London Borough of Kingston

Kingston Decentralised Energy Network

Feasibility and Business Case Study

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Executive Summary

Arup was appointed by The Royal Borough of Kingston (the Council) to undertake a feasibility study investigating the potential for delivery of an area-wide Decentralised Energy (DE) scheme in Kingston Town Centre, delivering lower-cost, lower-carbon energy to households and businesses.

Conclusions from previous studies – Royal Borough of Kingston-Upon-Thames Heat Mapping Study (URS, June 2010) and the Royal Borough of Kingston-Upon-Thames: Energy Masterplan (AECOM, July 2013) – highlighted several areas in the borough which have the potential to establish district heating (DH) networks

While techno-economic modelling indicates potentially two viable commercial schemes, the stakeholder landscape at Kingston indicates that delivery of an area-wide scheme would depend on active involvement from Kingston Council to promote the network.

This report presents a technical and financial feasibility assessment for the full scheme, and investigates the means by which the Council might support its delivery.

Techno-economic summary

Two leading heat network scheme options emerged from the feasibility and techno-economic assessment. These are:

- A District Heating (DH) network served by a combined heat and power (CHP) and gas fired boiler energy centre at Ashdown road car park or other adjacent town centre site. Modelled annual carbon savings at the full build out of the network are expected to be 1,460tCO_2 per year, a 34% reduction on business as usual (BAU) baseline carbon emissions.
- A DH network served by a water sourced heat pump (WSHP) and gas fired boiler energy centre located at Eagle Brewery Wharf. Modelled annual carbon savings at the full build out of the network are 485tCO_2 per year, an 11% reduction on BAU baseline carbon emissions.

These scheme options were analysed for their financial viability and subjected to a range of sensitivity tests. The findings of this analysis were that both schemes were found to be viable but were highly dependent on the value of developer connection charges which could be negotiated. Connection charges for new development sites fell within a range of £2,500 to £4,000 per residential unit (other rates would apply to non-residential and to existing developments). Under some scenarios, the connection charges needed to reach a 12% internal rate of return (IRR) over a 20-year time horizon may exceed the developer's willingness to pay for a connection, based on an estimate of the developer's avoided costs of connection.

The effect of reducing the connection charge to below the developer's avoided costs would be to reduce the IRR to below 12%. In such a scenario it may not be possible to procure an ESCo-financed delivery solution.

The CHP-led option is recommended in favour of the WSHP option, for the following reasons:

- Development may not be permitted on the site identified for the WSHP energy centre. The CHP energy centre site is considered suitable for that use.
- Technical feasibility is more uncertain for the WSHP than for the CHP. Key issues are water intake compliance with Eel Regulations and other regulations, and the availability of a grid connection sized for the WSHP.
- The CHP achieves better carbon emissions reductions than the WSHP (although this reverses when calculated based on expected future grid carbon intensity).

If not pursued now, the WSHP option could be available as a low carbon replacement for the CHP plant when the CHP engines reach the end of their life, or as a second major heat source as the network grows.

Business case options

Depending on the desired degree of involvement three potential options for delivery of the DH network in Kingston Town Centre were identified:

- The Council as a Promoter
- The Council as Promoter and Funder
- The Council exercises only a planning function

However, with two large new developments in the centre each currently planning for separate site wide heating systems, it is unlikely that a district heating network will emerge in Kingston without leadership from the Council acting as the promoter. Acting as the promoter increases the certainty for a third party ESCo that a DH network will be created.

In a workshop held in February 2015 the Council expressed a preference to proceed only as a promoter, avoiding any funding role due to the fact that there is little heat demand under direct Council control considering too high risk any Council involvement in ownership of a network.

In any case, the study concludes that the Council would need to make land available for the energy centre, which would be either for a CHP Energy Centre on the Ashdown Road Car Park (or other town centre site) or at the Eagle Brewery Wharf for the WSHP option. An alternative to this would be to split the energy centre between the two main development sites, but this may carry additional commercial complexity.

Recommendations and next steps

The below list highlights the recommendations and potential next steps that follow the publication of this study.

- The Council to review findings and discuss their implications in the context of planning policy and wider economic and environmental goals

1 Introduction

1.1 Background to the project

The Royal Borough of Kingston upon Thames (RBK) is committed to reduce the impact of climate change as one of its key objectives within the Kingston Plan (2008) through energy management, behavioral change, energy efficiency measures and low-carbon energy generation. A district heating (DH) network in Kingston has the potential to address CO2 emissions, enhancing energy security and tackling fuel poverty.

Conclusions from previous studies[1] highlighted several areas in the borough which have the potential to establish district heating (DH) networks. The Kingston Town Centre area, with a wide range of existing domestic and non-domestic heat loads as well as significant planned redevelopment, was identified as a key opportunity to establish a DH network

The Kingston Energy Masterplan study (EMP) carried out in July 2013 proposes that a district heating network could be developed over phases, from “short term” focused on the town centre through to “long term” extending to Kingston Hospital and Kingston University Clay Hill campus. The study also highlights a number of potential energy supply options including CHP and water sourced heat pumps from the River Thames and local sewage treatment works.

The progressive decarbonisation of the electricity grid, partly reflected in the latest emissions factors used for Building Regulations, means that alternatives to CHP must be considered for any DE scheme. Different supply options result in different IRRs, however in nearly all cases considered in the Kingston Energy Masterplan (2013) the IRR was below 5% on a 25-year basis, which is not enough to be attractive from a commercial point of view.

The aim of this feasibility study is to develop the Kingston Energy Masterplan, identifying potentially viable heat networks based on existing and future heat loads in central Kingston and to establish a realistic delivery plan for the scheme. A key objective of this feasibility study is to interrogate the economic assumptions and to explore strategies for improving the economic performance while still remaining consistent with the other environmental and social objectives of the Council for this project.

Consequently the study considers the scheme from multiple perspectives:

- System technology and design parameters;
- Network route feasibility and land requirements;
- Likely costs and revenues, and potential long term investment performance; and
- Allocation of roles and risks for the design, installation, funding, operation and maintenance of the network.

[1] the Royal Borough of Kingston-Upon-Thames Heat Mapping Study, June 2010 produced by URS and the Royal Borough of Kingston-Upon-Thames: Energy Masterplan, July 2013 produced by AECOM.

This report presents the outcome of a process of analysis and refinement which takes the form of a deliverable “Core Scheme” serving a small number of major development sites in Kingston. Unless otherwise noted the information presented relates only to the Core Scheme.

1.2 Important disclaimer

It should be noted that all figures presented in this report are based on a variety of technical and financial assumptions. We have sought in every case to obtain data and assumptions from reputable sources or otherwise to test the validity of our assumptions. Nevertheless, should one or more of these assumptions change, the outcomes in terms of technical and financial performance of the scheme and the businesses which would operate some or all of the system could change significantly.

1.3 Structure of this report

This report is structured as follows:

- Sections 2 focuses on district heating, introducing the methodology followed in this study
- Sections 3 and 4 present the results of the heat demand, supply analysis and energy centre location studies.
- Section 5 presents the network routing options, key considerations and an appraisal of the risks associated with delivering the infrastructure.
- Section 6 highlights the fundamental techno-economic performance of the CHP and WSHP supply schemes.
- Section 7 investigates the sensitivity of the two schemes’ economic performance to key critical uncertainties.
- Section 8 covers the commercial and business cases for a selection of appropriate delivery mechanisms, from the perspective of the Council.
- Section 9 presents highlights of the risk assessment.
- Section 10 presents the procurement delivery plan for the Kingston Town Centre network.

Further technical detail, assumptions and results are presented in the relevant appendices.

2 Introduction to district heating

The UK established through the Climate Change Act 2008 a legal commitment to an 80% reduction in greenhouse gas (GHG) emissions by 2050 versus 1990 levels. Amongst other measures, this goal requires the decarbonisation of the nation's heat supply, which today is responsible for a third of total GHG emissions[2]. District heating represents one potential means of enabling this transition where it can capture and distribute low carbon heat sources such as electricity generating stations, combined heat and power facilities and large scale heat pumps.

2.1 Decentralised Energy

Decentralised energy refers to the generation and distribution of energy closer to the locations where energy is consumed. District Heating (DH) involves heat (and often power) generated in energy centres, with heat sent via pipes to customers[3]. Buildings are connected to the network via heat interface units that replace individual boilers for space heating and domestic hot water. The DH network is made up of two components; transmission pipework and distribution pipework. The distribution pipework are the pipes that directly connect a heat load to the rest of the network. The transmission pipes are sized to deliver heat from the energy centre to all connected heat loads. Unlike the distribution pipes, transmission pipes are sized to handle the heat demand from than one load and because of this, they tend to be larger and sized for future expansions.

Figure 1. An energy centre.
Source: Islington Council

[2] The Future of Heating: A strategic framework for low carbon heat in the UK

[3] So, while the electricity generation is decentralised, the heat generation is actually more centralised than previously.

Currently, electrical power in the UK is generally supplied from a relatively small number of very large power stations, most of which are in remote locations away from population centres. This approach creates a variety of inefficiencies in the overall energy system, of which the greatest is the inability to use the spare heat from power stations for beneficial purposes. By locating a generating station close to where the energy is used, decentralised energy offers the potential for the spare heat to be captured and distributed to buildings or industrial processes which need it.

Figure 2. Heat pipes.

District heating networks offer an affordable way of achieving a low carbon energy supply in densely populated areas such as London, meeting domestic, commercial and some industrial space heating and domestic hot water requirements.

The growth potential of district heating in urban areas is significant: scenario planning by the UK's Committee on Climate Change indicates a target of 30 million megawatt-hours (MWh) of heat to be provided through district heating systems by 2030, from around 1 million MWh today.

2.2 Combined Heat and Power with District Heating

A well design Combined Heat and Power (CHP) system with DH results in more efficient use of fuel, up to 80-90% efficiency resulting in primary energy savings of up to 30% compared with the conventional separate generation to achieve the same quantity of heat and power. Due to the efficiency of CHP, emissions to the environment are less than in separate generation of electricity and heat. This is represented in Figure 3.

The heat generated by CHP is then distributed in the form of hot water from the heat sources by means of district heating pipework to the consumers. Such are reliable, long life assets that can deliver heat regardless of the source. Indeed the heat source may change over time as the energy market and technologies change to favour new generation technologies or other more economic heat sources. The flexibility of district heating is improved as networks are interconnected allowing access to lower cost heat sources. According to the Digest of UK energy statistics 2014(DUKES) published by the Department of Energy and Climate Change (DECC), there are currently over 340 CHP schemes in the UK with capacities of over 1 MWe.

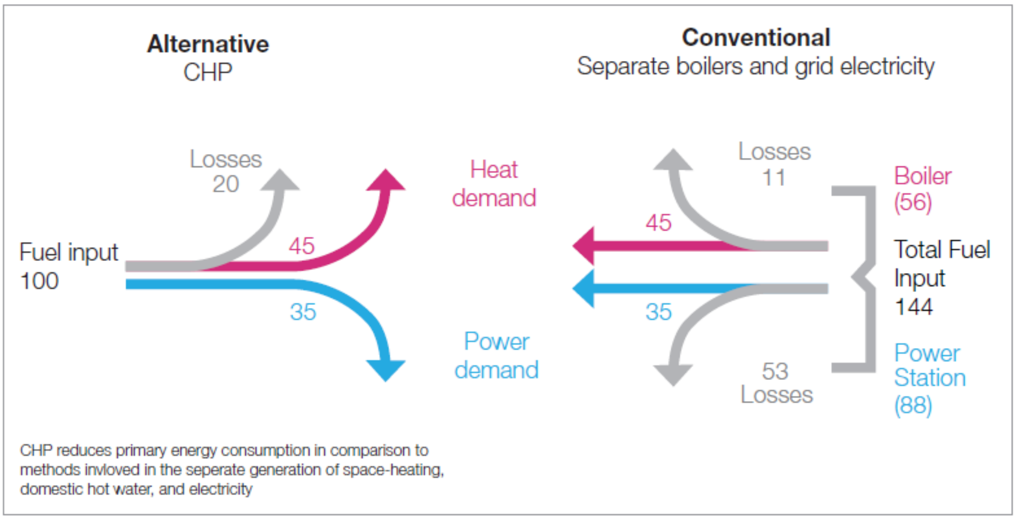

Figure 3. Benefits of Combined Heat and Power. *Source: London Heat Network Manual*

District heating networks are best suited for "high heat demand" density areas. New development areas provide an opportunity to gain economies of scale to provide heat at lower prices compared to individual building solutions, while meeting carbon reduction targets in a cost-effective way. District heating networks can help London meet its domestic energy needs while reducing the total fuel requirement, thereby delivering some mitigation of energy security risks and fuel price fluctuation.

Today, CHP district heating offers carbon savings over the conventional alternatives (gas boilers and grid-supplied electricity), primarily due to the carbon intensity of the electrical grid. However, as the grid continues to decarbonise (it is projected to reduce its carbon intensity by over 50% in the next five years[4]), the savings achieved by offsetting grid carbon emissions will greatly reduce. There exists the real possibility that in the coming years CHP technologies will perform worse in carbon terms than conventional or advanced heat supplies (heat pumps). This said, CHP is currently seen as a cost-effective means of enabling low-carbon district heating; once the engines are life-expired, they can potentially be replaced with future low-carbon options.

[4] Based on analysis of DECC Updated Energy and Emissions Projections, September 2014

2.3 Feasibility Study Methodology

This section will outline the methodology and approach undertaken for this feasibility study. The feasibility study began by gathering the heat demand data produced from two key previous studies undertaken for the Council; the Royal Borough of Kingston-Upon-Thames Heat Mapping Study, June 2010 produced by URS and the Royal Borough of Kingston-Upon-Thames: Energy Masterplan, July 2013 produced by AECOM. The initial heat demand data assessment began with a high level spatial analysis of this data in geographic information system (GIS) software ArcGIS. The two studies indicated of the 270 total potential heat customers. Of the 270 potential heat customers identified across the borough by URS (2010), the following AECOM (2013) study determined that the Kingston Town Centre area had the highest potential for DH network development upon which this feasibility study was based.

The heat demand data was updated along with information regarding potential dates of connection to a DH network (either development completion dates or plant replacement dates) were obtained through engagement with the Council and the various stakeholders. Standard Arup profiles were applied to the various heat demands based on the building typology to produce hourly profiles of the heat consumption throughout the course of a year. Throughout this study, a hierarchy of heat demand data was established (as illustrated in the Figure 4 below) from the more preferred data sources (i.e detailed energy modelling undertaken by new developments or recent metered heat or gas data) to the least preferred sources (i.e. Arup heat demand benchmarks utilising developer area schedules and heat mapping data).

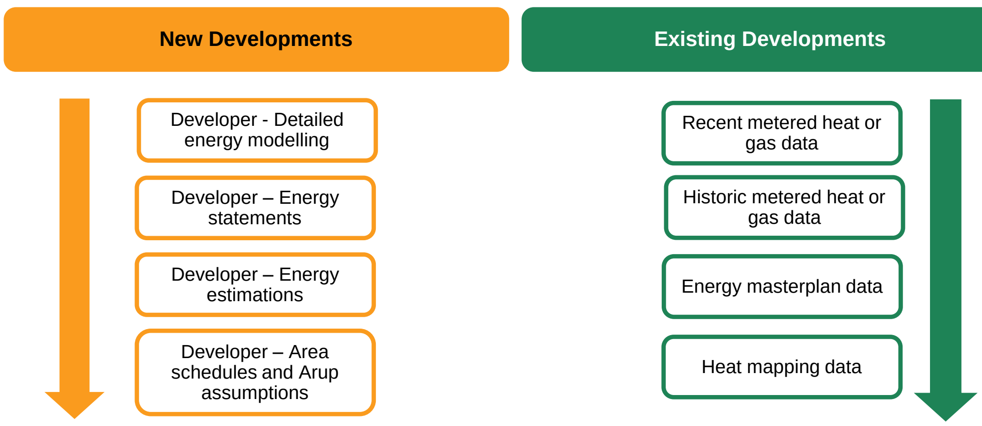

Figure 4 Heat demand assessment hierarchy

The previous studies undertaken for the wider area in the initial heat mapping study and the energy masterplan identify a number of potential heat customers in the wider area including Tolworth, towards the Cambridge Road estate as well as Kingston hospital and the Hogsmill sewage treatment works providing an opportunity to connect two additional heat sources. The Figure 5 below highlights the various potential heat loads identified in both the previous heat mapping study and energy masterplan which represents approximately 170,000MWh of heat demand per year.

