heat demand analysis due to the magnitude of the loads involved and their distance from derived primary network routes.

For completeness, the data relating to these loads plus an indication of their approximate distance from proposed network routing (presented in detail within section 4 of this report) is presented in Table 9, totalling 4.7GWh/year.

Table 9: Additional non-residential Greenwich loads (not included in analysis)

	Heat Load (MWh)	Distance from provisional network route (m)	Heat Density (MWh/m)
Birchmere Centre	654	390	1.7
Heronsgate Primary School	443	250	1.8
Nathan Way Amenity Site	101	155	0.7
St Margaret Clitherow School	163	320	0.5
Bishop John Robinson C.E. School	138	4700	0.0

2.3 Heat Demand Summary

The combined heat load identified and derived for all planned developments and selected existing buildings within the study area totals 139 GWh/year, at the time of full build-out.

The phased increase of heat load over time is illustrated in Figure 13, with splits between development areas provided for clarity.

HEAT DEMAND DEVELOPMENT

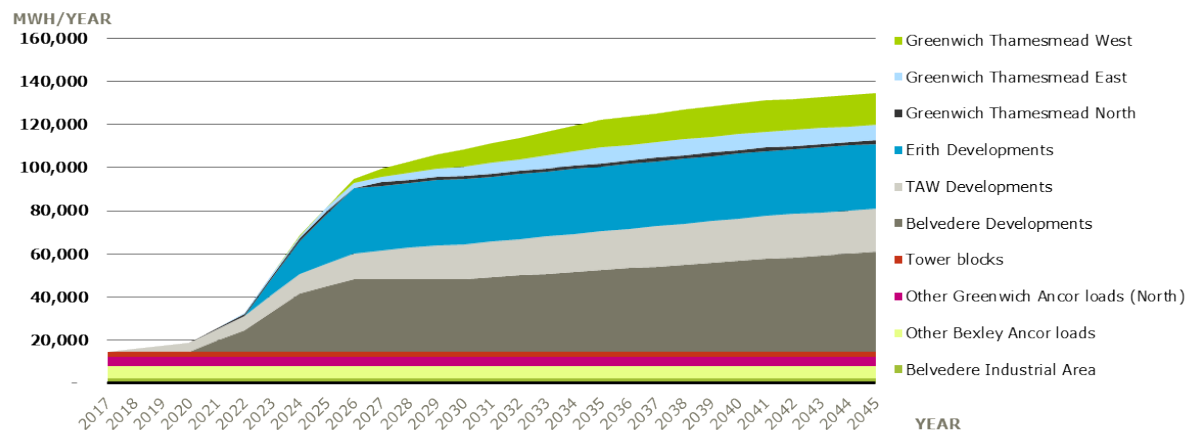


Figure 13: Overall Heat Demand Development

As can be seen, redevelopment within the Belvedere area comprises the largest single heat load cluster, with build-out commencing in 2020 and continuing for some 35 years.

Alongside Belvedere, the other earliest clusters to be developed are those in the Thamesmead/Abbey Wood area of LBB.

The location, scale and timing of all assessed loads is displayed in Figure 14. Also shown in this graphic, for reference, are indications of the radial distance of all identified loads from the Cory EfW plant.

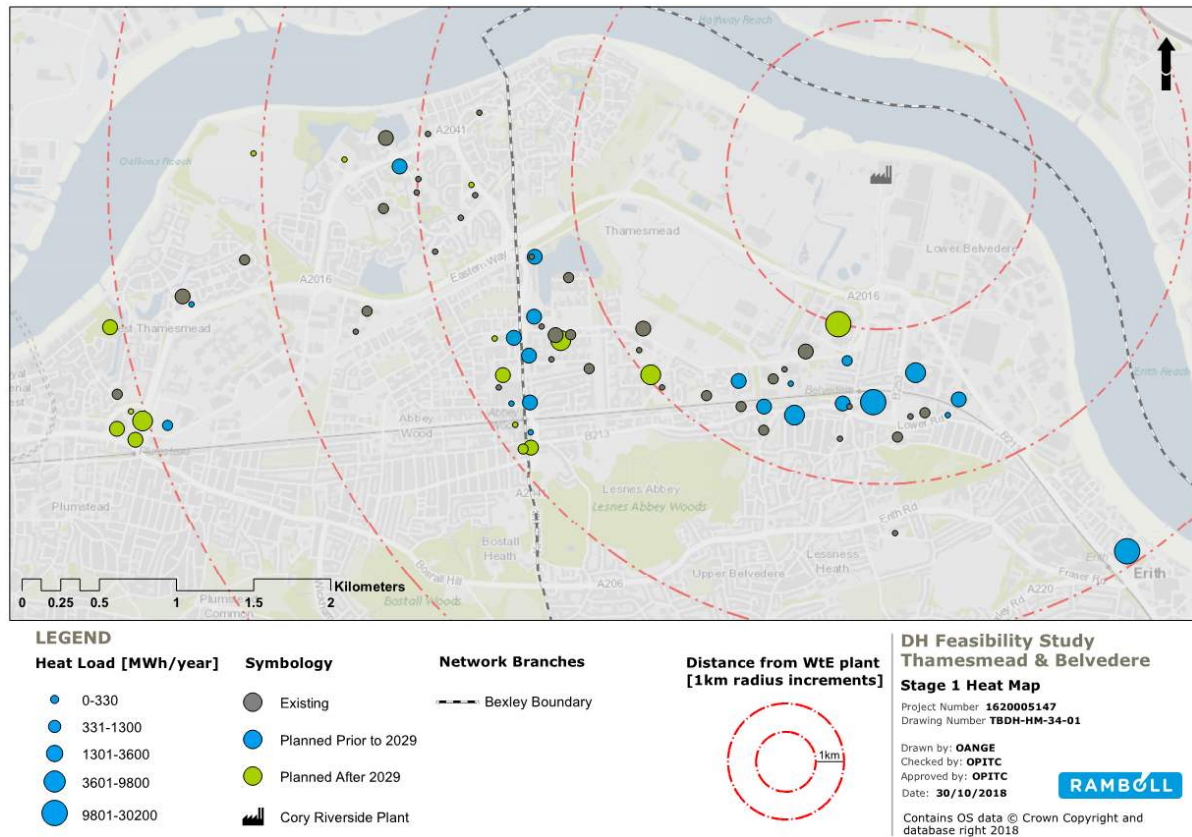


Figure 14: Full assessment area heat map

Table 10 summarizes the heat demand available for connection in each building cluster along with the type of consumer. A full breakdown of all the loads along with the respective heat load cluster, consumer type, heat demand, year of completion and council can be found in Appendix 1.

Table 10: Heat Demand per consumer type in each development cluster.

	Care Home	Education	Industrial	Leisure	Residential	Retail	Total
	MWh	MWh	MWh	MWh	MWh	MWh	MWh
Belvedere Developments					50,343		50,343
Belvedere Industrial Area			2,470				2,470
Erith Developments					30,110		30,110
Greenwich Thamesmead East					7,340		7,340
Greenwich Thamesmead North					1,499		1,499
Greenwich Thamesmead West					14,459		14,459
Other Bexley anchor loads	700	3,675		471	562		5,408
Other Greenwich anchor loads (North)	57	2,272		2,015		317	4,661
TAW Developments					20,043		20,043
Tower blocks					2,616		2,616
Total	757	5,947	2,470	2,486	126,972	317	138,948

2.4 Next Steps for Work Package 2

As part of the detailed techno-economic feasibility work to be carried out during WP2, the following steps will be taken to refine and confirm details of energy demand modelled to date:

- i. Further granularity of new residential development quanta to be sought and applied in relation to the Erith area.
- ii. Any energy consumption data available for the retained/refurbished Southmere and Parkview residential towers to be sought and applied.
- iii. The status and load information for existing non-residential loads considered for connection to be confirmed and updated as required.
- iv. Any information on existing infrastructure and data available for energy consumption of largest industrial sites within Burt's Wharf to be sought and applied.

3. ENERGY SUPPLY ASSESSMENT



The Cory Riverside Waste-to-Energy plant was previously identified as the key heat supply opportunity for the area under Bexley's Energy Master Plan³ produced by Ramboll in 2015.

Engagement with Cory has continued since this time and they have been included as a key stakeholder within the undertaking of this detailed feasibility study.

3.1 Cory Riverside Waste to Energy Plant

Cory Riverside Energy is the largest Waste to Energy facility in the UK, located at Thames bankside north of Belvedere. The facility processes circa 750,000 tonnes of waste annually producing 525,000 MWh of electricity, enough to power 160,000 households⁴.



Figure 15: Cory Riverside Plant

The gross power output of the plant is 60 MW_e, all of which is currently exported direct to the Grid. The EfW facility was designed to be future-proofed for accompanying heat offtake, either as steam or hot water.

3.2 Heat Offtake Arrangement

Whilst the Cory plant currently operates in a power-only mode, the plant's steam turbine is designed to be "CHP ready". The proposed heat offtake approach would feature a 2-stage heating

³ London Borough of Bexley Energy Masterplan, Ramboll, October 2015

⁴ <https://www.coryenergy.com/about-us/our-history/>

concept, whereby low-pressure steam is used to pre-heat the DH water return while a second stage sees the water further heated to meet the required network supply temperature.

This approach is common practice and the most energy efficient way to produce heat via steam extraction from a turbine when the DH network temperature rise is in the order of 50 °C. This is the likely maximum network temperature difference, if operating with flow-return of 90°C-40°C, with the ability for temperatures to be mixed down within the pumping station as required.

It was also confirmed with Cory that an existing space adjacent to the EfW facility has been earmarked as a location to house new plant associated with heat offtake and also pumping for new low-temperature hot water (LTHW) circuits.

3.3 Heat Supply Capacity

It has been indicated that a total of 28.6 MW of heat could be made available for offtake, in the form of LTHW exported to serve a new DH network. Assuming 90% availability and 90% utilization of the 28.6 MW capacity, the EfW plant could therefore supply up to 200,000 MWh/year.

This level of annual generation/supply is displayed in Figure 16, set against both the total identified heat demand and also the distance of the cumulative load from the EfW plant.