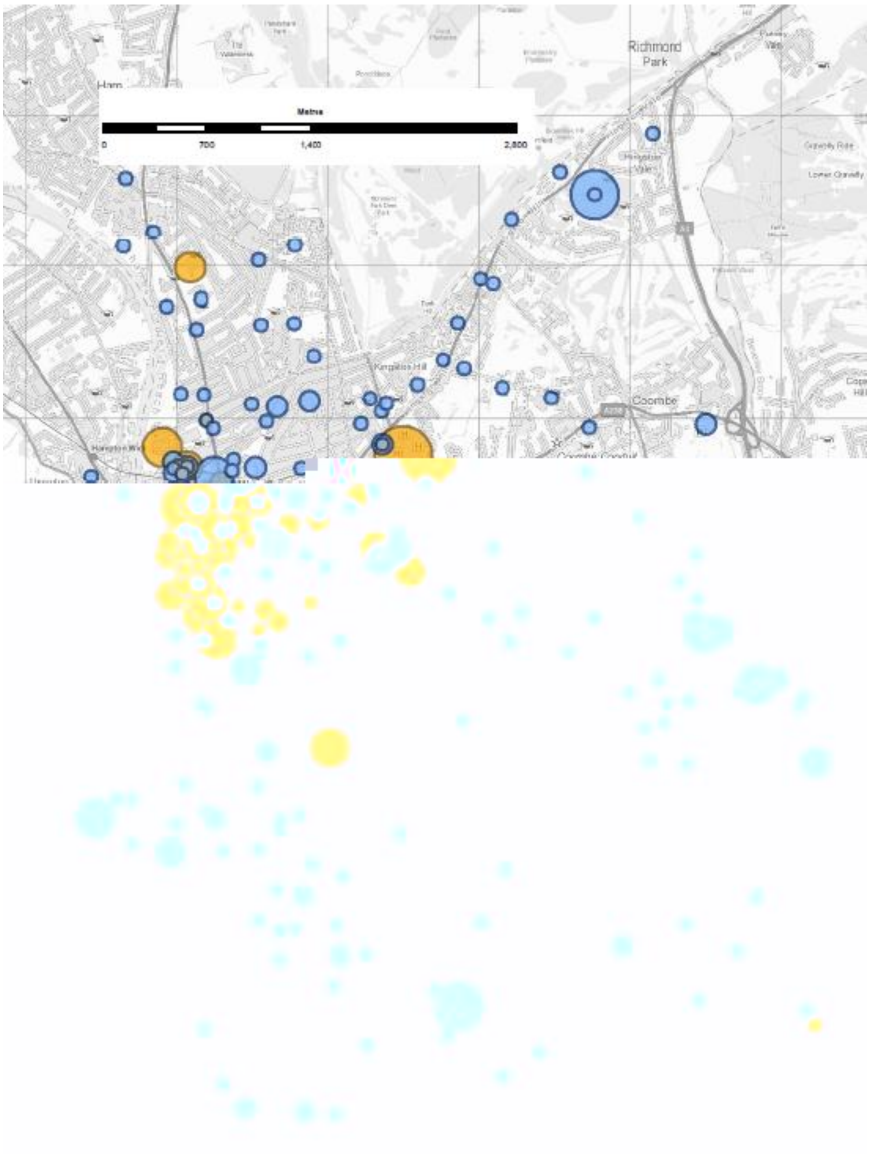

Figure 5 Kingston wider area heat demands identified from URS (2010) and Aecom (2013)

The potential supply options to meet these heat demands draws on previous assessments by AECOM (2013) for the Kingston Town Centre area and undertake a qualitative assessment of their land take, technical and carbon performance to shortlist options for techno-economic appraisal. A key part of the supply analysis is the identification and evaluation of potential energy locations suitable for the various supply options. Building on the previous work undertaken in the area, desktop studies and stakeholder engagement a number of sites were shortlisted for further techno-economic appraisal.

The potential DH network route is then determined based on the spatial arrangement of the heat demands and location of potential supply options. The DH pipework is sized based on the connected heat demands utilising the various building profiles to determine the peak heat demand of each heat customer as well as considering the future expansion of the network based on the previous study undertaken by AECOM (2013).

The feasibility of the DH network route is assessed in further detail through desktop studies, route walkovers and any available utility information to refine the routing and highlight any sections which may present difficulties in installation a DH network and therefore any feasibility study risks.

The costs assembled for the various aspects of the techno-economic model are based on published and Arup benchmark data for capital, operation and maintenance costs. The scheme's revenues incorporate previously undertaken Arup research into the market price of heat at retail and wholesale prices as well as any potential electricity sales and RHI revenues.

Once all elements are assembled into the techno-economic model, a variety of network scenarios are tested by starting with all loads connected and then turning off loads progressively to identify the impact of each connection on the commercial viability of the network. The output of this analysis is a core DH network in the Kingston Town Centre area which can be implemented in various phases depending on the potential customer connection dates which meets the target commercial viability threshold. This core network is evaluated against the various energy supply options and associated energy centre locations with further refinement to the connected heat customers if necessary.

As the DH network is developed and agreed, a number of workshops with the Council and ongoing discussions are used to test various commercial delivery options leading to a shortlist presented in this report.

3 Demand analysis

This section describes the demand analysis of potential heat customers undertaken in the Kingston Town Centre area.

A number of customers previously identified in the URS (2010) and AECOM (2013) studies were found either to be technically unsuitable for connection due to the current heating systems being individual apartment electric heating systems. Connections to buildings with individual apartment electric heating systems requires a significant investment cost for connection with the requirement to install wet heating systems within each apartment as well as additional secondary distribution pipework in the building which may not be technically feasible depending on the current available space.

Further information from the initial heat demand assessment can be found in the Appendix A1.

The final identified list of potential heat demands to be evaluated with techno-economic modelling are illustrated in the Figure 6 below and outlined in the Table 1. Table 2 describes the connection confidence of the potential heat customers.

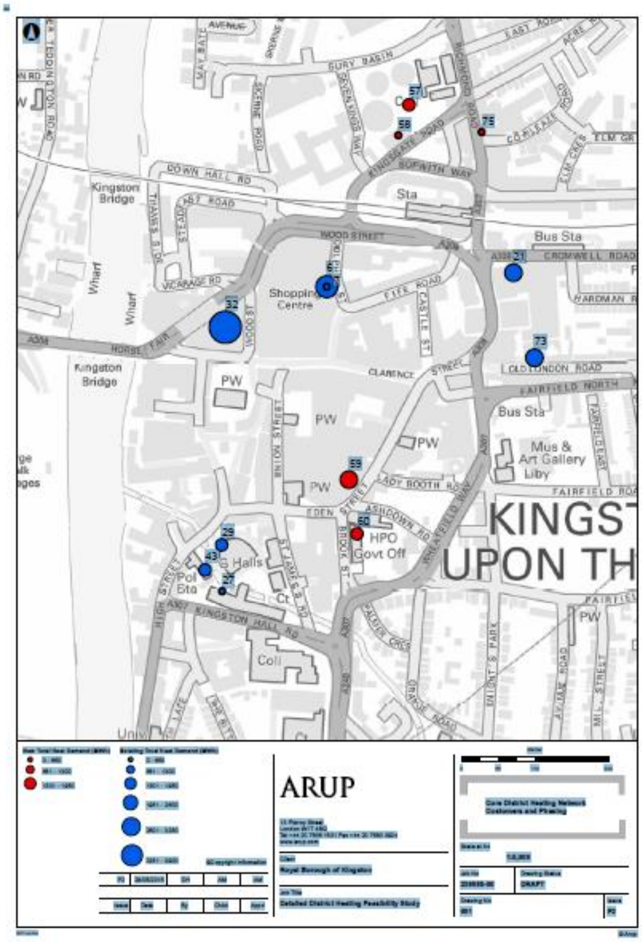

Figure 6 – Kingston Town Centre potential heat customers

Although there are a number of large heat loads, some of them were not suitable for connection to an initial DH network for various reasons (e.g. plant replacement cycles) the potential for expansion and connection to a potential Kingston Town Centre DE network in the future should be considered.

The core scheme's techno-economic performance will be discussed in Section 6.

Table 1 Kingston Town Centre potential heat demands information

Customer	Map Reference	Heat Demand [MWh/year]	Peak Heat Demand [MW]*	Connection Year
Bentall Department Store	6	2,426	0.98	2023
Bentall Centre	7	352	0.14	2023
David Lloyd Gym & Rotunda	21	1,360	0.42	2017
Guildhall	27	425	0.16**	2026
Guildhall 2	29	707	0.26***	2026
John Lewis PLC	32	3,787	1.53	2023
Kingston College	35	397	0.25	2017
Kingston College North – Kingston Hall Road	36	1,153	0.74	2029
Kingston College South – Kingston Hall Road	38	1,153	0.74	2029
Kingston Crown Court	39	2,000	0.73	2029
Kingston Police Station	43	500	0.18	2026
Marks & Spencer Ltd	55	960	0.39	2023
Primark	61	105	0.04	2023
Surrey County Hall	70	2,450	0.90	2029
Travelodge Central	73	1,529	0.52	2017
Kingsgate House – Goldcrest Development	58	649	0.25	2017

Customer	Map Reference	Heat Demand [MWh/year]	Peak Heat Demand [MW]*	Connection Year
Eden Walk – British Land Development	59	1,600	0.61	2017
Old Post Office – St. George Development	60	1,466	0.59	2017
Kingston Gala Bingo Development	73	429	0.16	2017

* Peak heat demand calculated from Arup annual building profiles utilising heat demand information provided. Installed peak heating capacity may be different.

** Heat demand for Guildhall has been reduced from previous gas metered data due to potential forthcoming energy efficiency Re:FIT measures.

*** Heat demand for Guildhall 2 has been reduced from previous gas metered data due to potential forthcoming energy efficiency Re:FIT measures.

Table 2 Kingston Town Centre potential heat demands characterisation

Customer	Map Reference	Connection Confidence
Bentall Department Store	6	**Medium / Low:** Known communal boiler heating system although interest for connection and plant replacement date currently unknown. Large heat demand connected to the scheme would increase overall carbon savings.
Bentall Centre	7	**Medium:** Small common boiler heating system although interest for connection if there is a business case. Plant replacement estimated 2020 ahead of current 2023 connection date in analysis.
David Lloyd Gym & Rotunda	21	**Medium:** Known communal heating system although plant replacement date and interest for connection is unknown.
Guildhall	27	**High**: Communal heating systems suitable for connection and high interest for connection to a low carbon network. Location of plantroom in the Guildhall facilitates a simple connection however location of plantroom in Guildhall 2 at roof level may require external pipework if alternative route cannot be located through the building.
Guildhall 2	29	
John Lewis PLC	32	**Medium:** Communal heating system however current plant replacement estimated 2025 with a current connection date of 2023. Interest in connection to a DH network is primarily led by the potential carbon savings as well as the heat price to determine if there is a business case for John Lewis to connect.
Kingston College	35	**Medium:** Communal heating system although the plant replacement cycle, interest and drivers for connection are unknown.

Customer	Map Reference	Connection Confidence
Kingston College North – Kingston Hall Road	36	**Medium / Low:** Communal heating system with previous studies and investigation undertaken by Aecom (2013). The plant replacement date and connection interest is unknown.
Kingston College South – Kingston Hall Road	38	**Medium / Low:** Communal heating system with previous studies and investigation undertaken by Aecom (2013). The plant replacement date and connection interest is unknown.
Kingston Crown Court	39	**Medium / Low:** Communal heating system available for connection although connection interest and drivers unknown.
Kingston Police Station	43	**Medium**: Communal heating system although plant replacement date is unknown. Connection interest and drivers unknown.
Marks & Spencer Ltd	55	**Medium:** Communal heating system although the plant replacement date is unknown. The connection interest to a DH network is known although Marks & Spencer have very public sustainability drivers which may motivate a connection.
Primark	61	**Low:** The heating system, plant replacement dates, connection interest and their drivers are unknown.
Surrey County Hall	70	**Medium / Low:** The heating system is communal however consultation with the Surrey County Hall revealed the current plant replacement cycle is likely to occur in the next few years. Interest in connection primarily heat price and whether there is a business case for connection.
Travelodge Central	73	**Low:** The heating system for the Travelodge is unknown along with its connection interest and drivers.
Kingston Gas Holder Site	57	**Medium:** Planning consent granted although the proposed system is a communal heating system incorporating a CHP engine therefore compatible with future connection and high likelihood of interest for connection since communal system is already proposed. Minimal design changes required.
Kingsgate House – Goldcrest Development	58	**Medium:** Planning consent granted and proposed heating system unknown. No energy strategy submitted at this stage.
Eden Walk – British Land Development	59	**High:** High level of interest in connection to a DH network. The current proposed energy strategy of a communal heating system with a small gas fired CHP is compatible with future connection.
Old Post Office – St. George Development	60	**High:** High level of interest and site wide heating system proposed.
Kingston Gala Bingo Development	73	**Medium**: Planning consent granted although communal heating system with a small scale CHP system proposed therefore connection possible.

Customer	Map Reference	Connection Confidence

3.1 Summary of stakeholder engagement

All key stakeholders identified were issued a data request pro forma and attitude survey. In most cases this was returned swiftly and with information of suitable quality for the needs of the analysis. The below table presents a summary of this engagement.

Table 3. Summary of stakeholder engagement

Stakeholder	Considerations	Appetite
Old Post Office Development: St. George	Residential led development in Kingston Town Centre on the site of the old H&M Customs office and Old Post Office being managed by St. George. A planning application has been submitted for up to 380 residential dwellings along with a small non-domestic area with initial phases planned to be complete in 2017. Suggested energy strategy incorporates a small CHP engine to supply a site wide heating network.	Engagement with St. George indicated a very high level of interest in connecting to a DH network was available at the time of completion since it is required to construct a basement plant area specifically for its heating systems. The key interest is in regards to the cost of connection to the DH network and the associated carbon emissions associated with the connection. Timing with the completion of the initial phases of the development are crucial to connection.
Eden Walk Redevelopment: British Land	A mixed use redevelopment of the existing Eden Walk shopping centre. To incorporate an additional 324 dwellings and up to 20,000m^2 of non-domestic retails floor space. Currently in pre-planning application discussions with the Council although following discussions current energy strategy incorporates a gas fired CHP engine and boilers to provide heat to the entire site.	British Land have a very high level of interest in connecting to a DH network if one was available at the time of completion. The key factors for British Land was the timescale of development along with the available heat load and tariff rates for connection. As with the Old Post Office development, the timing of the completion of the network with the completion of the initial development phases are crucial to connection.

Stakeholder	Considerations	Appetite
Royal Borough of Kingston	The Council own a number of properties within the Guildhall complex which house the majority of their offices. The Council does not own or manage any residential buildings within the Kingston Town Centre area. There are a number of potential development sites on Council owned land in the Eden Quarter which are being progressed.	The Kingston Council is supportive of a DH scheme in the Kingston Town Centre and through its planning department encourage the connection for new developments as well as its own buildings subject to the heat tariff presenting a saving on the Council's heating systems. The Council is reluctant to own and operate a DH scheme however preferring a third party ESCo own and operate the scheme. This will be discussed in further detail in Section 8.
Kingston University	Kingston University has interests and owns a number of properties across the borough with the Penrhyn Campus at the south of the Kingston Town Centre area being one of the key interests considering its size, sustainability drivers and preliminary plans to implement a 600kWe CHP engine and site wide heating network on the Penrhyn Campus.	The University was considered both as a candidate for connection to the DH network as well as supplying part of the network utilising its excess heat produced from the engine on the Penrhyn campus. Although strong drivers for sustainability the consideration of the business case for the investment is key for the University for the Penrhyn Campus CHP engine. There was insufficient space on the campus to install the necessary heat generation to supply the wider DH network solely from the campus. The findings from the initial analysis for the University as both a customer and supplying part of the network heat demand indicated the cost of connection was not justified through the heat sale revenues.

4 Supply analysis

A district heating network can be supplied by a variety of low carbon technologies with a number of possible back-up technologies. Different supply technologies were evaluated according to their suitability across a range of sites along the heat network. The options described in this study are usually designed for operation in conjunction with the electrical grid connection, contributing to the baseload of a building or site and thereby offering resilience to systemic failures.

4.1.1 District heating CHP with gas boilers

Combined heat and power (CHP) integrates the production of usable heat and power (electricity), CHP systems capture the heat released during the power generation process, resulting in increased energy efficiency. CHP is the most common technology for baseload generation in mixed land-use and high density modern developments.

The heat to power ratio normally determines the size of the gas CHP unit that is viable for a given building or site load. The typical target for CHP engines are to ensure at least 6,000 running hours per annum (out of a total of 8,760 hours in a year).

A well-designed gas CHP can reduce carbon emissions due to its higher efficiency compared to the alternative case of conventional gas boiler and grid electricity produced mostly by large distant “power only” power stations. As in the case of all other embedded generation options presented here, gas CHPs located close to the point of consumption eliminate electricity distribution losses and therefore reduce carbon emissions.

Typically a CHP system provides the best economics when all electricity is consumed locally, i.e. to offset electricity imported from the grid due to the low export price normally obtainable by a small electricity producer.

Although CHP engines would be installed in modular units, the viability of the CHP investment will be poor until the heat network builds up to a sufficient load to ensure steady operations of the engines. Overall, a hybrid approach where boilers are used to provide top-up heat yields better resilience for the heat network (and better economics). Gas boilers are the most conventional solution for heating in the UK. Gas boilers provide top up and back up when deployed in conjunction with any other technology option discussed here. They are likely to offer the cheapest solution even with the subsidies available to the renewable alternatives discussed here.

4.1.2 Air-source heat pumps

Air-source heat pumps (ASHP), ground-source heat pumps (GSHP), and solar thermal generation were also investigated as alternative heat-only supply options.

Their essential advantage is that they move the heat that already exists and hence do not require that heat to be generated.

ASHPs work like back-to-front refrigerators; turning a unit of high-grade electrical energy into multiple units of low-grade heat energy. This ratio of input electric power to output thermal power is called the coefficient of performance (COP). The COP varies through the year depending on the temperature of the air as well as the required heating output temperature from the system. Warmer air gives a higher COP while the higher the supply temperature, the lower the COP. Average – or seasonal – COPs for ASHPs are typically around 2 to 3.

ASHPs are eligible for Renewable Heat Incentive (RHI) payments providing an additional potential revenue subject to meeting minimum efficiency criteria. The potential future electricity grid decarbonisation could result in future carbon emission reductions as the ASHP supply option energy input is grid electricity.

ASHPs have a relatively low power density which means they need large areas of floorspace to meet the required peak heating demand. They also require large volumes of air intake and discharge to extract any available heat, offering limited economies of scale. ASHPs are more typically suitable for individual building solutions rather than for a centralised energy centre powering a heat network.

Nevertheless, ASHPs typically represent the poorest heat pump option, with ground source, water source and other secondary heat source heat pumps offering higher COPs and therefore better carbon performance.

4.1.3 Ground-source heat pumps

A ground source heat pump system in its most basic form consists of pipes buried in the shallow ground near the building, a pump and a heat exchanger. Deep boreholes (typically 100-200m in depth) are an alternative method of extracting heat which results in a more constant temperature as it is less subject to variations in ambient air temperature as well as higher levels of heat extraction.

The system can be used for a variety of applications including preheating of domestic hot water and space heating. The heat pump can also be reversed in the summer to provide cooling with a separate cooling network. A typical seasonal COP for a well-designed GSHP system is around 4.

Unless the GSHP is assisted with a mechanism for replacing the heat extracted from the ground, it will get increasingly costly to extract heat from the ground that is getting cooler. Inter-seasonal heat transfer is good engineering practice to avoid this. ASHPs and GSHPs are best suited for low temperature heat networks, generally requiring boiler top-up if they are to be used on high temperature networks (and to cope with winter peak demand).

A large floor area is required to extract the necessary heat for a GSHP system to serve a large DH network for the installation of both buried pipes and deep boreholes (which typically require 9m separation between boreholes) therefore extremely large brownfield sites are often necessary to install such a large system. The nature of the development sites within Kingston Town Centre does not make this a suitable technology to supply the DH network.

4.1.4 Water source heat pumps

A water source heat pump operates on the same principle as a ground source heat pump extracting heat from large bodies of water using a heat exchanger. Water source heat pumps operate with similar efficiencies to GSHP systems with seasonal COP's around 4.0 depending on the output temperature of the heat pump and the temperature of the body of water. The greater the water source temperature, the greater the COP of the system and conversely, the lower the output temperature the higher the COP of the system.

Aquatic ecology impacts from WSHPs for heating are less of a concern than for cooling. The removal of heat from the water source will cool the water and thereby help to raise dissolved oxygen compared with the use of water sources for cooling (i.e. to reject heat) which has a higher ecological risk. The water abstraction system would be required to install the necessary filters and cleaning systems to comply with the recently introduced Eel Regulations (January 2010) implemented to protect eel species from river obstructions and abstraction systems.

The WSHP is one of the least established DH network supply technologies with only a few examples worldwide with the technology being implemented in wider DH networks. For example in Drammen, Norway, 14MW of heat pumps have been installed extracting heat from seawater.

The location of Kingston Town Centre adjacent to the River Thames presents an important potential supply option for a DH network. However, the installation of a large scale heat extraction system from the river may be problematic if introduces a hazard for vessels navigating the river. The location of the water abstraction system and equipment is crucial to mitigate this risk as demonstrated by the recently installed and operational River Thames abstraction system supplying localised heat pumps to the Kingston Heights development.

4.1.5 Solar thermal

Solar thermal systems collect solar energy to generate heat. Solar thermal technologies are well-suited for use in urban areas and widely used in many cities. The main applications in the UK are for heating domestic hot water (DHW). Other uses are possible but the limited yield normally makes it more suitable to focus on a single specific use.

Commercial solar water heating technologies are mature and there are no fundamental technical issues remaining- however since each installation is unique, technical competence in system design, specification, construction and support is essential. Solar thermal technologies continue to evolve in terms of improved performance, lower costs, greater flexibility and lower deployment costs.

Solar thermal might be compatible with a low temperature heat network powered by heat pumps or boilers, but it would be less compatible with a CHP engine, since the solar thermal contributions would reduce the running time of the CHP or would mean a smaller engine was specified.

There are a number of examples of solar thermal systems being used to feed DH networks throughout Western Europe however these typical require large roof or land areas to concentrate the position of the solar thermal system and feed into the wider DH network in a single location providing both technical and cost benefits. In the UK, winter performance can be significantly reduced versus summer levels.

The nature of Kingston Town Centre and the absence of a large new development proposing a large solar thermal installation makes this technology unsuitable as a key supply technology for the DH network.

4.1.6 Conclusions

Of the various potential supply technologies considered, the two key technologies which would be suitable for a DH network in the Kingston Town Centre are the gas fired CHP and WSHP systems with gas boilers to cover the peak load. CHP systems are a well-established technology in DH networks often providing the most attractive commercial case for a project. The location of Kingston Town Centre and the availability of a significant secondary heat resource in the form of the River Thames make WSHP an attractive option for a DH network supply technology further reducing the town centres dependence on fossil fuels in the form of natural gas.

4.2 Energy Centre Locations

The potential energy centre locations evaluated in this study are developed on previous studies from Aecom (2013) which have been reviewed and developed further. Earlier studies identified a number of potential energy centre locations including distributed energy centres, Hogsmill sewage treatment works and one of the new developments coming forward in Kingston in the near future.

The location of the energy centre impacts both on the potential construction costs of the energy centre as well as the cost of the DH network. The location is key since dictates the required pipework sizes to supply heat to all of the connected customers. Energy centres supplying heat at the end of a DH network will require larger pipe sizes to accommodate the cumulative heat demand of all of the connected buildings at the other end of the DH network. Whereas, an energy centre located centrally in a network should reduce the cumulative heat demand connected to the key transmission pipes and therefore the size and cost of the pipework to supply heat to all connected customers.

Following a review of the previous energy centre location suggestions proposed in earlier studies as well as incorporating recent changes and developments in the Kingston Town Centre area, four key energy centre locations have been identified. These are illustrated in Figure 7 below.

Figure 7 Kingston Town Centre energy centre locations (numbered below)

The four key locations are summarised below and are covered in further detail in the Appendix A2.

1. **Ashdown Road Car Park**: Owned by the Royal Borough of Kingston and currently operating as a surface car park. The car park is located adjacent to the two large new developments (Eden Walk and the Old Post Office) and anchor loads in Kingston Town Centre as well as close to the key DH network transmission route passing through the town centre area minimising the cost associated with the DH network. As the car park is currently operational and represents a revenue stream for the Council, the land value of £5/ft^2 as per the Council's guidance has been taken into account in the techno-economic modelling. This is considered to be the preferred location of the energy centre and is used as the location for the modelling of the baseline CHP supply solution.

2. **Split energy centre in British Land and St. George:** Two large new developments in Kingston Town Centre both proposing site wide communal heating systems and CHP engines as well as being key heat loads, offers the opportunity to collocate an energy centre across the two developments.

3. **Bus Station and Car Park:** An alternative location for the energy centre is also a surface car park owned by the Royal Borough of Kingston. Located further to the east of the main DH network route, an energy centre located in this area would increase the required DH network length and associated costs however presents a good alternative to the Ashdown Road Car Park if it the Ashdown Road car park was no longer available.

4. **Eagle Brewery Wharf:** This location has been proposed as a location for a water source heat pump energy centre however there is a high level of uncertainty regarding the potential use of this riverside open space and whether development or construction of an energy centre would be permitted. Any energy centre in this location may have to be located below ground at significant additional cost for the associated civil engineering works. As per the Ashdown Road car park, the use of the land

owned by the Council has been taken into account in the techno-economic modelling at a rate of £5/ft^2 as per the Council's recommendations however it has been advised this is likely to be too low for the loss of riverside open space.

4.3 The Kingston energy supply solution

There are a number of energy supply solutions which are technically viable to supply the Kingston Town Centre DH network however considering the various technical aspects and the assets of the area the two key supply technologies suitable for the DH network are;

1. CHP and gas fired boilers located on the Ashdown Road car park (or other town centre site)
2. WSHP located on Eagle Brewery Wharf

The supply solutions have been sized based on the potential full build out of the Kingston Town Centre network with an estimated diversified peak heating demand of 5.3MWth and a total heat demand of 19,970MWh per year.

Due to the number of existing heat customers connected to the network, the network and efficiencies of the supply solutions (in particular the WSHP) are based on DH network temperatures of 80˚C supply and 60˚C return. This is to ensure that the DH network is capable of supplying all of the heating requirements for existing secondary systems which are typically designed to operate at higher temperatures than newer developments.

4.3.1 CHP solution

Based on the potential full build out of the DH network, the provisional footprint for the CHP energy centre for the Kingston DH network is estimated to be 670m^2 with an internal plantroom height of at least 5.2m to accommodate any required thermal storage over a single level. A preliminary energy centre layout is indicated in Figure 8.

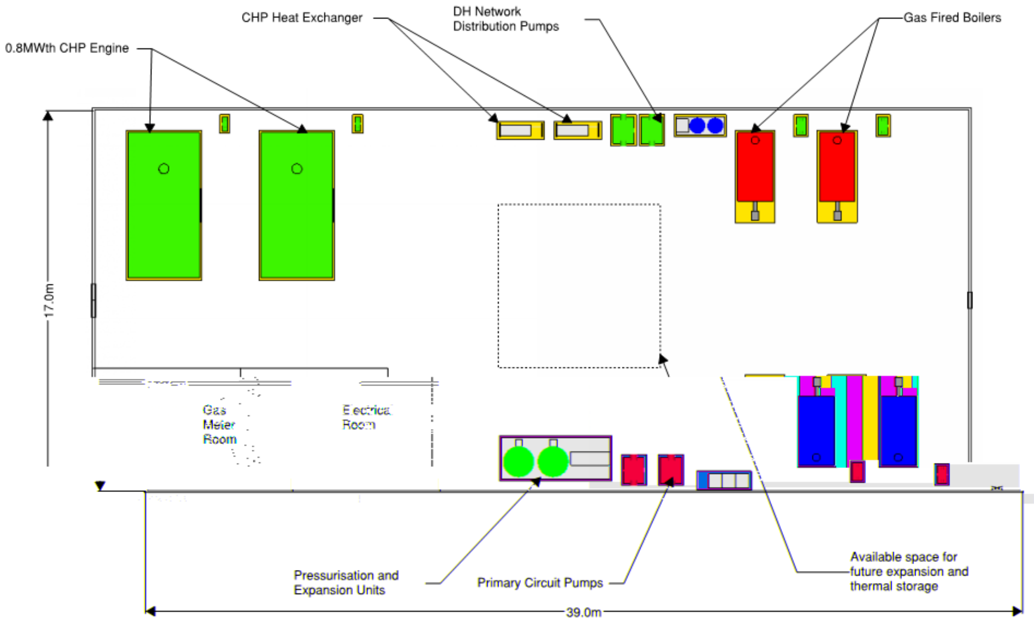

Figure 8 Preliminary CHP supply option energy centre layout

For a split energy centre (either across two levels or for example across two separate sites as per the colocation between the Eden Redevelopment and the Old Post Office Site) it is estimated that footprints of 435m^2 (to accommodate the necessary CHP plant and ancillary equipment) and 345m^2 (to accommodate the boiler plant) is required. Separating the energy centre over two levels or two locations results in a small space efficiency loss requiring a total area of 780m^2. The split level energy centre preliminary energy centre layout is provided in Appendix A7.

There are a number of additional design considerations for a CHP solution for example the required height of the flue taking into account neighbouring buildings, air quality requirements for Kingston Town Centre which may require higher levels of filtration and utility connections in the area. In areas of constrained gas and electricity utility capacity, new connections to the utilities can incur high costs especially if the connection requires network reinforcement which is included as an additional cost to the new connection. Additionally, power export to the local electricity network may be restricted. It is currently assumed that electricity export from the CHP energy centre to the local electricity network is feasible however if the CHP supply option is selected and developed further UK Power Networks (UKPN) should be consulted to begin the approvals process for grid connection.

The network routing and techno-economic modelling of the gas fired CHP solution that follows this section are based on the assumption that the energy centre is located in the Ashdown Road car park.

4.3.2 Water Source Heat Pump Solution

Based on the potential full build out of the DH network, the provisional footprint for the CHP energy centre for the Kingston DH network is estimated to be 830m^2

with an internal plantroom height of at least 5.2m to accommodate any required thermal storage over a single level (see Figure 9 below).

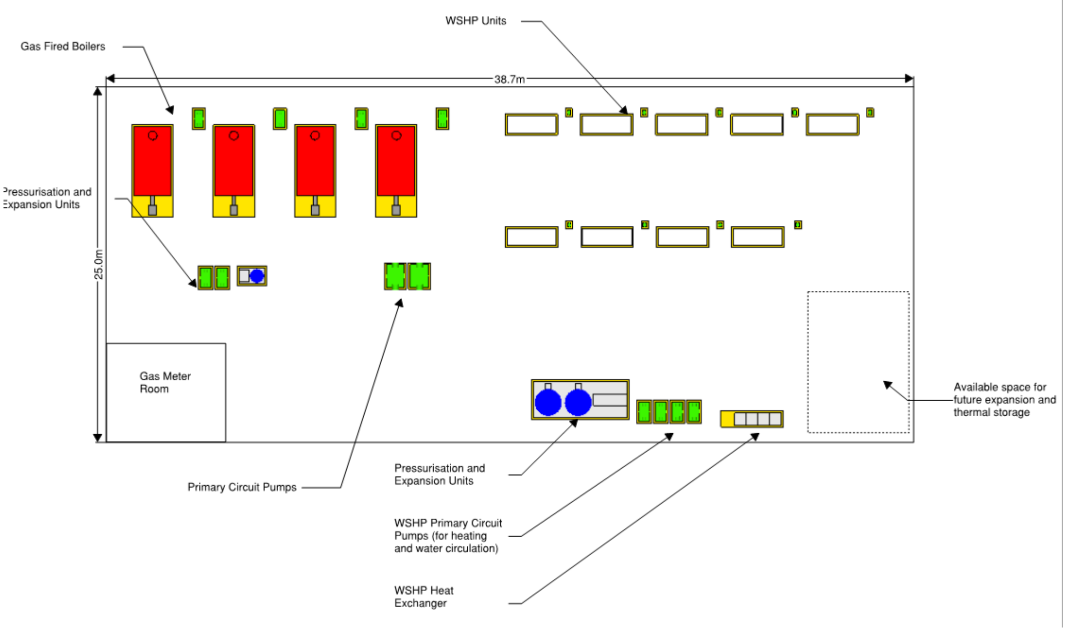

Figure 9 Preliminary WSHP energy centre layout

For a split energy centre over two levels, it is estimated that footprints of 440m^2 and 345m^2 is required to accommodate the WSHP and boiler plant required respectively. Additional area may be required close to the water abstraction location to accommodate any additional filters or equipment which might be required for the water intake.

The heat demand development is identical for both supply options however the phasing and installation of the WSHP is more flexible than the CHP option as heat pumps have a greater turndown and ability to meet fluctuations in heat demand.

The WSHP solution is assumed to be located at Eagle Brewery Wharf as described previously to be located adjacent to the River Thames and minimise the distance required for any water abstraction pipework. There are numerous ways to extract heat from bodies of water ranging from a water abstraction system to the use of large heat exchangers placed directly in the water. Placing heat exchangers in the River Thames and the introduction of objects which may impact on the navigable depth of boats is generally not permitted therefore it is likely an abstraction system would be required to transport the water to a heat exchanger located in a plantroom. On passing through the heat exchanger, the available heat is extracted and returns the water to the River Thames between 3-6˚C cooler than the intake.

The network routing and techno-economic modelling of the WSHP solution that follows this section are based on the assumption that the energy centre is located at the Eagle Brewery Wharf.

4.4 Future Low Carbon Solutions

The typical life of a CHP engine is around 15 years, therefore based on the current estimated phasing and development of the Kingston network the first cycle of plant replacement will occur around 2030. Based on DECC projections of grid carbon intensity, it will be necessary to introduce new sources of generation to continue to achieve a lower carbon network than the alternative of grid electricity and gas boilers which will be particularly important for the expansion of the network to new developments requiring to meet new building regulations and what are likely to be more stringent carbon targets.

The focus of this study has been on identifying a commercially viable delivery strategy to initiate a low carbon decentralised energy network in Kingston which has identified two potential supply solutions (the WSHP and CHP solution). The CHP-led solution meets these criteria (discussed in further detail in Section 6) against the business as usual case under today's building regulations and grid electricity carbon intensity.