HEAT DEMAND VS LINEAR DISTANCE FROM EFW PLANT

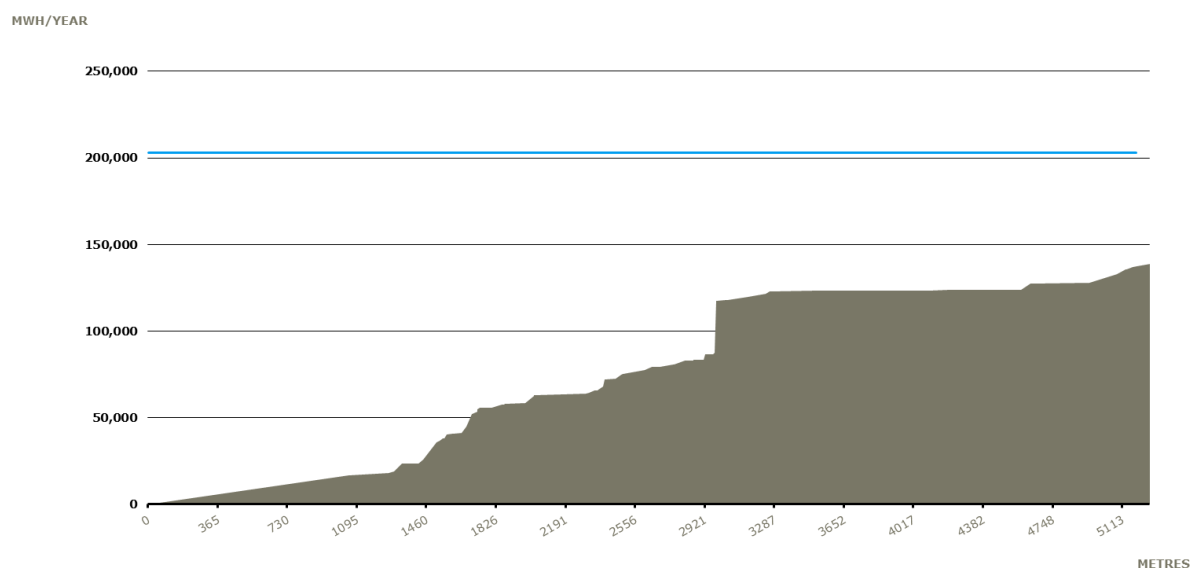


Figure 16: Heat Demand density development

3.4 Cory Engagement

To inform the high-level assessment of heat supply options required during Work Package 1, early information was sought from Cory in terms of key technical and commercial parameters associated with a new heat offtake connection from the existing plant.

The initially requested and provided data in this regard are summarised in Table 11.

Table 11: Initial data from Cory

<i>Data Requested of Cory</i>	<i>Data Provided</i>
Current Z-Factor	4.3
Current Electrical Export Prices (£/MWh)	61 in summer 65 in winter

There is a commercial requirement from Cory and LBB in order to form a sustainable business case that revenue derived from bulk heat purchase will offset all costs incurred in facilitating, operating and maintaining its offtake. For this reason, along with parameters in Table 11, the costs involved with the heat offtake need to be determined.

During the initial high-level WP1 assessment, Ramboll have applied a number of assumptions in order to derive an indicative bulk heat purchase price, against which a range of sensitivity has then been used within subsequent economic modelling.

Full details of the initial heat purchase price calculation undertaken is included within section 5.2. All assumptions made at this stage will be further tested and validated with Cory during the more detailed WP2 work.

3.5 Planned Future Site Expansion

Whilst the scope of this study has been limited to considering the heat offtake availability from the existing EfW plant, engagement with Cory has included details on their plans to expand the current site and introduce a new low carbon energy park, including a range of generation technologies including energy from waste and anaerobic digestion.

A detailed Planning submission for the Park is to be made soon, with intentions for all new plant to be fully operational by 2024. The additional electrical generation capacity of the expanded site could comprise 96MW.

In addition, 30 MW of further heat capacity could be available for offtake and distribution via any heat network in place at that time.

3.6 Next Steps for Work Package 2

As part of the detailed techno-economic feasibility work to be carried out during WP2, the following steps will be taken to refine and confirm details applied within the study in relation to heat offtake arrangements from the Cory plant of energy demand modelled to date:

- i. Liaising with Cory and their technical advisors on requirements and costs involved with achieving required heat offtake from plant.
- ii. Liaising with Cory and their commercial advisors on methodology and metrics to be applied in derivation of assumed bulk heat purchase pricing.

4. ENERGY DISTRIBUTION SYSTEMS



This section presents the development of early technical detail in relation to distribution of heat taken from the Cory EfW plant, with focus on the pumping station required to serve a new heat network and the routing of related pipework to connect to the identified loads.

Figure 17 displays the sequence of plant and infrastructure envisaged to form the entirety of the heat network arrangement, from initial heat offtake within the Cory plant through to individual dwelling/building systems.

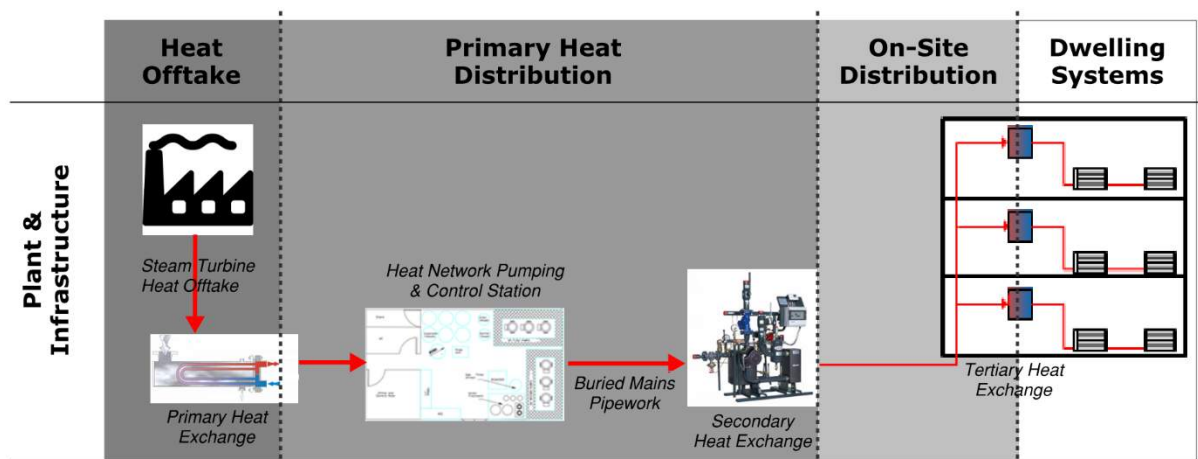


Figure 17: Plant & infrastructure elements comprising heat network

As indicated, heat offtake within the Cory plant connects to the heat network via primary heat exchanging arrangement, providing hydraulic separation between the steam turbine offtake and network LTHW circuits.

From this point, a heat network pumping station controls the distribution of heat throughout the mains distribution pipework. This main network terminates at the boundary of connecting sites or buildings, where hydraulic separation is provided via bulk heat substations.

Subsequent distribution pipework connects to individual buildings or customers, with final heat exchange assumed to occur at heat-interface units (HIUs), though it is acknowledged that an option exists for the use of direct connection beyond the bulk heat substations given suitable buy-in from the designers and operators of the final dwelling/building systems.

4.1 Heat Network Pumping & Control Station

With heat offtake taking place inside the existing plant (and/or within a purpose-built extension), the subsequent heat distribution network will be operated through a primary pumping station located in close proximity to the existing EfW facility.

4.1.1 PLANT REQUIREMENTS

This pumping station will act as the operational and control centre for the network and incorporate all tasks related to heat distribution, including water treatment, pressure holding, pumping, monitoring and control through a SCADA system. As such, it is recommended that a personnel room and storage space be allowed for.

Flexibility in heat offtake will be required in order to meet fluctuating demand profiles without compromising the integration with Cory's optimisation of power production. A key part to supporting this will be adequate space provision for thermal stores, likely located outside the pumping station itself due to large volume requirements.

Further work will be undertaken as part of Work Package 2 to assess suitable capacities for centralised thermal storage.

Early discussions with Cory have indicated that planned periods of plant downtime are limited to 3 days of pressure system testing, conducted every 2 years, and that even at these times heat can still be generated for export.

For this reason, it is not proposed that centralised back-up boilers form part of the heat offtake and pumping arrangements located on the Cory site.

4.1.2 INDICATIVE LAYOUT

In order to help inform further discussions and development of space requirements for the network pumping station, an indicative layout has been derived as shown in Figure 18.

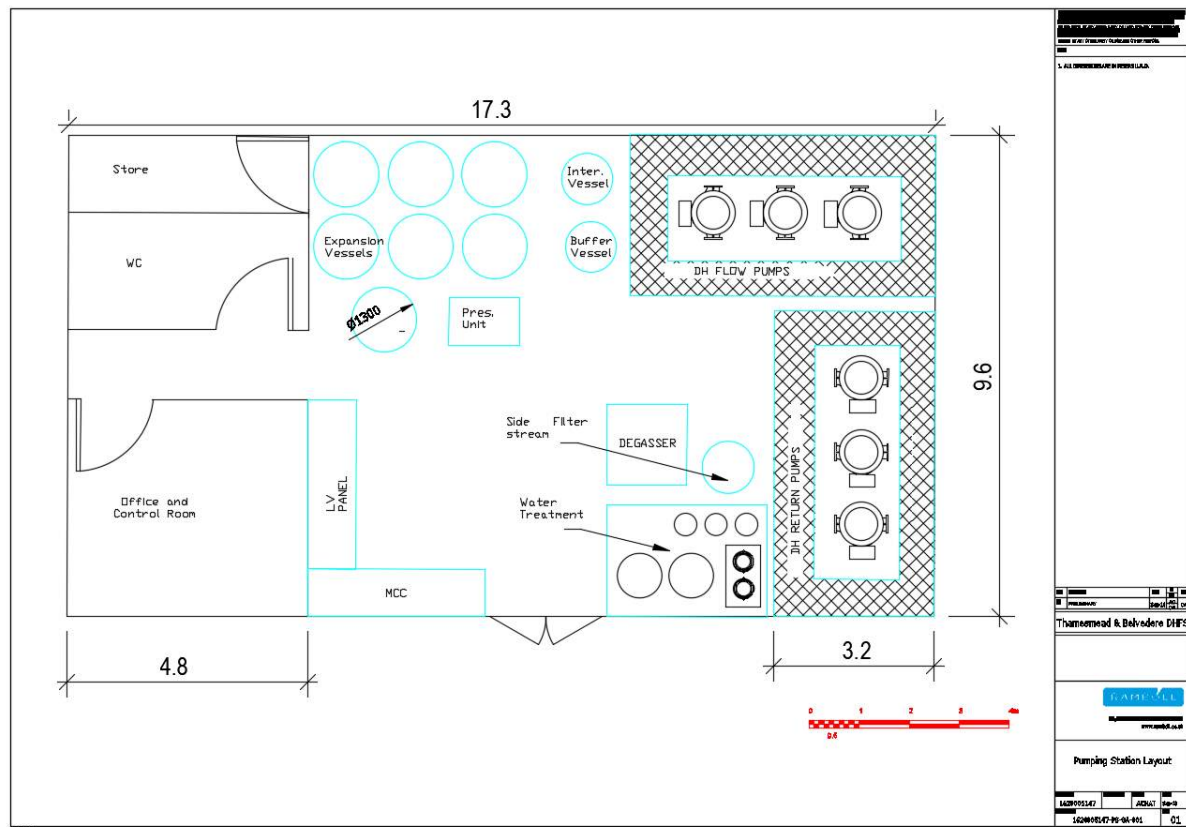


Figure 18: DH pumping station General Arrangement (excluding thermal stores)

As noted, this layout and footprint does not include for provision of thermal storage, on the basis this would likely sit external to any new building.