In addition to grid decarbonisation, technological development and scaling up of production of alternative heat supply systems over the next 10-15 years will present a different set of commercial and carbon choices in the 2030s than are currently available today. The value of investing in a district heating network today in Kingston is to create a heat supply infrastructure which will widen the choices available to decision makers at that time and enable supply switching to take place on a system wide scale to viable alternative heat supply sources for example WSHP. Recommendations for "future proofing" the network to allow for that supply switch in the 2030s are identified in Section 9, Risk Assessment.

5 Network Routing

This section summarises and discusses the routing and phasing strategy of the DH network through Kingston Town.

The DH network is proposed to be installed across four distinct phases beginning with the connections to all of the new proposed developments (both at the Gas Holders site and the larger town centre developments) in the first phase. On construction of the first phase of the network, the identified potential non-domestic connections along this route are also considered to be connected in this phase. The second (connection of John Lewis and the Bentalls connections) and third phases (Guildhall complex) are installed in 2023 and 2026 respectively to align with the estimated plant replacement dates of the non-domestic connections. The potential fourth phase of the network extends the network south towards the Surrey County Hall and connects the Crown Court and Kingston College. The connection of the fourth phase is not economically viable at this stage of the network development the fourth phase is not considered to be installed at this stage. The key issues relating to the installation of the wider DH network (including the fourth phase) will be discussed below for future consideration.

The core scheme is to link a potential energy centre at either the Ashdown Road energy centre or the Eagle Brewery Wharf to connect to the Guildhall complex, the two key developments in the town centre and additional retail loads to the north of the town centre.

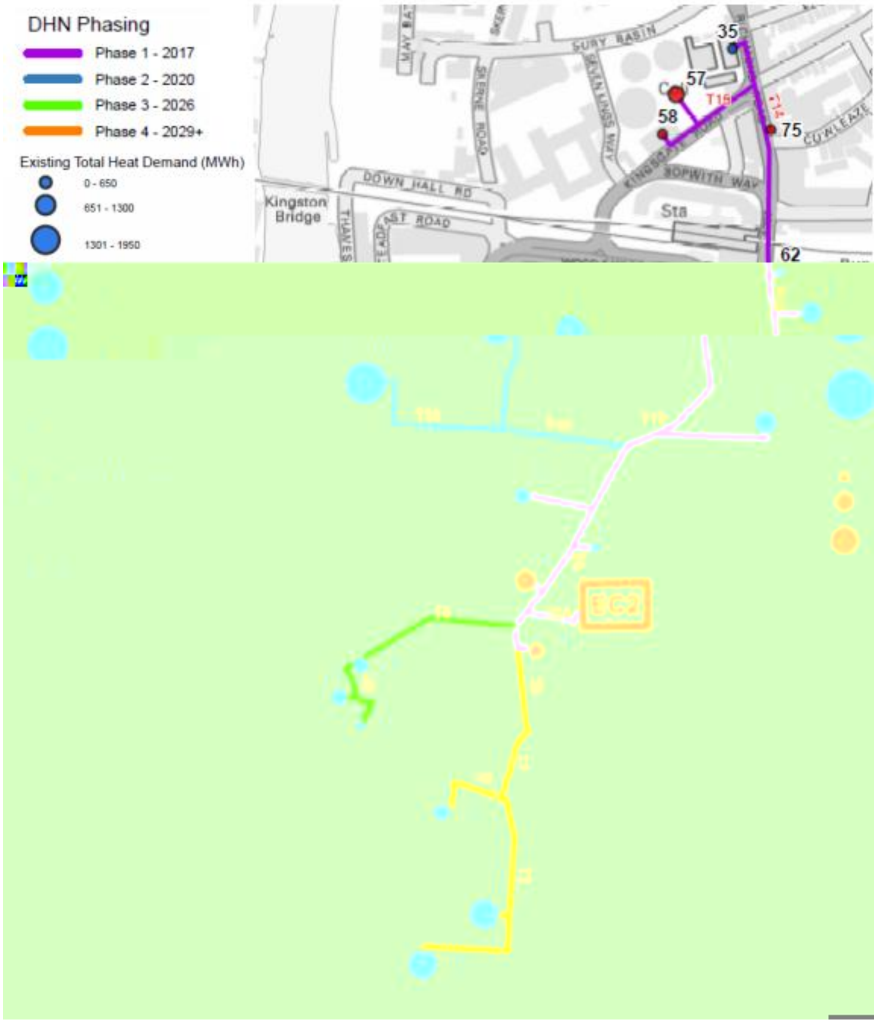

Figure 10 Kingston Town Centre DH network route and preliminary phasing for the Ashdown Road car park energy centre location

The DH network has a core spine running through the middle of the Kingston Town Centre along Eden Street and then north along Wheatfield Way. The location of the various energy centres impacts the location of connection to the network and the associated costs and network pipe sizes. The closer the energy centre is located to the core network, the lower the cost of the required pipework. The energy centre location will also impact the required length of pipework that is required to be future proofed for future expansion of the DH network.

A route feasibility assessment was undertaken with site visits and high level analysis of available utility information to determine any potential areas of difficulty for the installation and routing of a DE network through Kingston Town Centre. This is key to determine any sections of the network which may present additional cost or technical difficulties as well as optimise the route to reduce the overall distance and associated cost.

Following the network routing study, a number of areas were identified which would require further investigation due to there being large utilities for example along Penrhyn Road, Kingston train station and along Brook Street which has a number of utilities passing down the carriageway as well as surrounding large trees which may pose obstructions to passing pipework. The carriageways in these areas are wide therefore it is unlikely that the pipework will be unable to pass through these areas although further utility surveys and trial holes will be required to determine the precise pipework routing. Further information on the route feasibility assessment and utility information can be found in Appendix A3.

5.1 Hogsmill River Crossing

One of the key sections identified in the DH network feasibility assessment is the crossing of Hogsmill River for the development of the network south of Kingston Town Centre towards Kingston College and Surrey County Hall if these are deemed suitable for connection in the future.

There are two existing bridge crossing of Hogsmill River, one across St. James's Road and one across Wheatfield Way. The current network route proposes the crossing of Hogsmill River across Wheatfield Way as discussed in Appendix A3.2.2.

Figure 11 Hogsmill River crossing along Wheatfield Way

One of the determining factors regarding the future routing of the network for connection to the south of Kingston Town Centre is the feasibility of the network crossing the river using one of the existing bridge crossings. As discussed in Appendix A3, there are currently existing utilities which cross Hogsmill River however the precise location and routing of these utilities are not known. The crossing on Wheatfield Way is more recent therefore there may be a utility services provision within the crossing for the installation of future utilities. The bridge design and potential utility crossing provision at both Wheatfield Way and St. James road should be investigated further. If no existing utility service corridor can be utilised at either of the bridge crossings further work would need to be undertaken to determine the potential crossing either under the Hogsmill River or crossing attached to either of the bridges and determine whether the bridges would be able to support the additional load of the network pipework.

5.2 Phased build-out of the network

The overall scheme of the network is built out over a 10 plus year programme in three distinct phases beginning with the connection to the large new developments in Kingston Town Centre. The full build out of the network is predicted to occur in 2026 with the connection of the third phase to the Guildhall complex and Council owned buildings.

The network is modelled both on transmission and distribution pipework based on the spatial layout of the connected heat loads.

5.3 Phasing considerations

Construction of transmission and distribution pipelines is assumed to precede the phasing of the related developments by a year. One-year construction periods are allowed for the distribution pipes to be ready for connection to the secondary heat systems at the dates of development phase completion.

5.3.1 Timeline

The first phase of the DE network is dictated primarily by the two large new developments in the Kingston Town Centre (the Eden Walk redevelopment and the Old Post Office site development). It is crucial that the first phase is operational prior to the completion of the two large developments otherwise the connection to the two developments may be missed until their next plant replacement cycle dates. This would have a significant impact on the commercial viability of the network since it the network would not benefit from any future developer contributions from the two developments due to the DE network providing several avoided cost benefits.

The first phase also connects to the new developments at the Kingston Gas Holders site (including Kingsgate House and the Kingston Gala Development) to ensure that the new developments are connected prior to completion. The connection to the Kingston Gas Holders site in the first phase significantly increases the potential first phase of the network with a total installed network length of 1,350m.

5.3.2 Existing Plant Replacement

The phasing for the future phases of the DE network is primarily dictated by the future potential plant replacement dates for the various connections from information provided by the various stakeholders throughout the feasibility study. The second phase of the network to connect the Guildhall complex is based on preliminary estimates for the replacement of plant in the Guildhall and Guildhall 2 buildings within the next 5 years. Similarly, phase 3 of the network in 2023 is on the basis that the plant replacement cycle for the Bentalls Centre, Bentalls department store and John Lewis will be around this time. The plant replacement date for the Bentalls Centre is known in 2025 along with the John Lewis predicting that major replacement of its heating system will be in 2023, the replacement cycle for the Bentalls department store is unknown. At this stage, only estimates can be made and were provided by the various stakeholders upon which the network phasing has been based. This should be updated and reviewed in the future as more precise plant replacement dates for the various customers in the future are known as the heating systems approach their predicted replacement dates. It should be ensured that the required network branch to connect heat loads in future phases is established prior to a customers plant replacement date or temporary heating plant is supplied to ensure that the customer connects to the network in the future if the decision is made to delay investment in the network until more heat customers on the branch will connect.

5.3.3 Utility and Highway Works

Future utility and highway works along the network route should be considered for the construction and installation of future DE network phases since there may be an opportunity for cost savings by sharing the cost for any required road closures, parking suspensions and civil engineering works which can represent a significant proportion of the overall network costs. There are currently no know significant carriageway or utility works occurring in Kingston Town Centre at the time of the DE network phasing.

5.4 Costing and Future Proofing

Pipework costs account for the pairs of flow and return transmission and distribution pipes, plus the cost of trenching, installation, fitting, and burying in the varying ground conditions. The pipe diameters are sized to allow for the flow rates required to cover the connected peak heat loads with additional heat losses throughout the network.

No secondary distribution pipework within the various developments (e.g. the site wide distribution pipework for the Old Post Office development) is included in the model as the cost of this pipework would still be required for each of the developments and assumed to be borne by the developers.

The economic analysis of the scheme assumes that the ESCo will be responsible for the main DH network including all connections to the buildings along with the heat substation located in the buildings along with the supply and maintenance of Heat Interface Units (HIU) within the new developments. The secondary pipework between the heat substation and the HIUs is assumed to be paid for by the developer (or in the case of existing buildings remains unchanged) along with the tertiary pipework within each apartment.

5.4.1 Future Proofing

Although the feasibility study is focused on the development of a core DH network, consideration of the potential future development of the DH network must be taken into account considering the lifetime of the DH pipework and infrastructure will be in excess of 50 years. The key elements of the DH network connecting to the future potential loads and areas within the Kingston borough identified in the Energy Masterplan have been future proofed by oversizing the pipework to accommodate greater flow rates and therefore are able to transport a greater amount of heat.

The elements of the network which have been future proofed are illustrated in Figure 12 below with the pipework installed with a diameter of 300mm in line with the network sizes outlined in the Energy Masterplan, July 2013 for future phases. Future proofing the network has different impacts on the WSHP supply solution and the CHP supply solution due to the differing energy locations and transmission network lengths.

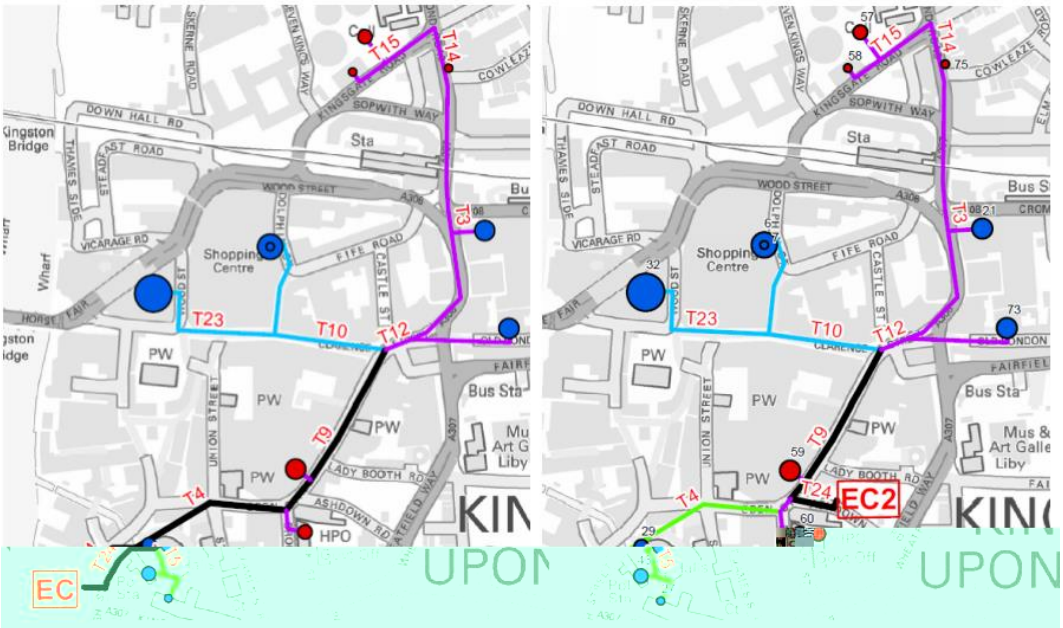

Figure 12 Future proofed elements (indicated in black) of the Kingston Town Centre DH network. WSHP energy centre (left) and CHP energy centre (right).

The future proofing of the CHP supply solution DH network results in an additional cost of £200,000 increasing the total transmission network costs from £2,100,000 to £2,300,000.

The future proofing of the WSHP supply solution network has a larger associated costs due to the increased pipework lengths which connect to the energy centre resulting in an increase in cost of £250,000 from £2,450,000 to £2,700,000.

6 Scheme Techno-Economic Performance

This section highlights the techno-economic performance of the core scheme for the two supply options presenting the key financial and technical information. The assessment of the core scheme was carried out for a 20-year project analysis period, with year 0 being 2015 and year 20 being 2035. It should be noted that the date of full build-out of heat demands on the scheme occurs after this date.

This whole-system assessment is carried out from the perspective of a single body responsible for financing, design, construction, operation, maintenance, revenue collection, and further expansion, to ensure that the overall viability of the scheme is confirmed. Section 8 explores the allocation of costs and responsibilities to the council and other key stakeholders.

The capital costs, operational costs and revenues are based on the following ownership and responsibility schematic for a third party ESCo.

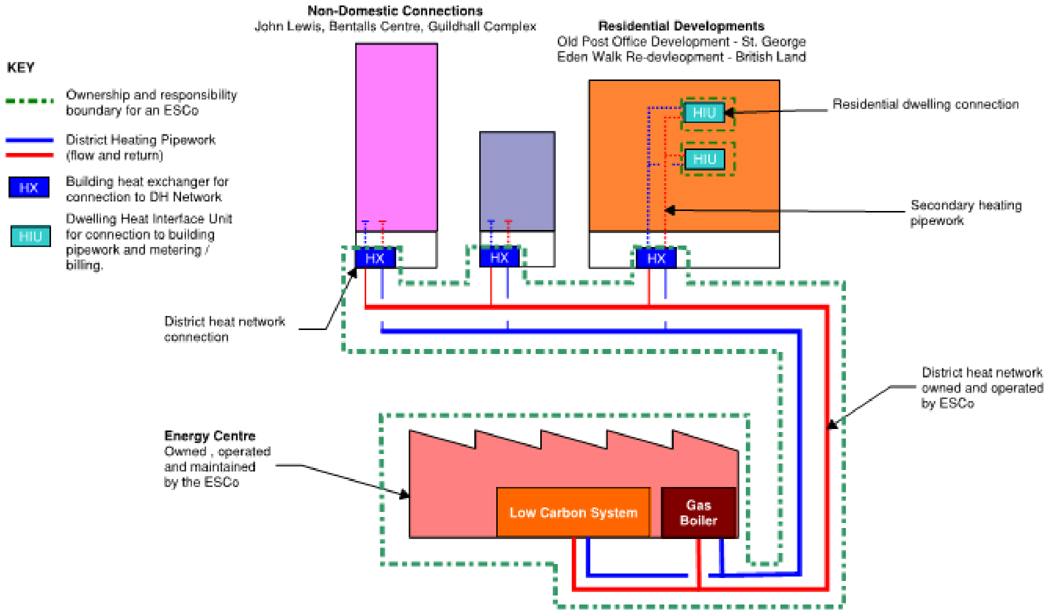

Figure 13 Kingston Town Centre ESCo ownership and responsibilities

Through the techno-economic modelling process, the potential heat demand list was further refined based on the economic performance of the various individual and groups of connections. Often, smaller heat demands do not justify the costs of connection over the course of the analysis period through the connection charge and heat revenues alone. These are therefore not connected to the initial DH network to ensure a commercially viable network is developed in the first instance. The techno-economic analysis which follows is based on the final list of core customers which have been identified as part of this initial DH network.

6.1 Scheme supply options

The two supply options which will be evaluated in the following section are;

- **Supply Option 1**: CHP and gas fired boiler energy centre located at Ashdown road car park.
- **Supply Option 2**: WSHP and gas fired boiler energy centre located at Eagle Brewery Wharf.