4.2 Heat Network

4.2.1 NETWORK DESIGN CRITERIA

It has been established that a heat offtake arrangement could supply a peak load of 28.6 MW, equating to approx. 200,000 MWh/year.

4.2.1.1 Operating Temperatures

The optimal operating network temperatures will depend upon a combination of heat offtake arrangement efficiency, final network length and (most critically) the return temperatures achievable by/from the connecting loads' heating systems.

Best practice for heat network design is the reduction of operating temperatures as far as possible to restrict heat losses, usually done by defining a maximum allowable return temperature and a delta T of 30 or 40 °C.

In larger heat distribution schemes, however, the flow temperature will often be increased in order to facilitate a larger delta T, leading to an ability to reduce distribution pipework sizes and associated costs, both for initial system CAPEX and also ongoing pumps costs.

The assessment undertaken into the type, location and timing of potential heat loads for connection to a network in Bexley indicates that the combined total load being served from the plant and infrastructure initially installed will comprise a mix of existing and new buildings and also grow steadily over a period of time.

For this reason, it is important that this plant and infrastructure be selected and sized such that both initial and future operating scenarios are considered and facilitated. This could include a designing of the network to operate at a higher delta T, in the order of 90°C/40°C, in order to reduce infrastructure costs.

Such a network would have the flexibility to initially operate at a lower temperature difference, as required by mix of existing and new-build loads, until full build-out occurs whilst still providing adequate capacity to meet future peak load conditions.

In order to inform early sizing of distribution pipework, provision of the maximum indicated 28.6 MW heat load has been assumed with a network delta T of 35°C. This results in a primary distribution main size of DN300.

4.2.1.2 Additional Heat Sources

The scale at which a final network may develop could see future opportunities to incorporate the use of additional heat sources, increasing further the network capacity and options for further geographical expansion.

Whilst further consideration would be required during technical design of the network in order to develop such an arrangement, the flexibility provided by the approach to operating temperatures and related main pipe sizing at this stage will facilitate this.

4.2.1.3 Distribution Heat Losses

Use of pipework manufacturer's design tools was made to determine annual heat losses, resulting at 1.7% of peak supply, however a larger factor of 10% was allowed for within the modelling work undertaken in order to account for additional connection and storage losses. Secondary losses within residential developments were not accounted for at this stage.

4.2.2 HEAT NETWORK ROUTING

In the first instance, a preliminary heat network route was derived on the basis of supplying all heat loads identified within this study. From this, further iterations of smaller-scale networks were tested via the removal of outlying loads, by geography and timing of build-out, in order to test their relative techno-economic feasibility.

4.2.2.1 Full Network

Figure 19 displays the preliminary routing derived for a network connecting to all assessed heat loads within the study area, with the exception of only those deemed to too small or far away from distribution mains (as previously noted within section 2), with loads categorised by their construction date and calculated annual heat demands.

Also reflected in this layout is the lack of heat load resolution available and associated with the residential development quanta for Erith, resulting in a single main being shown to a notional central point.

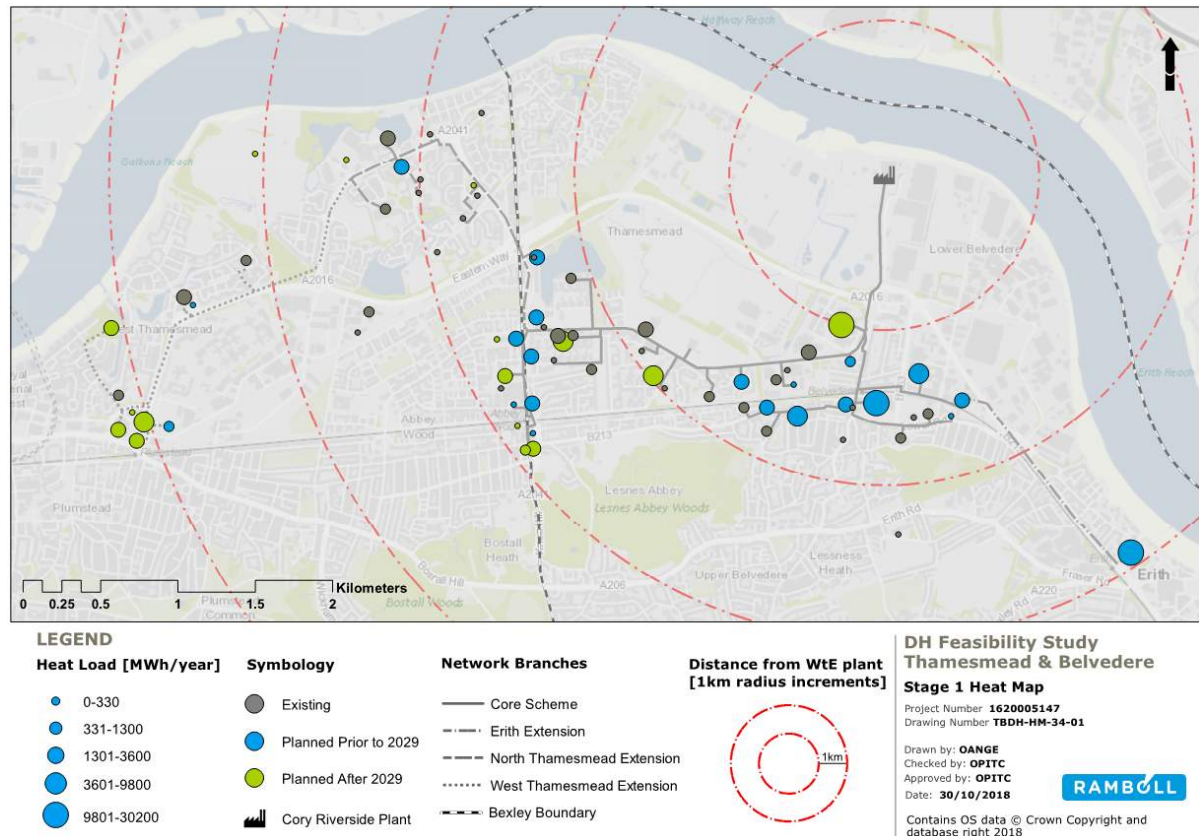


Figure 19 : Full heat network route

The network routing was selected on the basis of the following priorities:

1. Minimising distance between primary mains and largest load centres.
2. Maximising pipe routing within public domain.
3. Minimising of routing within major roadways, to mitigate cost and disruption associated with trenching and installation.
4. Avoidance of railway crossings due to increased costs and logistical challenges involved.
5. Circumnavigating of water courses where present.
6. Prioritising of soft ground routes where available, to reduce associated trenching costs.

Despite applying these priorities, the proposed network route includes the need for one railway crossing in the vicinity of Belvedere station. This is required in order to reach the majority of loads involved with the redevelopment of the area adjacent to the station.

Whilst not part of the current layout, a further network routing option was identified and discussed during the network assessment. This option would see pipework following the route of an existing easement granted by Thames Water (as the land owner) in relation to installation of HV electrical cabling.

The extent of this easement corridor is shown within Figure 20 and would represent an opportunity to replace the trenching required to install pipework in or adjacent to Norman Road, leading to the Cory plant, with a section of soft-dig to the immediate west of the Crossness Nature Reserve.

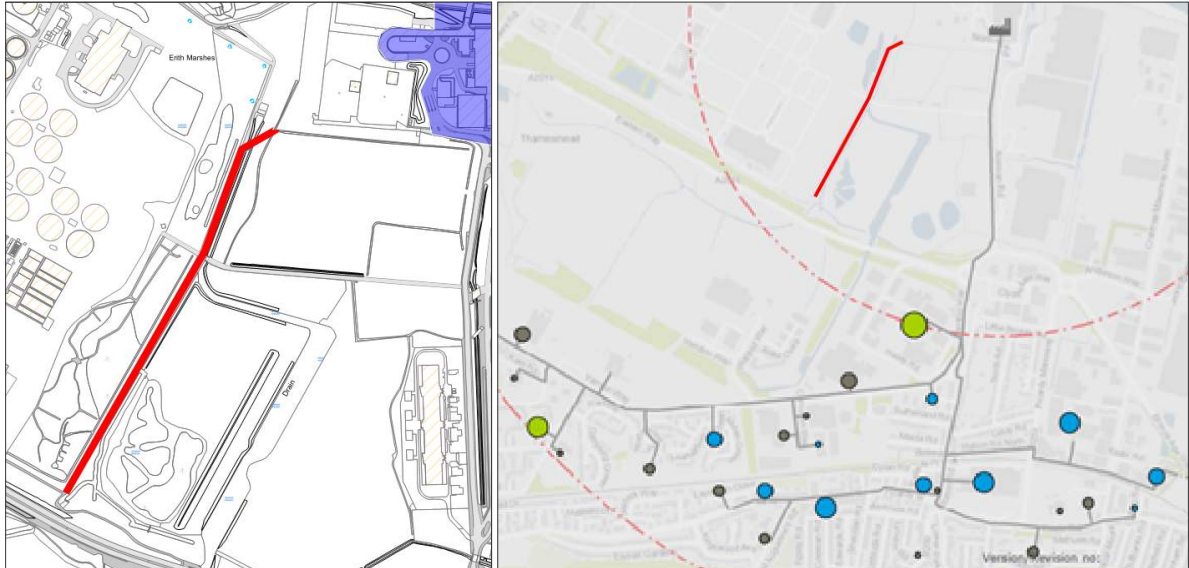


Figure 20: Extent of existing Thames Water Easement corridor

From this point, the potential exists to route further within soft ground all the way to Thamesmead South, however would require the crossing of Eastern Way. Routing in this way would also require a separate circuit to head east in order to reach the Belvedere redevelopment area.