These two supply options and their respective DH network routes are illustrated in Figure 14 below.

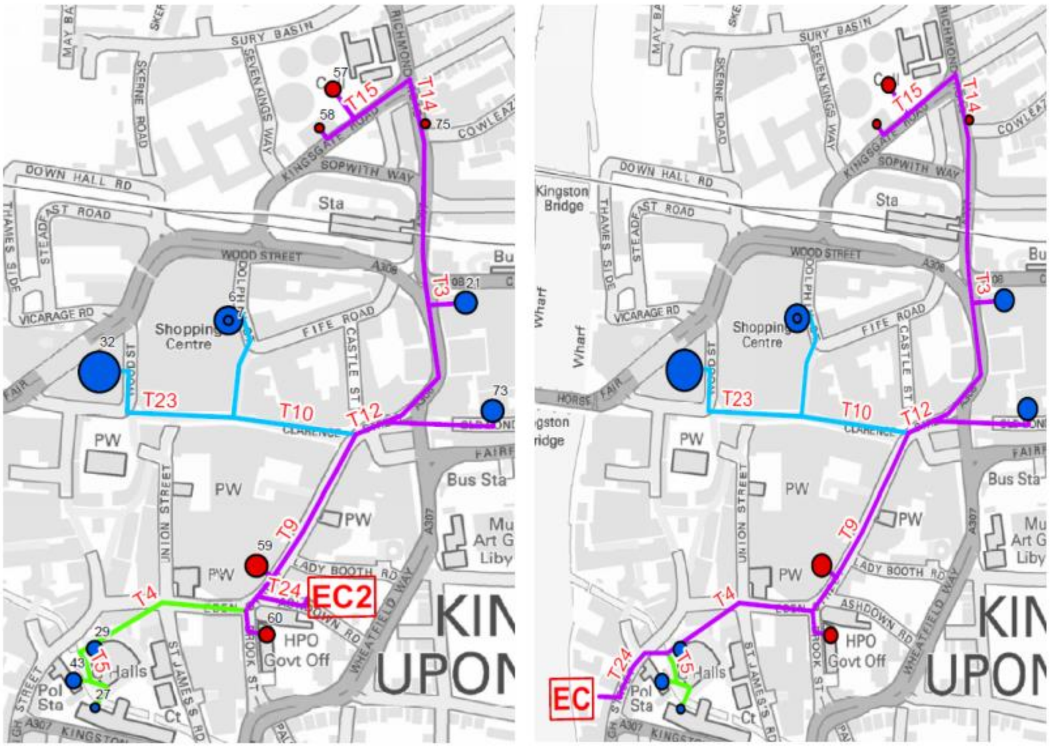

Figure 14 The CHP supply option located at Ashdown Road Car Park (left) and the WSHP supply option located at Eagle Brewery Wharf (right)

6.2 Network operating assumptions

Both supply options have been modelled assuming a 20˚C temperature difference (called ΔT) between the flow (at 80˚C) and return (at 60˚C) and a maximum pressure drop of 100Pa/m. This provides a conservative estimate on the required pipe sizes as well as a system which is capable of connecting to and supplying heat to existing building systems. An upper limit on the network supply temperature of 80˚C has been selected as this is the maximum supply temperature for the WSHP system (while still meeting the minimum required Renewable Heat Incentive efficiency requirements) to enable a more direct comparison of the two supply technologies.

The temperature difference between flow and return can have a significant impact on both the capacity and efficiency of the system. The greater the temperature difference between the flow and return, the greater the amount of heat the network can transmit for a certain flow rate. A DH network operating with a 30˚C ΔT at a specific peak heat demand would result in a reduction in the required flow rate of 33% compared to a network operating with a 20˚C ΔT. It would therefore be appropriate at the next stage of the project to determine whether a system with a larger ΔT can be delivered, leading to a reduction in pipework sizes and associated costs as well as operational savings with a reduction in pump power consumption.

In addition to temperature difference, the actual temperatures are also important considerations. Lower temperature systems (such at 55°C/35°C) incur lower thermal losses in the pipework and can more readily accommodate lower temperature, low carbon heat sources. However, the building heating systems would have to be compatible such operating temperatures (e.g. by use of underfloor heating and very well insulated building fabric). These requirements can be incorporated into new building designs with very little cost impact compared with a conventional system.

For existing building connections, the retrofit costs for a low temperature connection can be substantial, but not always: many building systems are oversized and poorly managed and require only minor physical changes and better management to be able to operate effectively at lower temperatures. This study has not investigated existing building systems to a level of detail which would allow confirmation of the level of retrofit works which would be needed to connect to a lower temperature system. Given that the Kingston network would include a significant number of existing building connections, our analysis has taken a low risk approach at this stage by specifying the system at 80°C/60°C.

Further analysis should be carried out at the next stage of the project to evaluate the potential for existing buildings to work with a lower temperature system.

6.3 CHP and Gas Fired Boilers

6.3.1 Technical Characteristics

The CHP engines are sized according to the annual hourly heat demand profiles embedded within the techno-economic model to ensure that the CHP engine runs for a minimum of 6,000 hours per year. The remaining heat demand will be met by the gas boiler capacity which has been set to meet the peak heat demand of the DH network. Based on this design criteria, a CHP capacity of 1.6MWth (and 1.5MWe) has been selected at full build out in 2026.

The modelled CHP capacity installation for the full Kingston Town Centre network in relation with the overall heat demand is illustrated in Figure 15 below.

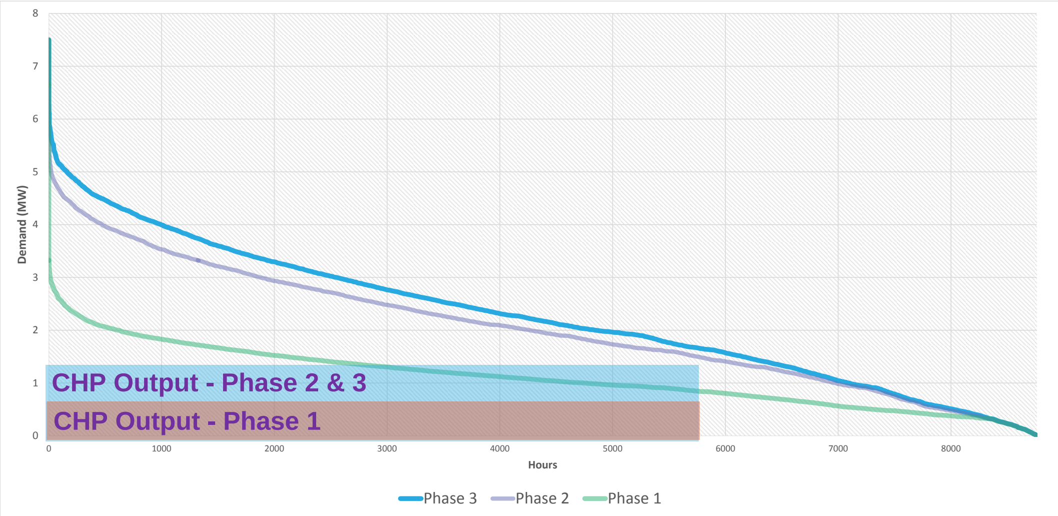

Figure 15 Kingston Town Centre heat demand duration curves and CHP installation

As shown in Figure 15, the phasing of the network allows the total CHP capacity to be installed in two phases, with an initial 800kWth CHP engine installed in Phase 1 followed by a second 800kWth engine in Phase 2.

Generally, CHP engines have limited ability to generate lower than 50% of their rated capacity or modulate their output depending on fluctuations in heat demand. The sizing of CHP engines is crucial to their performance, since operating at part load is both technically and financially inefficient. The increase in heat demand in Phase 3 over Phase 2 is small at 2,000MWh/year, which means that no additional CHP capacity would be installed at Phase 3. In addition, installing two identical engines provides operational benefits as there can be maintenance gains with a single set of spare parts required for the same engine type.

The model incorporates phased increases in gas boiler plant capacity in line with the growth of the network, to ensure that full system redundancy is always available.

6.3.2 Costs summary

Cost items are broken down into capital, operational (including maintenance), and commodity costs to be incurred by the developer and operator of the area-wide heat network.

6.3.2.1 Capital costs

Capital costs include the cost of the CHP and gas boilers, the energy centre shell and fit-out, and the transmission and distribution pipelines. Contingencies have been allowed for on energy centre and pipeline costs. All the costs described in this feasibility study are undiscounted costs.

Allowances are made for the replacement costs of the CHP, gas boilers (peaking and backup), and HIUs which occur at the end of their useful lifetimes. The 20-year analysis period used in the calculation of key financial indicators (i.e. NPV and IRR) allows for at least one replacement of each asset type. All capital and replacement costs over the 20-years are illustrated in Figure 16. Each plant item undergoes at least one replacement cycle to ensure that all potential capital and replacement costs are captured within this feasibility study.

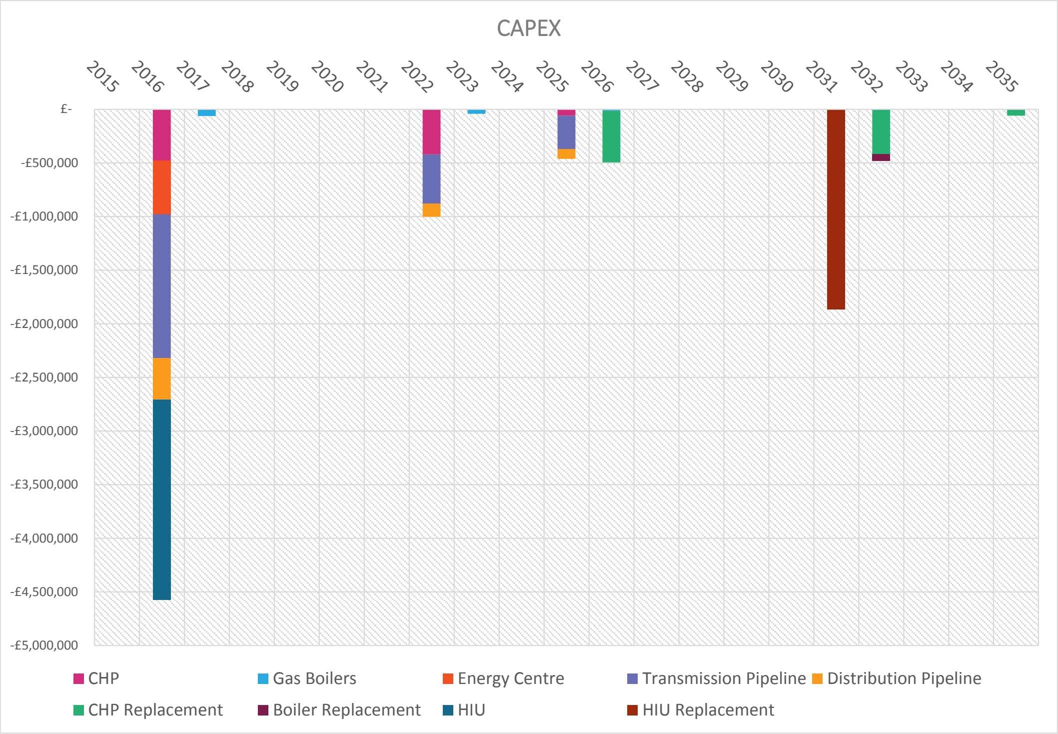

Figure 16 Kingston Town Centre CHP supply option capital and replacement costs

Some of the key CAPEX costs are outlined in Table 4 below;

Table 4 Key capital cost items

Item	CAPEX (over 20 years)
Energy Centre, Generation Assets and DH Network	£4.5M
Energy Centre, Generation Assets, DH Network, HIU's and replacement costs*	£9.8M
Initial Capital Investment Cost (Year 1)	£5.1M

* The capital and replacement costs associated with HIUs represent approximately 40% of the total capital costs.

The network would consist of a transmission network length of around 1,350 m with a distribution network of around 590m. As outlined previously, the boundary of the transmission and distribution pipework is up to the heat customer connection (i.e. heat substation).

The feasibility study incorporates the key capital costs of a CHP supply option scheme. There are however uncertainties for a number of costs which need to be developed further (for example precise utility connection costs for gas and electricity utilities to the EC). These figures are difficult to establish without determining connection locations and more detailed information. These costs can vary significantly depending on the local area and point of connection. A contingency has been incorporated into the techno-economic model to allow for these additional costs.

Further costs related to the application and connection of the energy centre to the local electricity distribution network for power export are also included within this contingency and should be developed further. The costs of the connection and any use of system charges (if applicable) would be provided by the Distribution Network Operator. The application and connection process can take up to 12 months.

6.3.2.2 Operational costs

Operational costs include CHP and gas boiler maintenance costs (based on £/MWh heat output assumptions for both CHP and gas boilers), the annual management fees associated with energy centre, the energy centre land lease cost and service fees for HIU maintenance as illustrated in Figure 17 below.

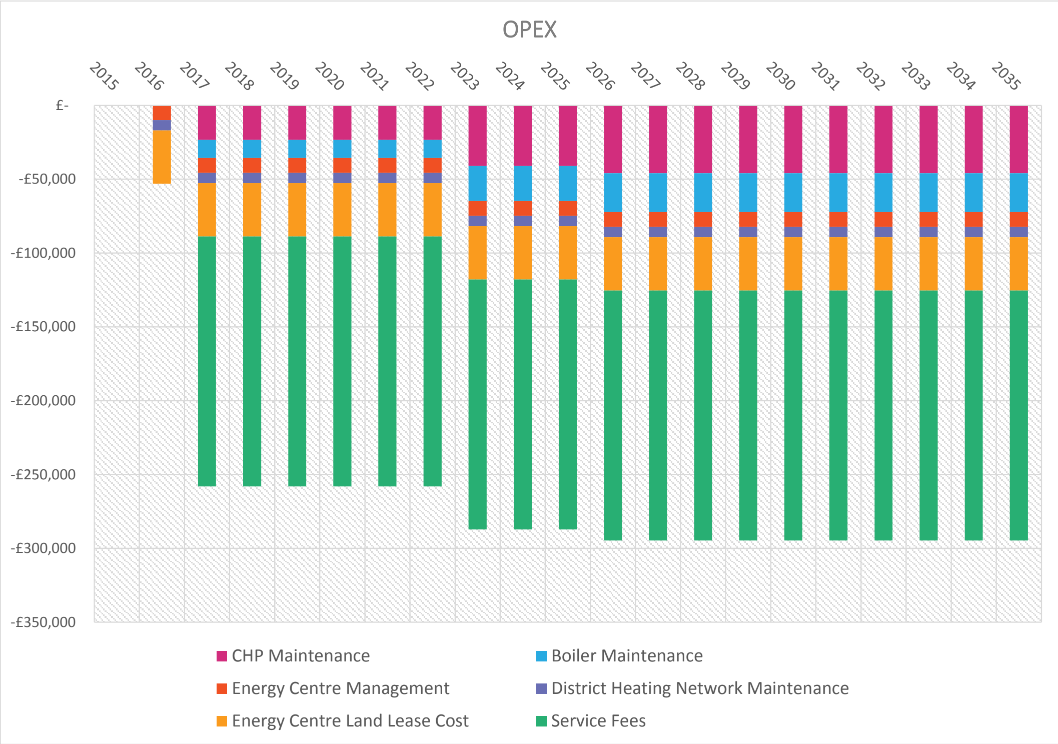

Figure 17 Operational costs of the Kingston Town Centre DH network

6.3.2.3 Commodity costs

The commodity costs included the costs incurred in the consumption of wholesale gas and electricity. For the CHP supply option, the primary commodity cost is the cost of wholesale gas for the CHP engine and gas fired boilers.

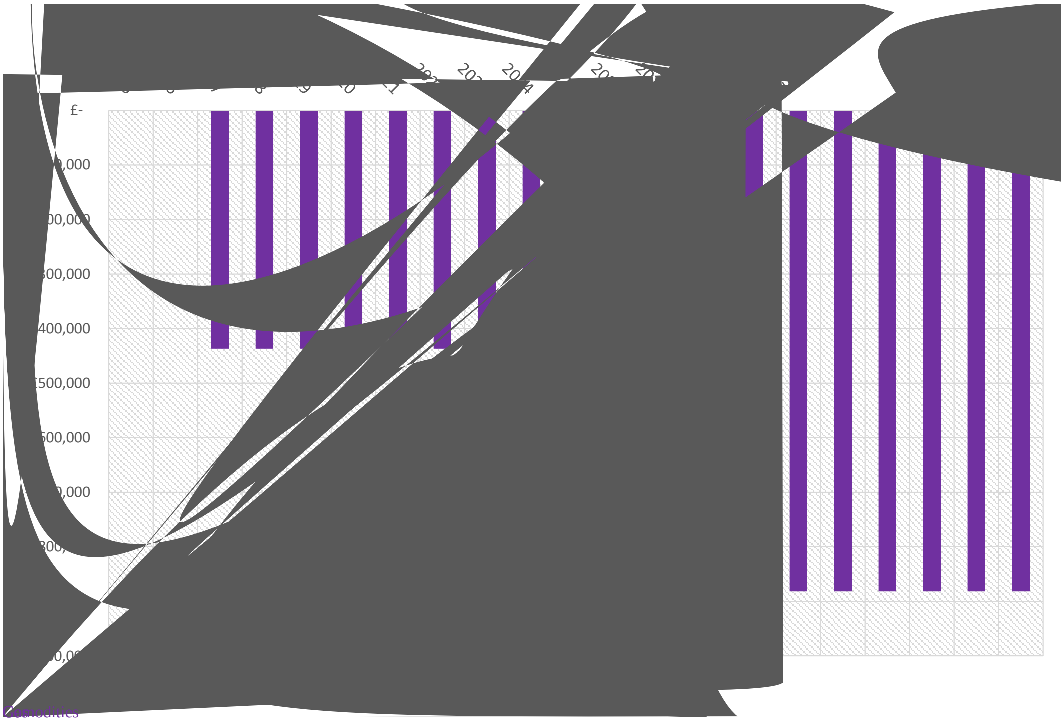

Figure 18 Commodity costs for CHP supply option

The costs rise from just over £400,000 per year in Phase 1 to £800,000 per year in Phase 2 rising finally to just under £900,000 on connection of the Guildhall Complex in Phase 3.