Whilst this option will be assessed in more detail during Work Package 2, the current proposed routing was selected to form the basis of initial analysis, on the basis of maximising the number of identified heat loads which could be connected to a network routing along Yarnton Way.

4.2.2.2 “Core Scheme” Network

In recognition of the improved heat density offered by an initial focus on connected loads closest to the Cory plant, an alternative reduced network arrangement was derived and termed the “Core scheme”, featuring the connection of loads located within a 2.5 km radius of the Cory plant.

This network arrangement comprises all pipework required to connect to loads within the Belvedere, Thamesmead South and Abbey Wood areas whilst removing the subsequent extensions to serve loads in Erith and further Thamesmead sites within RBG, as shown in Figure 21, whilst retaining the pipe diameters and capacities to allow their future connection.

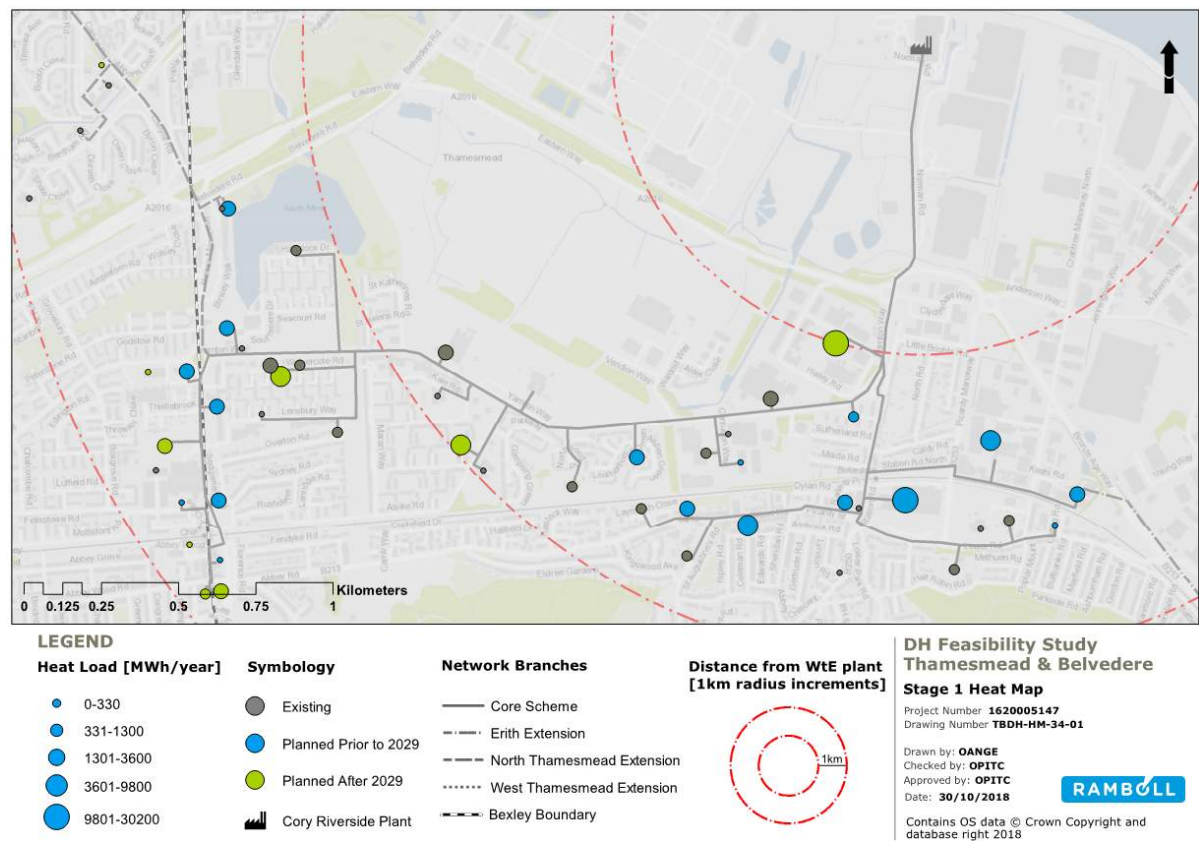


Figure 21: Core scheme heat network route

Table 12 provides a breakdown of the total pipework length associated with the derived Core scheme, plus the additional pipe lengths comprising the additional extensions required to connect loads further afield.

In the absence of information detailing the split of total heat load associated with the residential development quanta in Erith, early estimates for additional branch pipework were based upon the ratio of branches-to-main pipework derived for other network extensions.

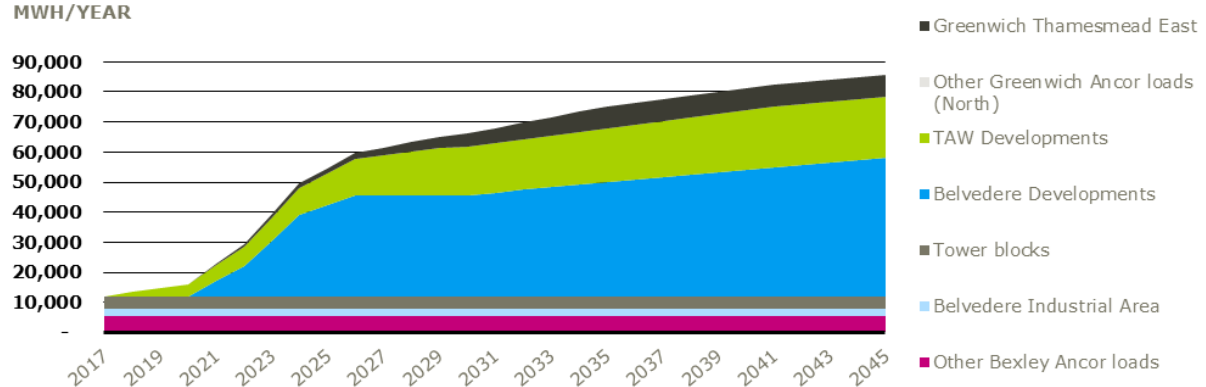
Table 12: Breakdown of heat network pipe lengths

	Main Spine (m)	Branches (m)	Total length (m)
Core Scheme	3,960	7,112	11,072
Erith extension	1,617	1,169	2,786
North Thamesmead extension	2,052	1,484	3,536
West Thamesmead extension	2,143	2,140	4,066

Figure 22 displays the heat load build-up over time associated with the Core scheme, with around 75% of the total load in place by 2026 and primarily associated with new and refurbished residential developments.

CORE SCHEME HEAT DEMAND

MWH/YEAR

**Figure 22: Core Scheme Heat Demand Development**

Within section 5, the relative cost and outline economic performance of the Core scheme and the subsequent extensions have been assessed and compared.

4.2.2.3 Further Network Extensions

The current assessment of identified potential loads within the Boroughs of Bexley and Greenwich indicates that the available volume of heat from the Cory plant may exceed the viable heat demand for connection under an initial network.

Once further assessed during Work Package 2, the scale of remaining heat available will be summarised and considered in the context of potential for a new dedicated network link to the Borough of Barking, via a river crossing.

4.3 Next Steps for Work Package 2

As part of the detailed techno-economic feasibility work to be carried out during WP2, the following steps will be taken to refine and develop further detail in relation to heat distribution infrastructure:

- i. Information to be gathered on existing major buried infrastructure present within roads and areas proposed for heat network routing.
- ii. Assessment of alternative primary heat network main routing, adjacent to Crossness Nature Reserve.
- iii. Completion of detailed hydraulic and heat loss assessment of proposed heat network routing.
- iv. Assessment to be undertaken to determine thermal store sizing options.
- v. Options for network pumping station and thermal store locations to be assessed with Cory.
- vi. Details of existing heating systems (or though planned following refurbishment) to be sought for major retained buildings considered for heat network connection.
- vii. Acceptability of direct dwelling/building connections from bulk heat substations to be tested with site developer stakeholders.

5. ECONOMIC ASSESSMENT



This section presents the results from an initial economic assessment carried out in relation to the implementation and operation of a new heat network arrangement served from the Cory plant.

5.1 Stakeholder Roles

As part of creating an economic model for the heat network, it was necessary to consider and define the roles of the various stakeholders involved. This included the defining of which elements of plant and infrastructure would require investment and ongoing operation by each party.

The following key categories of stakeholder have been defined in the context of this project, as follows:

1. **Cory:** as operator of the EfW plant.
2. **Pipe Co.:** referring to the ultimate heat network operator.
3. **Site Developers:** being multiple parties overseeing design and construction of new buildings/sites to be served by the heat network.
4. **Heat Customers:** being either a building operator or heat consumer within new and existing buildings/sites for connection.

The initial point of physical interface, between the Cory plant and the heat network operator (referred to here as the "Pipe Co."), has been taken as the primary heat exchanger arrangement.

From this point, it has been assumed that the Pipe Co. delivers and operates the heat network pumping and control station and all mains distribution pipework, up to bulk heat substations.

Subsequent distribution pipework, connecting to individual buildings or customers, would be installed by relevant site developers as part of a heat network ready system, with the suggestion of subsequent adoption by the Pipe Co.

Figure 23 presents these proposed roles and points of interface between all parties.