6.3.3 Revenues summary

The scheme’s revenues accrue through five main income streams: connection charges, heat sales, standing charges, service charges, and electricity exports, discussed further below.

6.3.3.1 Revenues from heat

Heat sales, standing charges and service charges are all collected in return for the provision of heat. Heat sales are variable revenues based on heat consumption, whereas standing and service charges are fixed annual fees. These three elements form the overall heat price with the rates outlined in Table 5 below.

Table 5 Heat Price elements and rates

Heat Price – Elements	**Rate**
Heat Sales – Domestic	£42/MWh

Heat Price – Elements	Rate
Heat Sales – Non-domestic	£38/MWh
Service Charge – Domestic	£170/dwelling/year
Service Charge – Non-domestic	£70/dwelling/year
Standing Charge – Domestic	£220/dwelling/year
Standing Charge – Non-domestic	£10,000/MW/year

The heat sale price is set equal to the unit gas charge for domestic users and small non-domestic users which allows the heat tariff to be fair across the full range of connected domestic and non-domestic heat demands.

The domestic service charge is set to cover the annual maintenance cost of an HIU and the costs associated with metering and billing. Unlike the other two items on the heat bill, service charges are not received as a net income to the ESCo, but rather as a mark-up between the charges and fees for the service. The non-domestic service charge is lower since there are no HIU maintenance costs and just to cover the metering and billing costs of that connection.

In order to ensure a market-competitive heat tariff for the district heating network at the above-mentioned heat price and service charges, the standing charge is set such that the heat bill in the proposed Kingston Town Centre network offers a minimum 10% discount on the price of heat from counterfactual individual gas boilers.

Figure 19 captures the total price of heat paid by the domestic end-users using individual gas boilers, including the standing charge, fuel charge, boiler replacement costs, and boiler maintenance contracts. Figure 20 gives the breakdown of the domestic heat tariff (red line on both graphs) with the assigned standing charges, service charges, and variable heat price and Figure 21 the non-domestic heat tariff. There are a number of items which are currently excluded from the non-domestic heat tariff comparator for example gas inspection costs. The non-domestic heat price provides a guide to enable non-domestic customers to determine their business case for connection to the DH network.

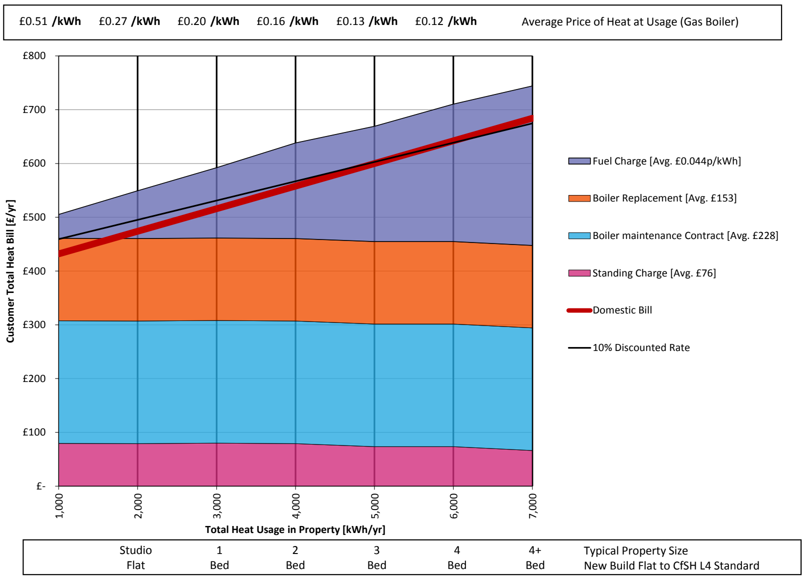

Figure 19 Price of heat for individual gas fired boilers and comparison to proposed Kingston DH network tariff (red line)

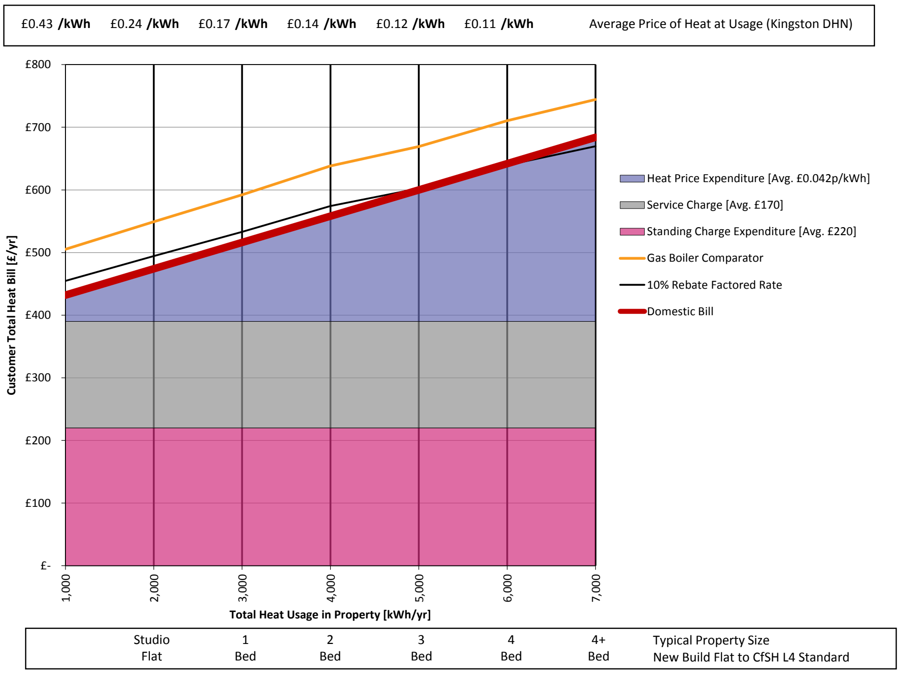

Figure 20 Kingston DH network domestic heat tariff and constituent components

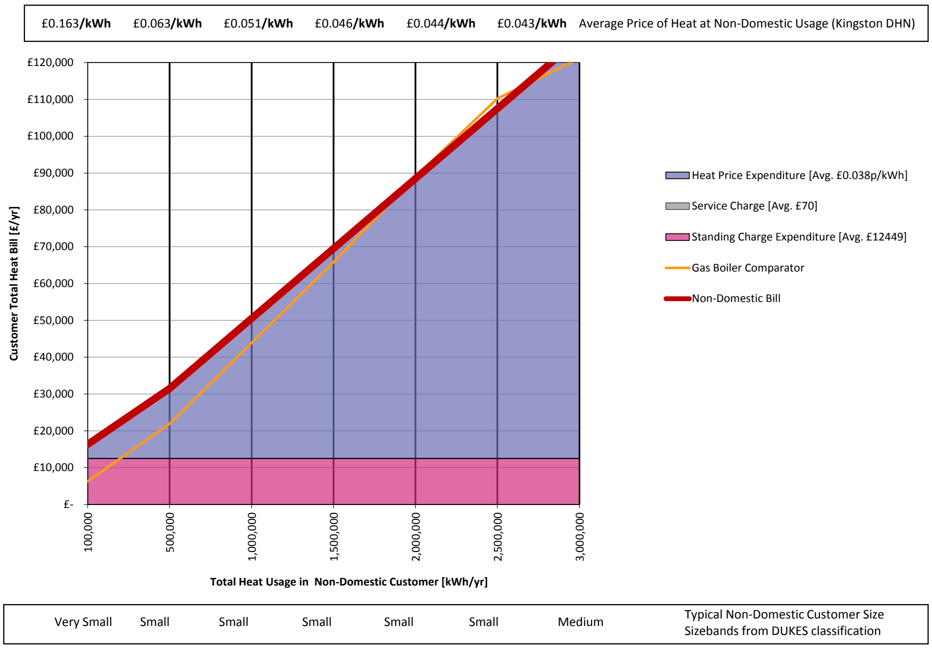

Figure 21 Kingston DH network non-domestic heat tariff and constituent components

6.3.3.2 Electricity export

In addition to the heat revenues, the electricity generated by the CHP units is assumed to be an additional revenue stream for the CHP supply option. The electricity generated can either be sold wholesale (around £45/MWh) to the electricity network or to a single large consumer of electricity at a price slightly below retail value (around £90/MWh). No large single consumers of electricity have been identified in the area surrounding the Ashdown Road car park therefore a private wire option was not currently deemed feasible. The Greater London Authority (GLA) is continuing its involvement to develop a new form of electricity supply licence referred to as 'licence lite'. The GLA's objective is to acquire a new licence and buy electricity from embedded generation (initially local authority CHP) at above wholesale prices and to sell it on at retail prices to selected consumers. The licence lite model would lower costs through a focus on matching local generation and consumption and the elimination of transmission use of system charges. By offering a power purchase price above wholesale rates, the licence lite service would improving the economic viability of CHP generation. Notwithstanding the potential for this economic benefit to CHP operations, we have applied a more conservative value of the standard wholesale price in our modelling. It is recommended that the progress of the GLA's licence lite operation is monitored as this project proceeds.

Despite the lower wholesale price, the electricity export for the Kingston DH network contributes 26% of the total annual revenue at full build out of the network representing a fairly significant factor in establishing a commercially viable scheme.

6.3.3.3 Connection charges

The connection charge (or developer contribution) is an up front and one-off financial contribution from the developers to the DH network. The value of this contribution is in practice a negotiated amount.

These net avoided costs normally include:

- The avoided cost of on-site energy centres and heat generation equipment (e.g. gas boilers);
- The avoided cost of other measures to achieve the carbon savings delivered by the heat network (e.g. rooftop solar PV);
- The land value associated with the site of the energy centre; and
- Additional costs (if any) which would be incurred in order to make the connection to the network.

The connection charges for existing non-residential customers are based on the avoided cost of gas fired boiler plant replacement.

The new residential development connection charges are typically based on the avoided costs for the developer's alternative heating system and additional renewable and carbon offsetting measures. Generally, existing residential developments have lower net avoided costs than new developments, resulting in lower or zero connection charges. This is primarily due to the fact that the new developments avoid the requirement to install heating plant in the first instance as well as any carbon reduction measures which might be required to comply with building and planning regulations which connection to the low carbon DH network may mitigate. There would not be any avoided cost for any additional low carbon measures for existing developments and the connection to a DH network. Based on the available information provided by the Old Post Office Development, the avoided cost of the development's heating and low carbon systems is estimated to be £2,800 per dwelling (see Appendix A4 for more information). The developers would be required to undertake a cost effectiveness calculation to determine their avoided costs in line with the GLA Guidance on Preparing Energy Statements (2015) which will provide a more detailed assessment of the avoided costs.

The assumed connection charge values are shown in the table below. The connection charges for the residential developments in this case are based upon the required connection charge for the scheme to hit an Internal Rate of Return of 12% (which is discussed below in Section 6.5.1).

Table 6 Assumed connection charges / developer contributions

Building type	Value
Existing Non-Resi - Public	£22,000/MW
Existing Non-Resi - Private	£22,000/MW
New Residential - Public	£3,500/dwelling
New Residential - Private	£3,500/dwelling
New Non-Resi - Public	£22,000/MW
New Non-Resi - Private	£22,000/MW

Based on the estimated avoided costs for the Old Post Office development, there is a shortfall of £700 per dwelling for the scheme to be commercially viable. Figure 22 below illustrates the importance and significance of the connection charges from the new residential developments in terms of the revenues in the first year of operation of the DH network. Over the course of the 20 year analysis period, the connection charges from all the domestic and non-domestic customers represents just under 15% of the revenues of the cumulative 20 year network revenues.

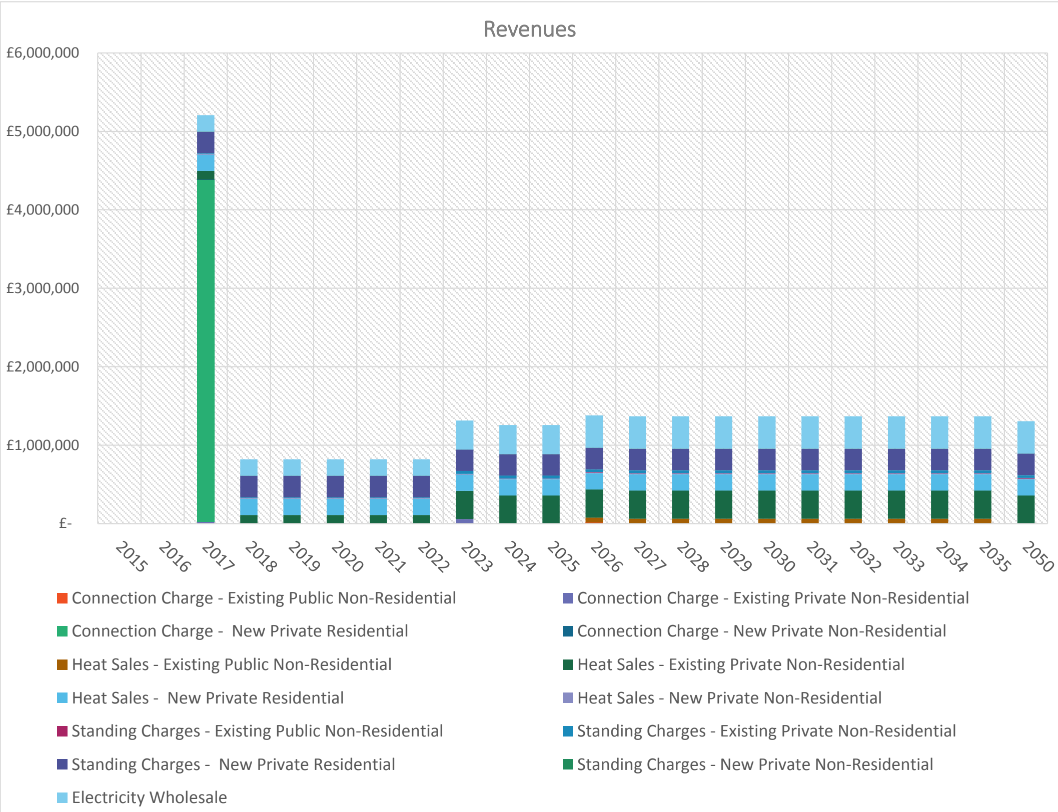

Figure 22 Kingston Town Centre DH network revenues for the CHP supply option

6.3.4 Financial performance of the scheme

A district heating investment can be justified financially if the expected internal rate of return (IRR) exceeds the hurdle rate. The hurdle rates for public and private sector investors differ due to their differing costs of capital and levels of risk aversion.

The analysis has applied the hurdle rate of 12% to represent the private sector financing options as this has been indicated as the preferred option by the Council (discussed in further detail in Section 8.3).

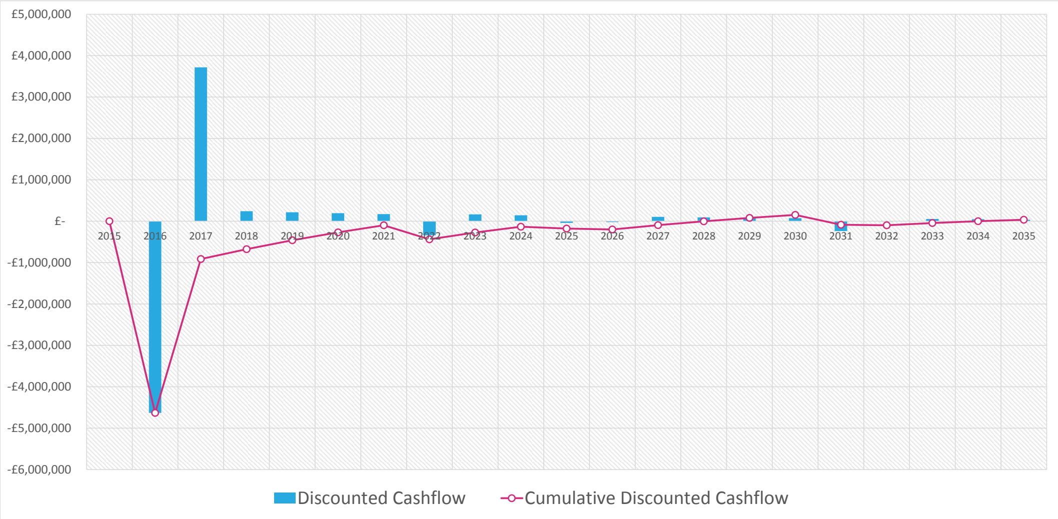

Figure 23 Discounted cashflow for the Kingston DH network CHP supply option for full build out at 12% discount rate

Figure 23 illustrates the financial performance of the Kingston DH network over the 20 year analysis period. As the new residential connection charges have been set to target an overall IRR of 12%, the NPV of the Kingston Town Centre network is £0 at a 12% discount rate over 20 years. The simple payback for this scheme for the ESCo is 4 years (with a discounted payback period of 17 years). A summary of the financial aspects of the CHP supply option is outlined in Table 7 below.