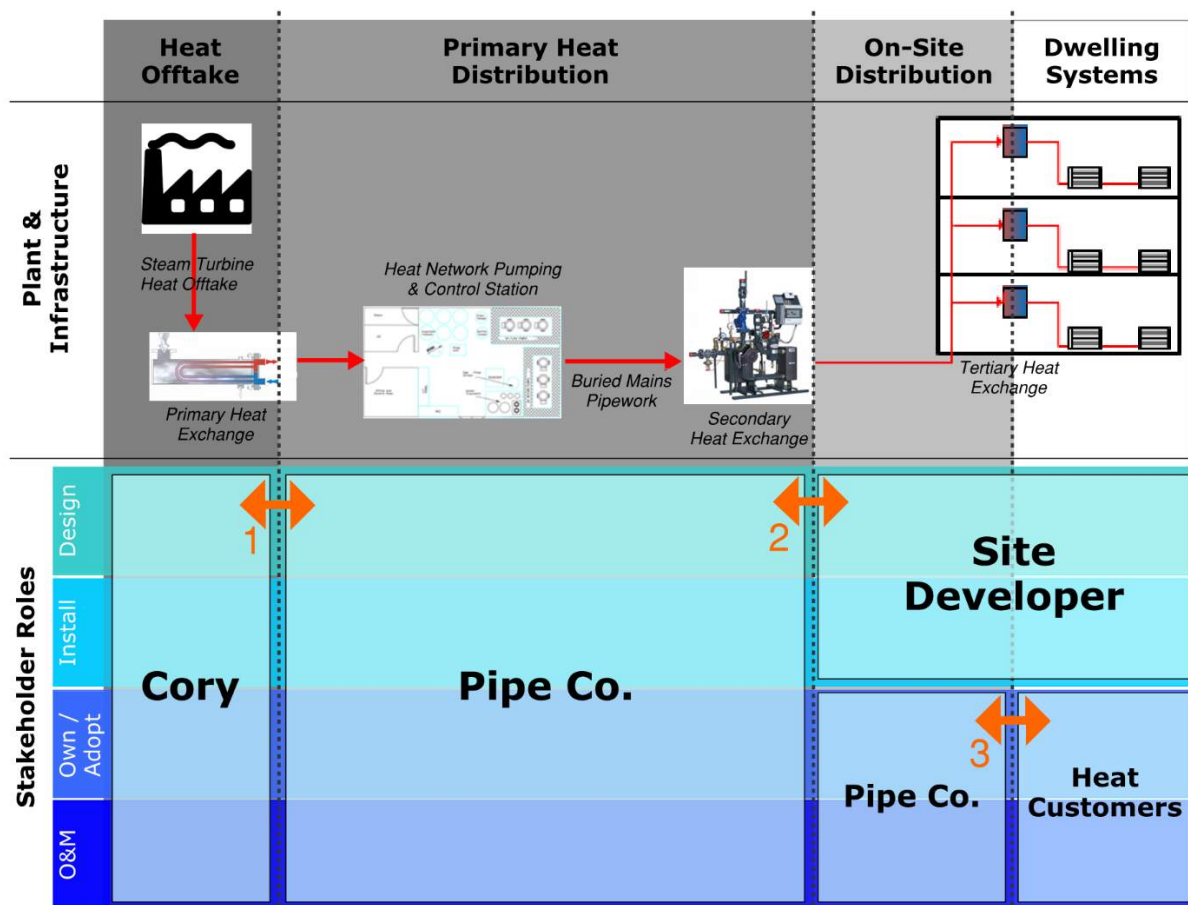


Figure 23: Heat network stakeholder role delineation

Economic/contractual interface points resulting from this arrangement are as follows and numbered within Figure 23:

1. Cory – Pipe Co.

A bulk heat price is paid by the Pipe Co. to Cory, set at a level required to cover all costs associated with the offtake arrangement and sacrifice of electrical generation.

2. Pipe Co. – Site Developer

Coordination will occur during the design of site and building heating systems to ensure compatibility with the primary network and heat substation arrangements. Of equal importance are the standards and specifications to which infrastructure is provided, with the Pipe Co. ultimately adopting and operating these systems

3. Pipe Co. – Heat Customers

A heat tariff is paid to the Pipe Co. from either the building operator or individual heat consumer.

5.2 Heat Tariffs

This section sets out the methodology applied to derive the costs applied in relation to heat purchase and sales within the initial economic modelling.

5.2.1 PURCHASE PRICE FOR HEAT OFFTAKE

The key assumptions applied in order to calculate the heat offtake purchase price are set out in Table 13. This is the price modelled as being paid by the Pipe Co. to Cory.

Table 13: Heat offtake purchase price calculator

Z factor (1 MWh of el to X of heat)	4.3
Exported electricity price (£/MWh)	63
Cost of heat (£/MWh)	14.651
Average build export volume (MWh/year)	58,351
Cost of heat (£/year)	854,914
CAPEX (£)	1,287,000
Shell& tube HEX lifetime (years)	25
OPEX (£ per year)	60,000
CAPEX Cover and OPEX (£/year)	111,000
Total cost per year (£/year)	£1,026,000
Total cost per unit of heat (£/MWh)	17.59

5.2.1.1 Electricity Purchase

In addition to the bulk purchase of heat, the operator of the DH network will require to purchase electricity to meet the demand of main circulating pumps, plus other parasitic loads associated with the control centre.

For the purposes of economic modelling, it has been assumed that the operator will secure a low power purchase price from Cory of £50/MWh in relation to these electrical loads, as part of the overarching commercial arrangement.

5.2.2 HEAT SALES TO RESIDENTIAL CUSTOMERS

A heat sale price for residential customers has been derived on the basis of the Pipe Co. adopting the necessary infrastructure in order to deliver heat to consumer HIUs.

This has included the use of a price comparator calculation to determine a sale price representing a 10% saving when compared to the marginal cost of heat produced by an alternative gas boiler arrangement.

The details of this price comparator are provided in Table 14.

Table 14: Heat Price comparator for Residential customers

Residential Heat Sales		
Annual heat demand (per dwelling)	5,000	kWh/yr
Unit gas rate (variable)	3.88	p/kWh (gross)
Standing charge	27	£/year
Boiler cover	138	£/year
Gas boiler lifetime	15	years
Boiler replacement cost	2,065	£/boiler
Boiler maintenance	132	£/year/boiler
Gas boiler efficiency	90%	
Gas net CV	91%	
Gas consumption	6,105	kWh/yr
Variable gas cost	237	£/year
Standing charge	27	£/year
Boiler cover & O&M	270	£/year
Total individual gas heat cost	533	£/year
Discounted rate	10%	%
BAU cost p/kwh	10.67	p/kWh
10% Discounted price	9.60	p/kwh

5.2.3 HEAT SALES TO NON-RESIDENTIAL CUSTOMERS

Heat sales prices for non-residential consumers have been determined to offer a similar 10% saving and related incentive for connection in place of the installation and maintenance of local heat generating plant, assumed as this scale to comprise high-efficiency gas boilers.

Table 15: Heat Price comparator for non-residential connections

Public building & other	
Heat Sold (kWh/annum)	300,000
Cost of Gas (£/kWh)	£0.0270
Cost of CCL (£/kWh)	£0.00339
Gas Boiler Efficiency (Seasonal)	80%
Cost of gas (ex VAT) £/kWh	£0.038
Total Cost of Gas £/annum	£11,396
Operation Maintenance (£/MWh)	£4.00
Operation Maintenance (£/Annum)	£1,200
Alternative cost of gas boiler(s) (3No. 138kW Boilers)	£16,181.82
Boiler lifespan (years)	15
Annualised Cost of gas boiler	£2,167.05
Total Annual Cost of Gas Boiler Heat	£14,763
Equivalent Cost of Gas £/kWh	£0.049
Saving	10%
Proposed Heat Sales Price (£/MWh)	£44.3

5.3 Project Costs

This section sets out all cost elements derived and applied within the cash flow section of the economic assessment undertaken.

5.3.1 CAPITAL INVESTMENT

Table 16 provides a breakdown of CAPEX associated with all heat offtake, exchange and distribution equipment.

Table 16: Heat offtake, exchange and distribution CAPEX breakdown

CAPEX breakdown		
DH Substations	59.5	per kW capacity
Pumping station	£ 1,040,000	
Heat offtake	£ 1,000,000	Covered in cost of heat

Table 17 provides a breakdown of CAPEX associated with all sections of the proposed heat network.

Table 17: Network Capital Investment

Network Options CAPEX breakdown (in isolation, not cumulative)				
	Core Scheme	Erith extension	North Thamesmead extension	West Thamesmead extension
Main spine pipework	£6,375,600	£2,603,370	£3,303,720	£3,450,230
Branch pipework	£6,315,456	£1,038,436	£1,317,792	£1,900,320
Major crossings	£600,000	£300,000	£150,000	£600,000
Totals	£12,691,056	£3,641,806	£4,621,512	£5,350,550

Within the economic modelling undertaken, an allowance has been made on top of these gross CAPEX figures for the associated cost of financing, on the basis of funding provision by LBB. This cost has been modelled as 4.5%, to represent the provided cost of borrowing at the time of writing.

One exception to this borrowing cost application is for CAPEX involved with facilitating heat offtake from the Cory plant, on the basis this is anticipated to be funded by Cory and recouped via the bulk heat sale price charged.

All network pipework has been preliminarily sized based on Ramboll's experience on the cost-effective trade-off between operational pressure drop / pumping power and CAPEX intensity.

Detailed hydraulic modelling will be undertaken during Work Package 2 in order to review pipe sizes and resulting costs.

5.3.2 HEAT NETWORK OPERATION AND MAINTENANCE COSTS

Table 18 presents a breakdown of assumptions applied to determine annual OPEX figures for the heat network.

Table 18: O&M breakdown

OPEX breakdown		
Pumping station	1	per MWh heat supplied
Water treatment	£96	£ per m3 network volume

OPEX breakdown		
Network fixed costs	0.015	of CAPEX (excluding major crossings)
Metering & billing	60	per connection / per year
Overheads	£40,000	per year
Parasitic elec. loads (pumping)	2.5%	% of heat supply
Elec. purchase price	£50	£/MWh assuming ppa with Cory

5.4 Economic Modelling Results

This section presents all results obtained from the early techno-economic modelling undertaken as part of Work Package 1 works.

5.4.1 ECONOMIC MODELLING

Table 19 displays the key economic performance indicators derived for the following network scenarios:

1. Core scheme (comprising loads in closest proximity to the Cory plant).
2. Core scheme plus North Thamesmead.
3. Core scheme plus North Thamesmead and Erith.
4. Core scheme plus Erith.
5. Network serving all identified loads.

These indicators comprise ranges of internal rate of return (IRR) and net present value (NPV) calculated over project periods of 25, 30 and 40 years. Receipt of external funding has not been considered in these figures, however has been tested within section 5.4.3.

Table 19: Economic performance of network scenarios

Core Scheme (Belvedere plus Thamesmead & Abbey Wood)			
years:	25	30	40
IRR	4.5%	6%	8%
NPV	£1,440,000	5,070,000	£12,530,000

Core Scheme plus Erith			
years:	25	30	40
IRR	6.5%	8%	9%
NPV	£5,620,000	£10,820,000	£21,660,000

Core Scheme plus Erith & North Thamesmead			
years:	25	30	40
IRR	4.0%	6%	7%
NPV	£980,000	£6,230,000	£17,240,000

Core Scheme plus Erith, North Thamesmead & West Thamesmead			
years:	25	30	40
IRR	2.2%	4%	6%
NPV	-£3,620,000	£1,870,000	£13,980,000

Core Scheme plus North Thamesmead			
years:	25	30	40
IRR	1.6%	4%	6%
NPV	-£3,210,000	£470,000	£8,110,000

The indication from this initial assessment is that, of the scenarios modelled, the Core scheme and the addition to this of the Erith extension achieve the best economic performance.

Figure 24 illustrates the related project cashflow associated with the Core scheme, indicating an initial return of investment after 15 years of operation.

PROJECT CASHFLOW

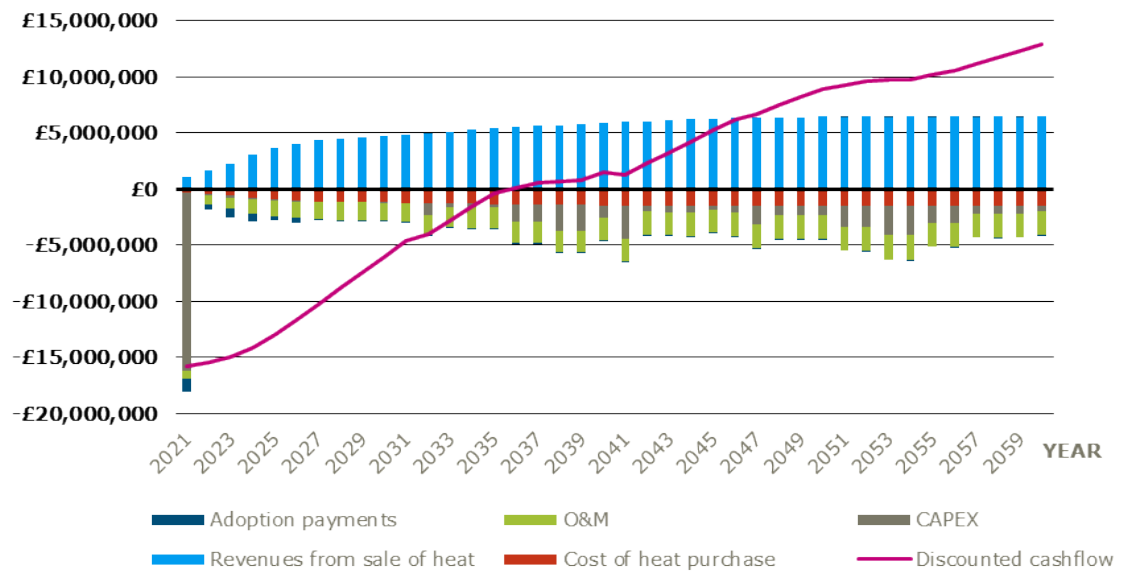


Figure 24: Core scheme cashflow

5.4.2 SENSITIVITIES (CORE SCHEME)

To further test the economic performance of the proposed Core scheme network, a series of sensitivity analyses have been undertaken in respect of the following key variables:

1. Heat network CAPEX
2. Heat offtake price
3. Heat sale prices (to Residential and non-Residential consumers)
4. Connected heat load
5. Cost of financing/borrowing (assigned to LBB CAPEX items)

Table 20 below summarizes key sensitivities assessed for the core scheme option.

Table 20: Sensitivity analysis on Core Scheme

IRR	Project Period	-20%	-10%	0%	10%	20%
DH Network CAPEX	25	7.2%	5.8%	4.5%	3.4%	2.4%
	40	9.8%	8.7%	7.8%	7.0%	6.3%
Heat Offtake Price	25	6.4%	5.5%	4.5%	3.5%	2.4%
	40	9.2%	8.5%	7.8%	7.1%	6.3%
Heat Sale Price (Residential)	25	-20.7%	2.5%	4.5%	6.3%	10.7%
	40	0.3%	6.4%	7.8%	9.1%	12.6%

IRR	Project Period	-20%	-10%	0%	10%	20%
Heat Sale Price (non-Residential)	25	3.6%	4.1%	4.5%	5.0%	5.4%
	40	7.2%	7.5%	7.8%	8.1%	8.4%
Connected Heat Loads	25	1.6%	3.1%	4.5%	5.8%	7.0%
	40	5.7%	6.8%	7.8%	8.8%	9.6%
Cost of Financing/Borrowing	25	4.7%	4.6%	4.5%	4.5%	4.4%
	40	7.9%	7.9%	7.8%	7.8%	7.7%

Of the variables tested, the Heat Sale Price to Residential customers has been determined as having the greatest bearing on the network business case, followed by levels of Connected Heat Load and the Heat Offtake Price paid to Cory.

SENSITIVITY ANALYSIS (25 YEARS LIFE TIME)

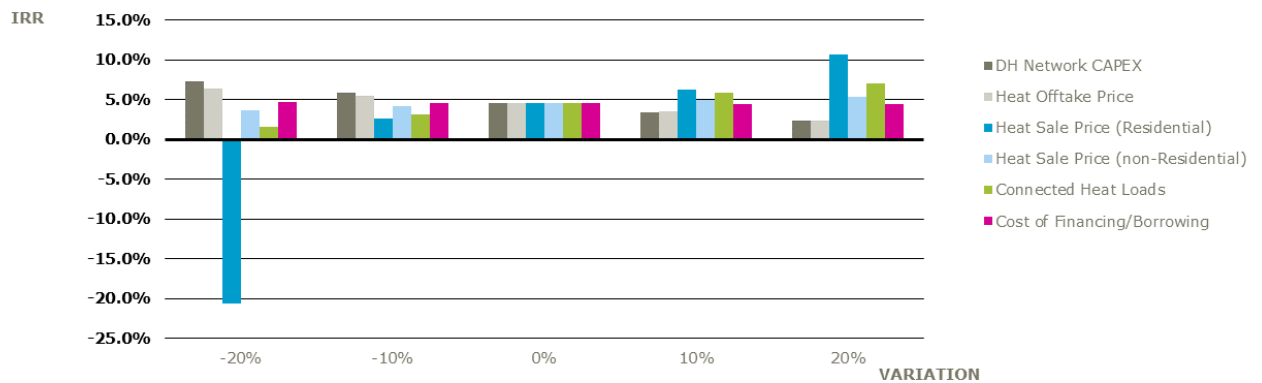


Figure 25: Sensitivity analysis on Core Scheme

5.4.3 CAPITAL FUNDING (CORE SCHEME)

The potential impact on the business case for the Core scheme network of receipt of capital funding has also been assessed, with Table 21 setting out the level of capital funding derived as required to achieve given return of investment levels.

Table 21: Capital funding requirements for set IRR levels

Capital Funding	IRR (25 years)	6.0%	8.0%	10.0%	12.0%
	Funding amount (£K)	1,800	3,800	5,500	6,800

Potential sources for capital funding to support the project's delivery will be assessed during Work Package 2.

5.4.4 CARBON SAVINGS (CORE SCHEME)

Here the CO₂ savings of the core scheme are set out and compared to a counterfactual case, which is assumed to be provision of heat via either localised or centralised boiler plant.

Table 22: CO2 emissions savings from Core Scheme operation

Years of Operation:	25	30	40
Carbon Savings (tons CO2)	213,794	297,076	560,160

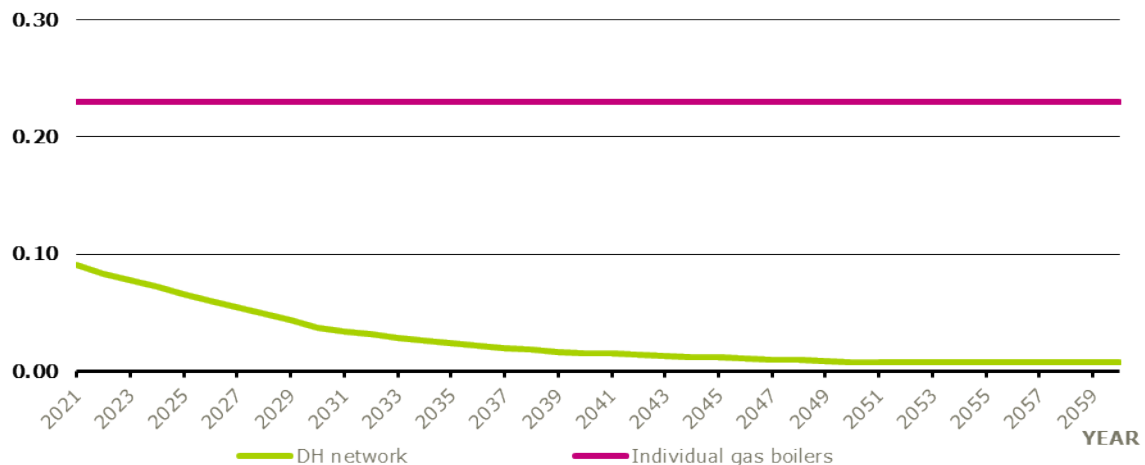
It is acknowledged that this counterfactual case will require revision during Work Package 2, in order to account for emerging details of alternative plant options proposed for specific sites to which network connection is being proposed.

Figure 26 illustrates the intensity of heat of the scheme, including allowance for primary network losses, when compared to a notional counterfactual case of local heat provision from gas boilers.

The large carbon savings produced by displacement of fossil fuel use for heat generation are further supplemented over time by the projected decarbonisation of grid electricity consumed for associated network pumping.