Table 7 CHP supply option financial performance summary

Indicators	
Internal Rate of Return (IRR)	12%
Net Present Value (12% discount rate)	£0
New - Residential Connection Charge	£3,500
Initial Capital Investment (including HIUs)	£5.1M
Full Build Out Capital Investment (including HIUs)	£6.9M

Indicators	
HIU Cost	£1.9M
Replacement Capital Cost	£2.9M
Project Lifetime Capital Cost	£9.8M
Project Heat Sales Revenue	£19.9M
Project Electricity Sales Revenue	£6.5M
Project Connection Charge Revenue	£4.5M

6.3.5 Carbon performance of the scheme

One of the key drivers for the development of a DH network is to provide low carbon heat to customers and significant carbon savings in the borough. This is also an important factor in the decision for various customers to connect to the DH network in particular new developments since this would provide them with a low carbon heat source helping meet building regulation and planning carbon targets.

A CHP system which meets the minimum criteria to qualify as Good Quality CHP under the Combined Heat & Power Quality Assurance Programme (CHPQA) (and the associated European Directive on cogeneration) will ensure that primary energy savings are being provided for the fuel source. There are additional benefits for systems to qualify as Good Quality CHP granting exemption from the Climate Change Levy on natural and qualifying for Enhanced Capital Allowances.

The carbon intensity of the DH network heat and annual carbon savings are calculated based on the Non-Domestic Building Services Compliance Guide 2013 Edition calculation methodology and 3-year grid and gas emissions factors outlined in the Standard Assessment Procedure, 2012 (SAP 2012). This is to ensure that the carbon intensity of the heat calculated can be utilised by the new developments in their development of planning targets and building regulation.

The base case against which the DH network carbon savings are calculated is against individual gas fired boilers as per the notional building scenario in accordance with the National Calculation Methodology guide for new developments and against the current heating system for existing developments.

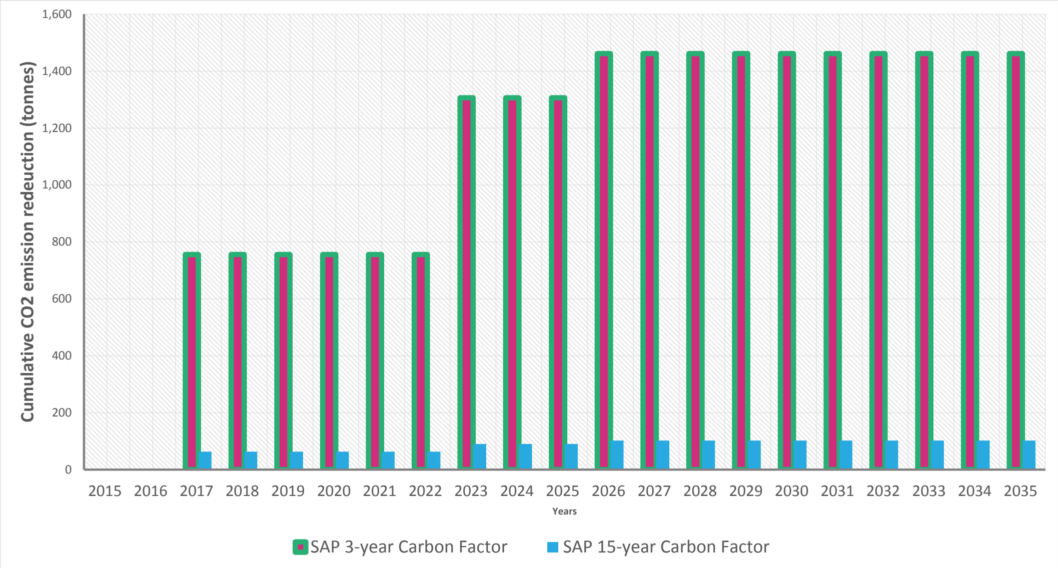

Figure 24 Annual carbon savings for the Kingston Town Centre DH network against the base case of individual gas fired boilers utilising the 3-year SAP carbon emission factors

Figure 24 above illustrates the increase in carbon savings as further connections are made to the network and the CHP capacity of the energy centre is increased thereby displacing a greater amount of grid electricity compared to individual gas fired boilers.

Annual carbon savings at the full build out of the network are 1,460tCO_2 per year (a 34% reduction on the baseline carbon emissions). The cumulative carbon savings over the 20 year analysis period are 23,000tCO_2. The overall carbon intensity of the heat is estimated to be 0.190kgCO_2/kWh.

The carbon savings associated with CHP led DH networks under the current building regulation carbon calculation methodology are primarily dependent on the carbon intensity of the grid electricity. With the latest revision of the Part L Building Regulations and the Standard Assessment Procedure for calculating carbon emissions for dwellings, a long term 15-year projection[5] of carbon factors was released reducing the grid electricity carbon factor from 0.519kgCO_2/kWh to 0.381kgCO_2/kWh and increasing the mains gas carbon factor from 0.216kgCO_2/kWh to 0.222kgCO_2/kWh. As a consequence of this, the carbon savings for the CHP and gas fired boiler led DH network reduce significantly resulting in annual carbon savings at full build out of 100tCO_2 per year (a 2% reduction on the baseline carbon emissions).

As the majority of the new developments in the Kingston Town Centre area have submitted their planning applications (with the exception of the Eden Walk redevelopment) they will be subject to the current revision of Building Regulation and therefore utilise the 3-year carbon factors outlined in SAP 2012 providing the developments with the carbon intensity of heat of 0.190kgCO_2/kWh outlined above.

[5] The 15-year carbon factors provided in SAP 2012 are not to be used for calculation for building regulation and Part L compliance.

6.4 WSHP Supply Option

6.4.1 Technical Characteristics

The WSHP supply system has been sized on 50% of the peak heating demand of the network (i.e. 4.4MWth) with gas fired top up boilers providing the remaining heat required. Sized at 50% peak heat demand, the WSHP is able to supply 80% of the network's heating demands over the course of a year. Where the heat demand exceeds the capacity of the heat pump, gas fired boilers provide additional heating to meet the required heat demand. The provisional footprint of the WSHP energy centre is estimated to be 775m^2 over a single level.

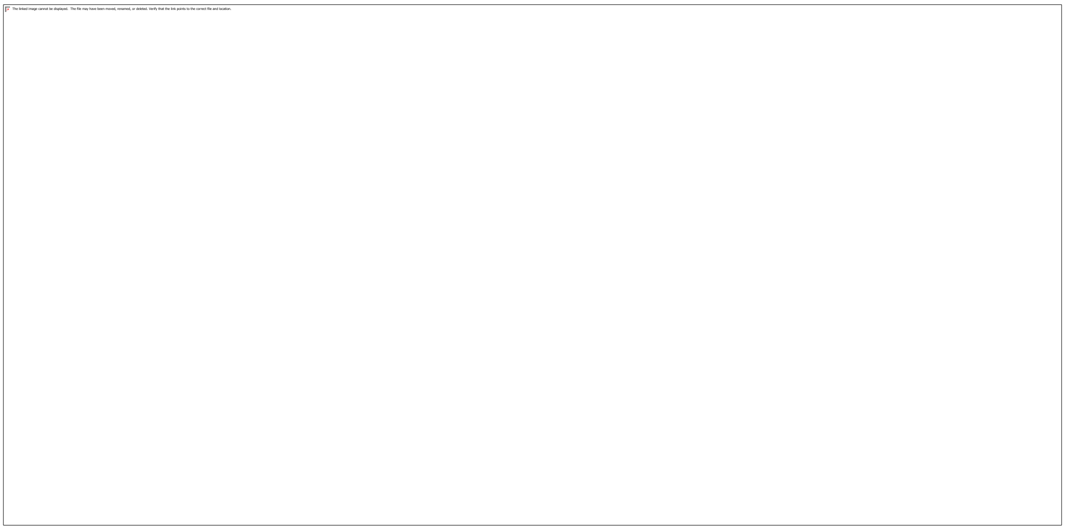

Figure 25 Kingston Town Centre heat demand and WSHP installed capacity

WSHP units are more flexible than CHP engines capable of greater turndowns and a greater level of responsiveness to fluctuations in heat demands. The Figure 16 above illustrates the total heat demand which can be met by the WSHP with an installation sized at 50% of the peak heat demand. Sizing the WSHP at 50% of the peak heating demand will enable up to 80% of the total annual demand to be met via low carbon heat, with supplementary (and backup) heat to be provided via the gas fired boilers. This mix of heat provision provides not only operational flexibility and security of supply but also strikes a balance between the higher capital cost (per installed kW) of WSHPs and providing carbon savings versus more traditional heat generation plant.

The WSHP system has been selected to be capable of supplying the DH network at the same operating temperatures as the CHP led solution (supply 80˚C and return of 60˚C) to ensure that all building heating systems including existing (which operate at higher temperatures) are able to be met by the heat pump. The gas fired boilers therefore provide heating when the heat demand exceeds the installed capacity of the WSHP. As discussed in Section 4, the higher the supply temperature the lower the efficiency of the heat pump. Supplying at a network temperature of 80˚C (with a return of 60˚C) would result in a COP of 2.90 based on preliminary manufacturer selections which is the minimum COP required for the system to be eligible for Renewable Heat Incentive payments.

The capital investment for the WSHP system and the backup gas fired boiler plant is programmed to occur during the years when the peak demand increases to respond to the expansion of the DH network.

6.4.2 Costs summary

Cost items are broken down into capital, operational, and commodity costs to be incurred by the developer and operator of the area-wide heat network.

6.4.2.1 Capital costs

Capital costs for the WSHP supply option are as per the CHP supply option analysis including the cost of the WSHP (included allowance for water abstraction system) gas boilers, energy centre shell and fit-out. All the costs described in this feasibility are undiscounted costs.

As previously, similar allowances are made for the replacement costs of the WSHP, gas boilers and HIUs which occur at the end of their useful lifetimes. All capital and replacement costs over the 20-year analysis period are illustrated in Figure 26.

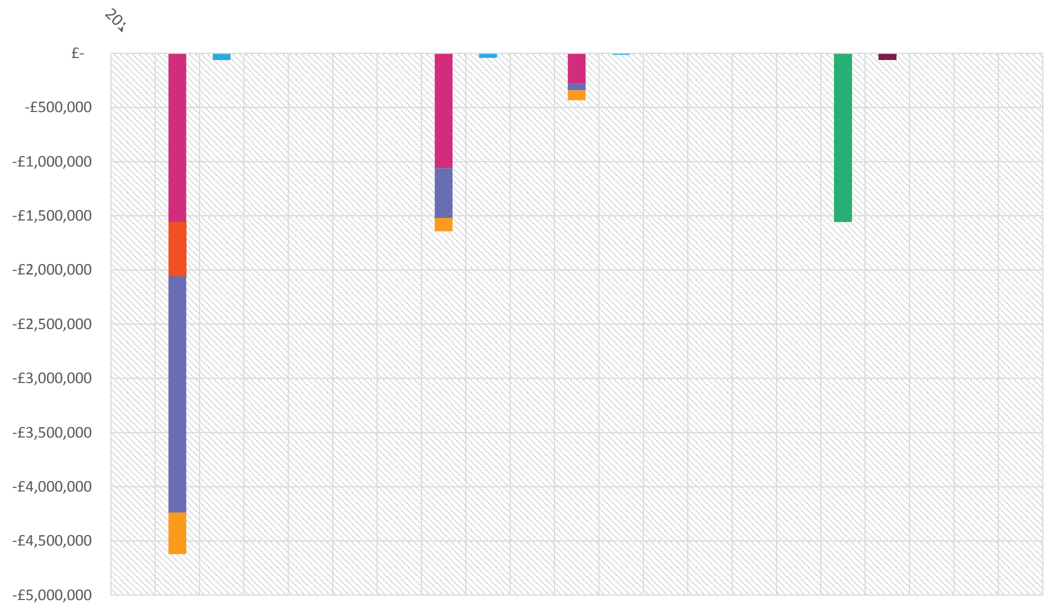

Figure 26 Kingston Town Centre WSHP supply option capital and replacement costs

Some of the key CAPEX costs are outlined in Table 4 below;

Table 8 Key capital cost items

Item	CAPEX (over 20 years)
Energy Centre, Generation Assets and DH Network	£6.8M
Energy Centre, Generation Assets, DH Network, HIU's and replacement costs*	£12.7M
Initial Capital Investment Cost (Year 1)	£6.9M

* The capital and replacement costs associated with HIUs represent approximately 30% of the total capital costs.

The network would consist of a transmission network length of around 1,440 m with a distribution network of around 590m. As outlined previously, the boundary of the transmission and distribution pipework is up to the heat customer connection (i.e. heat substation).

As per the CHP supply option, the feasibility study incorporates a contingency to allow for some additional costs (for example utility connection costs). The utility costs for the WSHP are likely to be greater than those for the CHP supply option as the gas utility connection will be similarly sized to meet the peak heating demand although with a greater electrical utility connection for the WSHP power supply. An allowance has been made within the WSHP capital costs for the water abstraction system however these costs can vary significantly depending on the location of the intake system and necessary civil engineering works.

6.4.2.2 Operational costs

Operational costs include WSHP and gas boiler maintenance costs (based on £/MWh heat output assumptions for gas boilers and a £/MW of installed capacity for the WSHP), the annual management fees associated with energy centre, the energy centre land lease cost and service fees for HIU maintenance as illustrated in Figure 27 below.

Figure 27 Operational costs of the Kingston Town Centre WSHP DH network

The annual operational costs for the WSHP DH network at full build out at are £286,000 which compares to the CHP DH network supply option operational costs of £295,000 at full build out.

6.4.2.3 Commodity costs

The commodity costs included the costs incurred in the consumption of wholesale gas and electricity. For the WSHP supply option, the primary commodity cost is the cost of electricity for the WSHP and gas for the gas fired boilers.

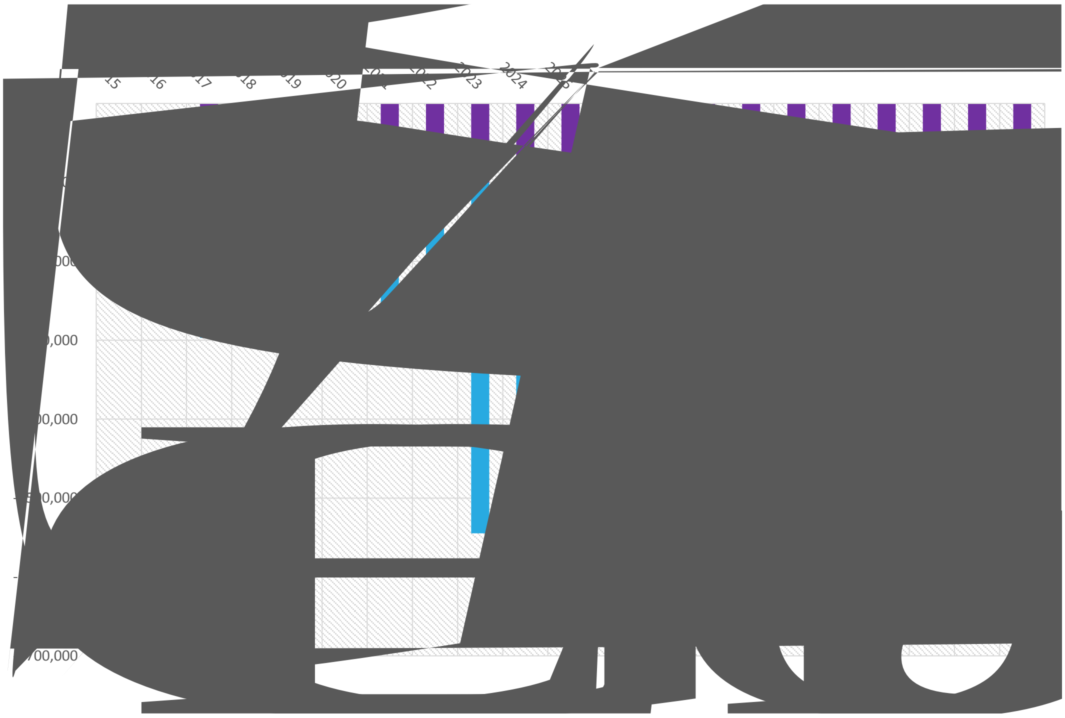

Figure 28 Commodity costs for CHP supply option

The WSHP sized at 50% of the peak heating demand of the network supplies over 80% of the annual heat demand of the network therefore the electricity cost are significantly greater than the gas purchase costs for the gas fired boilers.
The costs for the WSHP system rise from just under £300,000 per year in the first phase to £606,000 on full build out of the network compared to £900,000 at full build out of the network for the CHP supply option.