CARBON INTENSITY OF HEAT

KGCO₂/KWH

**Figure 26: Carbon intensity of heat**

5.5 Next Steps for Work Package 2

As part of the detailed techno-economic feasibility work to be carried out during WP2, the following steps will be taken to refine the business case modelling undertaken:

- Reflection of refined heat network modelling and sizing work in revised CAPEX allowance.
- Inclusion of revised costs involved with achieving required heat offtake from Cory plant.
- Incorporation of refined methodology and metrics applied in derivation of assumed bulk heat purchase pricing.
- Reflection of cost impacts from identified existing buried services and related impacts upon network routing.
- Application of further load sensitivity testing to reflect identified variances to potential future connecting heat loads.
- Identification of potential sources for project capital funding.
- Refinement of counterfactual case for heat provision to inform carbon savings calculations.

6. RECOMMENDED SCHEME OPTIONS



6.1 Conclusions

The combination of heat load and related techno-economic assessments undertaken as part of Work Package 1 have delivered the following key conclusions:

1. The total level of annual heat consumption derived for all identified loads for connection to a heat network can be met via the proposed volume of heat offtake from the Cory EfW plant.
2. Load clusters representing the greatest heat density exist within a radial band of 1 – 3 km, from the Cory plant and comprise developments in the Belvedere, Thamesmead South and Abbey Wood areas.
3. The planned phasing/build-out for these clusters occurs earlier than the other identified loads further afield.
4. Planned development in the Erith area represents a further potentially significant cluster within this band, though further granularity is required to enable full analysis.
5. A key constraint to connecting loads in the Belvedere is the requirement for network infrastructure to cross a railway line in the vicinity of Belvedere station.
6. Initial economic assessment indicates that implementation and operation of an initial “Core scheme” heat network could achieve IRRs in the region of 4.5 – 8% and positive NPVs, whilst delivering competitively priced heat to connected customers.
7. This economic performance may improve via network extension to serve additional loads in the Erith area, subject to further assessment and detail for loads in this area.

6.2 Recommended Scheme Options

The following recommendations are made in relation to further analysis of detailed feasibility for a new heat network served from the Cory EfW plant as part of Work Package 2:

1. Detailed feasibility work to focus on the identified initial “Core scheme” opportunity, whilst retaining future-proofing of pipework sizing/capacity to enable network expansion.
2. Assessment to be carried out of current heating systems and related works required to connect identified existing buildings/loads to heat network.
3. Further detail and granularity to be sought on development capacity in Erith area, plus review of any further potential loads for connection which could increase network heat density.

4. Undertake detailed hydraulic network modelling to refine distribution pipe sizing, plus further assessment of constraints (and opportunities) for network routing.
5. Details of heat offtake arrangement cost and resulting heat purchase tariff to be reviewed and developed further with Cory and their advisers.
6. Specific sensitivity analysis to be carried out on assessment results to approximate network expansion scenarios to incorporate other load clusters beyond Core scheme.

APPENDIX 1: HEAT DEMAND DATA

APPENDIX 1: HEAT DEMAND DATA

Table 23: Derived Future Heat Demand Data

Name	Heat Load Cluster	Typology	Heat Demand	Date of completion	Area
			<i>MWh/year</i>	<i>Year</i>	<i>Council</i>
Asda and B and Q Belvedere	Belvedere Developments	Residential	9,822	2024	Bexley
Gilbert Road Garage Shops and Resi	Belvedere Developments	Residential	1,318	2024	Bexley
Railway Place Shops Belvedere	Belvedere Developments	Residential	1,566	2024	Bexley
Picardy Street	Belvedere Developments	Residential	7,367	2024	Bexley
Yarnton Way Gasholders Redundant	Belvedere Developments	Residential	2,322	2026	Bexley
Centurion Way Industrial Estate	Belvedere Developments	Residential	3,600	2026	Bexley
Waterfield Close Estate Regeneration	Belvedere Developments	Residential	850	2026	Bexley
Crabtree Manorway South part East	Belvedere Developments	Residential	2,268	2026	Bexley
Crabtree Manorway South part West	Belvedere Developments	Residential	4,363	2026	Bexley
Culling Road	Belvedere Developments	Residential	141	2026	Bexley
Hailey Road (2030-2050)	Belvedere Developments	Residential	16,728	2050	Bexley
Binsey Walk	TAW Developments	Residential	1,587	2023	Bexley
Coraline Walk	TAW Developments	Residential	2,593	2025	Bexley
Southmere Village	TAW Developments	Residential	2,547	2023	Bexley
K&L	TAW Developments	Residential	4,363	2030	Bexley
Sedgemere Road	TAW Developments	Residential	1,527	2025	Bexley
Abbey Way	TAW Developments	Residential	268	2022	Bexley
M,N,O,Q,S,T	TAW Developments	Residential	2,924	2050	Bexley
E&F	TAW Developments	Residential	4,235	2050	Bexley
Single point south Erith	Erith Developments	Residential	30,110	2026	Bexley
Thames Waterfront	Greenwich Thamesmead North	Residential	-	2041	Greenwich
Thamesmead Town Centre	Greenwich Thamesmead North	Residential	-	2036	Greenwich
Gallions Reach Health Centre	Greenwich Thamesmead North	Residential	1,499	2026	Greenwich
The Moorings incl. Titmuss Ave Open Space	Greenwich Thamesmead North	Residential	-	-	Greenwich
The Moorings Community Hub	Greenwich Thamesmead North	Residential	-	2036	Greenwich

Name	Heat Load Cluster	Typology	Heat Demand	Date of completion	Area
			<i>MWh/year</i>	<i>Year</i>	<i>Council</i>
Lidl Abbey Wood	Greenwich Thamesmead East	Residential	-	2031	Greenwich
Harrow Manorway and Eynsham Drive Pet hospital redevelopment	Greenwich Thamesmead East	Residential	1,418	2026	Greenwich
Cross Quarter and Lyndean Industrial Estate	Greenwich Thamesmead East	Residential	1,820	2031	Greenwich
Lyndean Industrial Estate	Greenwich Thamesmead East	Residential	3,185	-	Greenwich
Abbey Wood Telephone Exchange	Greenwich Thamesmead East	Residential	-	2031	Greenwich
Abbey Wood Post Office and Abbey Wood Community Group	Greenwich Thamesmead East	Residential	676	2031	Greenwich
Abbey Place on Felixstowe Road	Greenwich Thamesmead East	Residential	241	2026	Greenwich
Griffin Manor Way HZ West Thamesmead Gateway. Hunter Plastics Ltd and Pettman Crescent	Greenwich Thamesmead West	Residential	442	2026	Greenwich
The Reach	Greenwich Thamesmead West	Residential	-	2026	Greenwich
Thames Reach Local Centre	Greenwich Thamesmead West	Residential	3,386	-	Greenwich
Broadwater Dock	Greenwich Thamesmead West	Residential	2,730	2031	Greenwich
Plumstead Bus Garage	Greenwich Thamesmead West	Residential	1,392	2036	Greenwich
Woolwich Trade Park	Greenwich Thamesmead West	Residential	-	2041	Greenwich
Pettman Crescent	Greenwich Thamesmead West	Residential	4,871	2031	Greenwich
McDonalds and Plumstead mail delivery office	Greenwich Thamesmead West	Residential	1,639	2036	Greenwich

Table 24: Derived Existing Heat Demand Data

Name	Heat Load Cluster	Typology	Heat Demand	Date of completion	Area
			<i>MWh/year</i>		<i>Council</i>
Southmere Lake	Tower blocks	Residential	805	Existing	Bexley
Yarnton Way	Tower blocks	Residential	-	Existing	Bexley
Yarnton Way South	Tower blocks	Residential	1,811	Existing	Bexley
Wurth	Belvedere Industrial Area	Industrial	713	Existing	Bexley
Allied Hygiene	Belvedere Industrial Area	Industrial	285	Existing	Bexley

Name	Heat Load Cluster	Typology	Heat Demand	Date of completion	Area
			<i>MWh/year</i>		<i>Council</i>
Ferndale Foods	Belvedere Industrial Area	Industrial	1,473	Existing	Bexley
St Augustine's Primary School	Other Bexley Anchor loads	Education	380	Existing	Bexley
Belvedere Community Centre	Other Bexley Anchor loads	Community	105	Existing	Bexley
Belvedere Infant School	Other Bexley Anchor loads	Education	397	Existing	Bexley
Woodside School	Other Bexley Anchor loads	Education	544	Existing	Bexley
Belvedere Family Resource Centre	Other Bexley Anchor loads	Leisure	95	Existing	Bexley
DOWLING HOUSE	Other Bexley Anchor loads	Care Home	430	Existing	Bexley
BELVEDERE HOTEL	Other Bexley Anchor loads	Hotel	-	Existing	Bexley
BELVEDERE JUNIOR SCHOOL	Other Bexley Anchor loads	Education	-	Existing	Bexley
Bexley College Upper Holly Hill Road	Other Bexley Anchor loads	Education	-	Existing	Bexley
St. John Fisher RC Primary School	Other Bexley Anchor loads	Education	131	Existing	Bexley
Parkway Primary School	Other Bexley Anchor loads	Education	235	Existing	Bexley
Northwood Primary School	Other Bexley Anchor loads	Education	426	Existing	Bexley
Bexley Business Academy	Other Bexley Anchor loads	Education	1,427	Existing	Bexley
The Beeches Primary Centre	Other Bexley Anchor loads	Education	135	Existing	Bexley
Hibernia Point	Other Bexley Anchor loads	Residential	333	Existing	Bexley
Thamesmead Library	Other Bexley Anchor loads	Library	165	Existing	Bexley
Tavy Bridge	Other Bexley Anchor loads	Residential	229	Existing	Bexley
Southlake Centre	Other Bexley Anchor loads	Leisure Centre	376	Existing	Bexley
Birchmere Centre	Other Greenwich Anchor loads (North)	Office	-	Existing	Greenwich
Bishop John Robinson C.E. School. Not in Traded Services	Other Greenwich Anchor loads (North)	Education	-	Existing	Greenwich
Discovery Primary School	Other Greenwich Anchor loads (North)	Education	416	Existing	Greenwich
Hawksmoor Primary School. Not In Traded Services	Other Greenwich Anchor loads (North)	Retail	317	Existing	Greenwich

Name	Heat Load Cluster	Typology	Heat Demand	Date of completion	Area
			<i>MWh/year</i>		<i>Council</i>
Hawksmoor Youth Club	Other Greenwich Anchor loads (North)	Community	57	Existing	Greenwich
Heronsgate Primary School	Other Greenwich Anchor loads (North)	Education	-	Existing	Greenwich
Linton Mead Primary School. Not in Traded Services	Other Greenwich Anchor loads (North)	Education	318	Existing	Greenwich
Nathan Way Amenity Site	Other Greenwich Anchor loads (North)	Waste Site	-	Existing	Greenwich
St Margaret Clitherow School. Not In Traded Services	Other Greenwich Anchor loads (North)	Education	-	Existing	Greenwich
Thamesmere Leisure Centre	Other Greenwich Anchor loads (North)	Leisure Centre	2,015	Existing	Greenwich
Windrush School. Not In Traded Services	Other Greenwich Anchor loads (North)	Education	302	Existing	Greenwich
Woolwich Polytechnic School. Not in Traded Services	Other Greenwich Anchor loads (North)	Education	1,236	Existing	Greenwich

APPENDIX 2: TECHNO-ECONOMIC ASSUMPTIONS

APPENDIX 2: TECHNO-ECONOMIC ASSUMPTIONS

Please also refer to section 5 of this report for further detail on the economic assessment undertaken during Work Package 1.

Technical Parameters	Value Applied	Units	Basis
Heat Demand Assessment			
Residential Annual Heat Consumption	56	kWh / m2 floor area	Estimated applying average dwelling area of 94 m2 (from English Housing Survey 2016-2017)
Non-Residential Annual Heat Consumption	87	kWh / m2 floor area	Averaged figure for mix of Retail, Commercial, Community and Leisure spaces
Non-Residential Space Provision (as ratio of Residential)	8.9	m2 / m2 floor area	Referenced from Peabody South Thamesmead development figures
Industrial Annual Heat Consumption	95	kWh / m2 floor area	Ramboll experience
Existing Residential Tower Annual Heat Consumption	201	MWh / year	Calculation of total Resi floor area associated with Towers
Energy Supply Assessment			
Available Heat for Export	200,000	MWh / year	Determined following conversations with Cory
Cory Plant Z-Factor	4.3		Provided by Cory
Network Pumping Station Electrical Consumption	2.5%	%age of heat delivered	
Primary Network Heat Losses	10.0%	%age of heat delivered	
Secondary System Heat Losses	15.0%	%age of heat delivered	

Economic Parameters	Value Applied	Units	Basis
CAPEX			
DH Substations	59.50	£/kW	Ramboll project experience
DH Mains Pipework	1,610	£/m	
DH Branch Pipework	888	£/m	
DH Major Infrastructure Crossings	150,000	£	
Primary Network Pumps	68,336	£	SPONS guidance
Thermal Stores	233,400	£	Nominal allowance
Primary Network Pressurisation Equipment	163,450	£	Ramboll project experience
Primary Network Water Treatment Equipment	216,688	£	

Economic Parameters	Value Applied	Units	Basis
Network Pumping Station Shell & Core	100,000	£	
Network Pumping Station Fit-out	71,350	£	
Network Pumping Station Controls Systems	185,024	£	
Network Pumping Station Metering	1,725	£	
HIUs	1,500	£/unit	
Cost of Finance (applied to CAPEX)	4.5	%	Reflects current LBB cost of borrowing
OPEX			
Primary Network Pumps	1	£/MWh heat supplied	Ramboll internal benchmark
Network Pumping Station Overheads	40,000	£/year	Ramboll estimate
Heat Network (fixed)	1.5%	%age of CAPEX	Ramboll estimate
Heat Network (variable)	2	£/MWh	Ramboll estimate
Heat Network Metering & Billing	60	£/year per connection	Industry standard
Water Treatment	96	£/m3	Ramboll estimate
HIUs (fixed)	60	£/unit/year	
HIUs (variable)	0.001	£/kWh	
Residential Service	75	£/customer/year	
HIUs Adoption Payment	500	£/unit	
REPEX			
Pumping Station Plant Lifetime	20	years	
DH Substation Plant Lifetime	20	years	
HIU Lifetime	15	years	
Heat Purchase / Sales			
Cory Electrical Export Price (summer)	61	£/MWh	Provided by Cory
Cory Electrical Export Price (winter)	65	£/MWh	Provided by Cory
Network Pumping Station Electricity Tariff	50	£/MWh	Assumed PPA with Cory

APPENDIX 3: RISK & CONSTRAINT ANALYSIS

DESIGN RISK ASSESSMENT



Project Name:		Thamesmead & Belvedere DH Feasibility Study		Job No:		1620005147		Document Ref:		0-05-054	
Stage / Section of works:		Work Package 1		Issue date/revision:		09.11.2018 / V1		Project Director Approval:		LPADF	

Activity /Element Cat ¹	Nº	Risk / Opportunity Item	Implication	Risk Estimation (Residual Evaluation)				Ramboll action to eliminate risk and maximise opportunity	Residual risks / actions that remain	Action By	Status
				Probability Rating (1-4) a	Severity Rating (1-4) b	Resulting risk level (1-16) a x b	Control / Influence				
	1	ENERGY DEMAND ASSESSMENT									
P	i	Applied energy consumption benchmarks are higher or lower than those occurring in reality.	Loads determined for connecting buildings/sites are either over or under-estimated, leading to over or undersizing of related distribution infrastructure.	2	2	4	C	Benchmarks used are based upon recent and historic Ramboll experience in this field.		Ramboll	Closed
P	ii	Modelled development quanta does not reflect that ultimately brought forward.	Loads are incorrectly determined and related distribution infrastructure not sized appropriately.	2	2	4	C	Development information has been consulted on with all relevant parties.	Quanta to be re-confirmed during Work Package 2.	Ramboll	Open
P	iii	Identified existing buildings/loads operate heating systems incompatible with connection to heat network.	Loads are incorrectly included and related distribution infrastructure not sized appropriately.	2	1	2	C	Only a limited range of previously identified existing load/buildings considered for connection to date.	Further details on exisitng building systems will be gathered during Work Package 2.	Ramboll	Open
	2	ENERGY SUPPLY ASSESSMENT									
P	i	Estimates of heat offtake availability from Cory plant are inaccurate.	Heat offtake and distribution equipment & infrastructure are incorrectly sized.	1	2	2	C	Data used has been generated in contact with Cory to ensure accuracy.	Cory will continue to be consulted during Work Package 2, so that any corrections or updates can be reflected.	Ramboll	Open
P	ii	Parameters used to determine heat offtake capacity and associated costs are inaccurate.	Impact upon accuracy of commercial case derived for new heat network.	1	3	3	C	Key parameters applied have been provided by Cory.	Cory will continue to be consulted during Work Package 2, so that any corrections or updates can be reflected.	Ramboll	Open
	3	ENERGY DISTRIBUTION ASSESSMENT									
P	i	Presence of obstacles or constraints preventing or limiting ability to route new heat network pipes as propsed.	Change in network routing leading to increased capital costs.	2	2	4	C	High-level assessment has been made of above-ground pipework routing constraints, with preliminary sums assigned for negotiating these.	Review of existing buried services to form part of Work Package 2.	Ramboll	Open
P	ii	Underestimation of pipework involved with connecting to new development loads within Erith area.	Alteration to hydraulic operation of network.	2	2	4	C	Early estimates assigned in lieu of better granularity of development quanta.	Further detail to be sought from LBB during Work Package 2.	Ramboll	Open
P	iii	Assumed pipe sizes for main distribution network are not approriate for final derived loads.	Potential limitation of network heat carrying capacity.	2	2	4	C	Initial estimates have been based on known loads and Ramboll design experience of pipe size optimisation.	Full hydraulic modelling to be undertaken during Work Package 2.	Ramboll	Open
P	iv	Works not completed to size thermal stores.	Space required for thermal stores not determined.	4	2	8	C	Nominal cost allowance has been made for thermal stores, to ensure this is allowed for within economic modelling.	Further modelling undertaken during Work Package 2 will lead to sizing of thermal stores.	Ramboll	Open
P	v	Selected approach to network hydraulic separation does not match Developer connection expectations.	Additional costs invovled with providing additional hydraulic breaks and heat exchange equipment.	2	2	4	C	Assumptions applied entail greater cost and are based upon recent Ramboll experience with Developer preferences.	Assumptions to be tested further during Work Package 2.	Ramboll	Open
	4	ECONOMIC ASSESSMENT									
P	i	Bulk heat offtake purchase price assumptions do not match those expected by Cory.	Impact upon modelled business case.	3	3	9	C	Parameters informing this price have been cross-checked with Cory at this stage.	Further coordination with Cory to understand their cost model and basis to form part of Work package 2.	Ramboll	Open
P	ii	Definition and delineation of heat network roles do not reflect stakeholders preferences.	Alterations required to economic modelling.	2	1	2	C	Initial role assumptions required in order to build initial economic model.	Further discussions to be held with stakeholders during Work Package 2, with new economic model being developed.	Ramboll	Open
P	iii	Price comparator calculations undertaken for Resi and non-Resi customers do not reflect true market values.	Impact upon modelled business case.	1	3	3	C	Comparator follows best-practice methodology, with results tested against other methodologies.	Prices to be further tested during Work Package 2.	Ramboll	Open
P	iv	Underestimation of CAPEX associated with plant and infrastructure.	Impact upon modelled business case.	1	4	4	C	Ramboll experience and means-tested benchmarks used to derive CAPEX figures.		Ramboll	Closed
P	v	Underestimation of pipework involved with connecting to new development loads within Erith area.	Impact upon accuracy of commercial case derived for new heat network.	2	2	4	C	Early estimates assigned in lieu of better granularity of development quanta.	Further detail to be sought from LBB during Work Package 2.	Ramboll	Open

1 (C) CDM / (P) Project / (E) Environmental

APPENDIX 4: GLOSSARY OF TERMS

APPENDIX 4: GLOSSARY OF TERMS

CAPEX	Capital Costs
CHP	Combined Heat and Power
CO2	Carbon Dioxide
DE	District Energy
DEEP	Decentralised Energy Enabling Project
DH	District Heating
EfW	Energy from Waste
EMP	Energy Masterplan
GLA	London Authority
HIU	Heat Interface Unit
LBB	London Borough of Bexley
LTHW	Low-Temperature Hot Water
MWel	Megawatts (electrical)
MWh	Megawatt hour
MWth	Megawatts (thermal)
OPEX	Operational Cost
PPA	Power Purchase Agreement
SCADA	Supervisory Control and Data Acquisition
TAW	Thamesmead – Abbey Wood Developments
WP1	Work Package 1
WP2	Work Package 2