6.4.3 Revenues summary

The WSHP scheme's revenues are similar to that of the CHP supply option which incorporate connection charges, heat sales, standing charges and service charges identical to those described in the previous CHP supply option section. The primary differentiator between the two supply option schemes is that there is no longer any revenue from electricity export which is effectively replaced by income received from the Renewable Heat Incentive (RHI) for WSHP systems.

The following section will outline the changes in the connection charge for the WSHP scheme and the RHI revenue only as heat revenues described earlier remain as per the CHP supply option.

6.4.3.1 Renewable heat incentive

The Renewable Heat Incentive (RHI) provides financial support for renewable heating systems (including biomass, biogas, energy from waste, solar thermal and ground and water source heat pumps). The RHI tariffs vary depending on the type and scale of the technology, providing higher tariffs to less well established and more expensive technologies to offset the additional costs.

There are two separate RHI schemes, one specific for domestic installations and one for non-domestic installations. District heating systems fall under the non-domestic installation where a single systems serves multiple homes or buildings.

The RHI tariff for WSHP (and GSHP) systems falls under two tariff tiers; tier 1 is paid at a rate of £88.4/MWh on all eligible heat output[6] up to a maximum heat output equivalent to the system operating at its rated capacity for 15% of the year.[7] The tier 2 tariff is paid at a much reduced rate of £26.4/MWh for any additional heat generation. The RHI tariff is payable over a 20 year period.

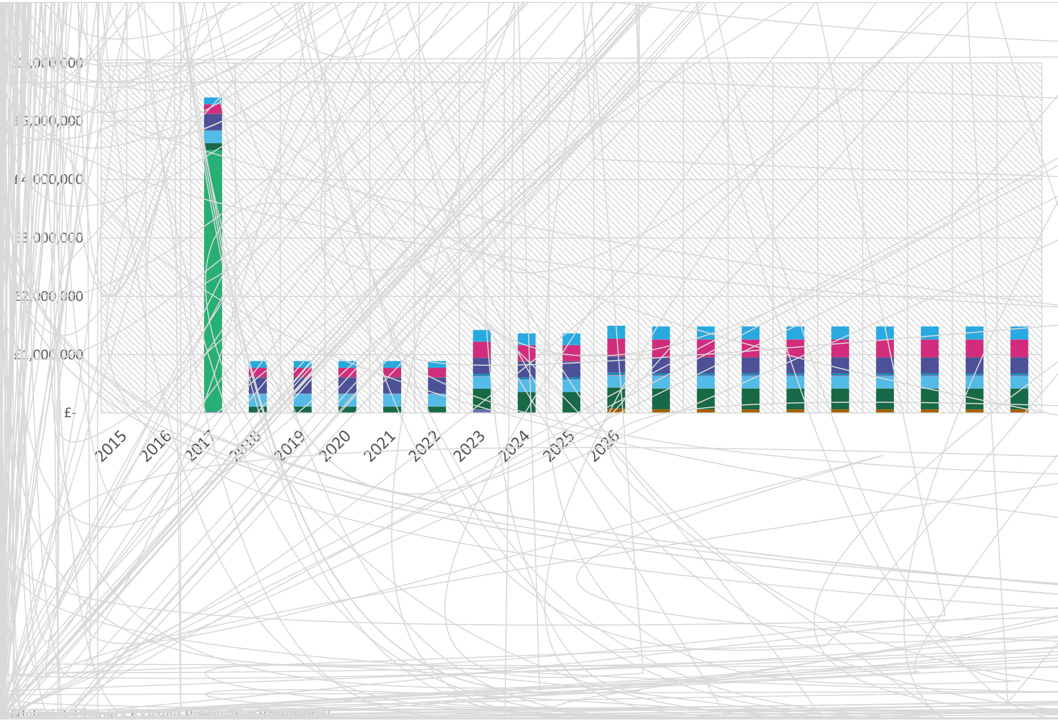

Figure 29 Revenues for the WSHP DH network

The total revenues at full build out of the Kingston Town Centre DH network in 2026 are just under £1.7M per year of which the RHI payments make up 31%. The RHI tariffs are based on those which apply for installations with an accreditation date on or after the 1st of April 2015. The difference in revenue between the CHP supply option and WSHP supply option (£1.7M against £1.58M) is due to the increase in revenue from RHI payments (of £530,000 per

[6] Eligible heat output for systems serving multiple dwellings excludes heat losses from the DH network and is attributed only to usable or metered heat.

[7] For example, if a WSHP was rated as 2.0MW, the upper band limit for heat which the tier 1 tariff can be paid is 2,628MWh per year. All additional heat generated receives the tier 2 tariff payment.

year) for the WSHP compared to the CHP electricity export revenue (of £410,000 per year).

The tariff levels are revised by DECC at quarterly periods following a review on the scheme's expenditure forecast. Therefore, there is a possibility that these tariff levels may be reduced prior to the WSHP scheme being delivered, impacting negatively on the economics of the scheme.

As discussed previously, WSHP systems are only eligible to receive RHI payments when they operate at or above the minimum COP of 2.90 which is the current modelled COP of the Kingston DH network. There is a risk that if the WSHP led system does not meet the minimum efficiency of 2.90, then there would be no RHI payment payable during the period[8] for which the COP of the system falls below 2.90.

6.4.3.2 Connection charges

As discussed previously, the connection charges for new residential developments are typically based on the avoided costs for the developer's alternative heating system and additional carbon offsetting measures. Those modelled in this feasibility study are the connection charges required to reach the IRR target of 12%.

The connection charges differ slightly for the WSHP supply option due to the increased capital cost of the scheme. Although the commodity costs and the heat revenues (due to the RHI) are greater than the CHP supply option, this differential does not offset the higher capital costs associated with the longer transmission network and WSHP capital costs.

Table 9 Assumed connection charges / developer contributions

Building type	Value
Existing Non-Resi - Public	£22,000/MW
Existing Non-Resi - Private	£22,000/MW
New Residential - Public	£3,600/dwelling
New Residential - Private	£3,600/dwelling
New Non-Resi - Public	£22,000/MW
New Non-Resi - Private	£22,000/MW

6.4.4 Financial performance of the scheme

The analysis period is taken as 20 years, which is seen as a conventional time horizon for an ESCo to evaluate the financial performance of a district heating network. This analysis period also allows for the replacement of the key relevant assets at least once.

A district heating investment can be justified financially if the expected internal rate of return (IRR) exceeds the hurdle rate. The hurdle rates for public and private sector investors differ due to their differing costs of capital and levels of risk aversion.

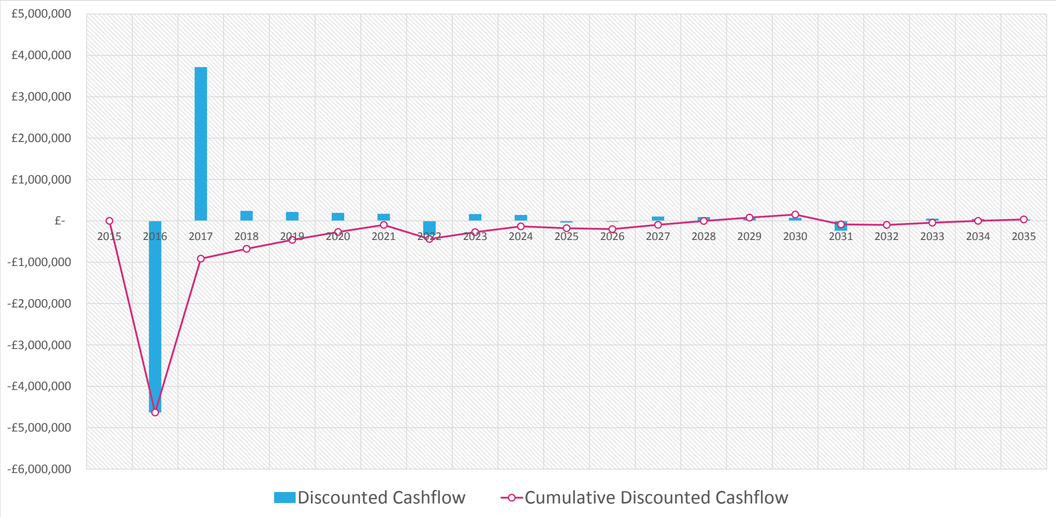

Figure 30 Discounted cashflow of the WSHP supply option for the Kingston Town Centre DH scheme

Figure 30 illustrates the financial performance of the Kingston DH network over the 20 year analysis period. As the new residential connection charges have been set to target an overall IRR of 12% the, the NPV of the Kingston Town Centre network is £0 at a 12% discount rate over 20 years. The simple payback for this scheme for the ESCo is 8 years (with a discounted payback period of 18 years). A summary of the financial aspects of the WSHP supply option and the CHP supply option for comparison is outlined in the Table 10 below.

Table 10 Financial performance indicators of WSHP supply options and CHP option for comparison

Indicators	WSHP Supply Option	CHP Supply Option
Internal Rate of Return (IRR)	12%	12%
Net Present Value (12% discount rate)	£0	£0
New - Residential Connection Charge	£3,610	£3,500
Initial Capital Investment (including HIUs)	£6.95M	£5.13M

Indicators	WSHP Supply Option	CHP Supply Option
Full Build Out Capital Investment (including HIUs)	£9.26M	£6.87M
HIU Cost	£1.87M	£1.87M
Replacement Capital Cost	£3.49M	£2.89M
Project Lifetime Capital Cost	£12.75M	£9.75M
Project Heat Sales Revenue	£19.89M	£19.89M
Project Electricity Sales Revenue	£0	£6.50M
Project RHI Revenue	£8.39M	£0
Project Connection Charge Revenue	£4.59M	£4.45M

6.4.5 Carbon performance of the scheme

A well designed WSHP and gas fired boiler system would result in carbon savings over the gas fired boiler baseline once the COP of the system (assuming the heat pump is sized at 50% peak capacity) is greater than 2.47[9] . Any increase in COP and system efficiency from this point, the WSHP system would produce carbon savings over the baseline as the difference in carbon intensity between the grid electricity (of 0.519kgCO_2/kWh) and natural gas (0.216kgCO_2/kWh) is overcome.

As with the CHP-led supply system, the carbon intensity of the DH network heat and annual carbon savings are based on the Non-Domestic Building Services Compliance Guide 2013 Edition calculation methodology.

The carbon savings during the development of the DH network are illustrated in Figure 31 below.

[9] Including primary and secondary distribution losses

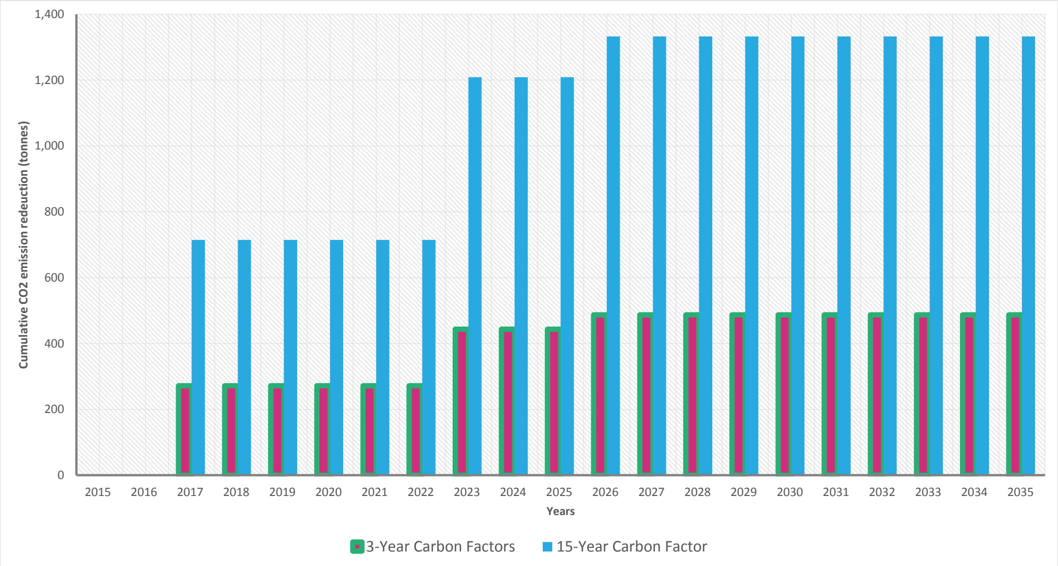

Figure 31 Kingston Town Centre DH network carbon savings for the WSHP supply option

Annual carbon savings at the full build out of the network are 4,85tCO_2 per year (an 11% reduction on the baseline carbon emissions). The cumulative carbon savings over the 20 year analysis period are 7,830tCO_2. The overall carbon intensity of the heat is estimated to be 0.255kgCO_2/kWh.

Since grid electricity is the main supply of the WSHP led DH network, the carbon savings are highly dependent on the carbon intensity of the grid electricity. As the grid carbon intensity is projected to decrease in the future, the carbon intensity of the heat delivered by the WSHP will also fall. Using the long term 15-year projections of grid electricity and mains gas of 0.381kgCO_2/kWh and 0.222kgCO_2/kWh respectively the carbon savings increase to 1,210tCO_2 per year (a 30% reduction on the baseline carbon emissions).

As discussed previously, the new developments in Kingston Town Centre have submitted planning applications or will likely submit their application prior to the next revision of the Part L building regulations therefore the 3-year SAP carbon figures and carbon intensity of heat of 0.255kgCO_2/kWh should be utilised.

The lower level of carbon savings associated with the WSHP led DH network may have consequential impacts on the wider economics of the scheme since it may not provide all of the necessary carbon savings for new developments to preclude the use of any additional carbon reduction or renewable measures. The connection charge may need to be reduced for new developers to connect due to the reduction in carbon savings and the associated premium on the connection charge.

6.5 Scheme Comparison

6.5.1 Financial

Although the two schemes vary significantly in terms of energy centre location, supply side technologies and costs, both schemes result in similar developer connection charges to reach a 12% IRR.

The commercial performance of the two schemes is evaluated on the basis of the required new residential connection charge to meet the required 12% internal rate of return hurdle rate for a third party ESCo for which the CHP supply led scheme has a marginally lower connection charge of £3,500 compared to a connection charge of £3,610 for the WSHP led scheme. Engagement with the developers to determine the connection charge and ensuring the developers undertake comprehensive cost effectiveness tests to demonstrate their business case is crucial in the future development of the DH network in Kingston Town Centre.

6.5.2 Carbon

The carbon performance of the two schemes taking into account both the current 3-year SAP carbon intensity figures and the 15-year projections highlights the significant decrease for the CHP supply scheme with the decarbonisation of the electricity grid along with the carbon performance improvement with the WSHP supply option. The Table 11 below outlines the carbon emissions for each of the supply options compared to the baseline solution for both the 3-year and 15-year SAP carbon emission factors. The potential future reduction in carbon emissions represents a risk to the expansion of the network however presently, the greater carbon savings from the CHP led solution using the current building regulation carbon factors leads the CHP solution to be the greater supply option for the initial launch and development of a network.

Table 11 Carbon emissions and savings for the CHP and WSHP supply options

Carbon Factors	**Baseline – Annual Carbon Emissions (tCO_2/year)**	**CHP Supply Solution – Annual Carbon Emissions (tCO_2/year)**	**WSHP Supply Solution - Annual Carbon Emissions (tCO_2/year)**
3 – Year SAP	4,315	2,850 **(-34%)**	3,825 **(-11%)**
15 – Year SAP	4,435	4,330 **(-2%)**	3,075 **(-31%)**

6.5.3 Future Proofing

The future proofing of the DH network has been incorporated into both supply options taking into consideration the potential future expansion of the network however considering the future potential decarbonisation of the electricity grid, the CHP supply option and the associated energy centre location will be impacted. A high degree of electricity grid decarbonisation may require additional investment in an alternative energy centre location to facilitate the switch to a WSHP led DH network if the CHP supply option is developed as the preferred option. This would primarily be required if large new developments in the Kingston area connect to the network and require greater carbon savings than the CHP supply option can deliver at the time.

6.5.4 Risk

The WSHP scheme however provides a genuine alternative to the conventional gas fired CHP supply option for the Kingston Town Centre DH network although there are a greater number of associated risks with this scheme. This includes the availability of the energy centre site, potential additional costs for the water abstraction system, utility connection costs and potential loss of RHI revenue dependent on the efficiency of the scheme which is currently at the minimum limit of eligibility. The level of investment (and therefore financial risk) required to launch the WSHP supply option relative to the CHP supply option is also greater with an initial investment of £6.95M for the WSHP compared to £5.13M for the CHP supply option along with a greater lifetime capital investment of £12.75M against £9.75M. Further analysis and studies would be required to determine whether there are any additional costs required with the water abstraction system for example and reduce the level of risk and unknown capital expenditure which might be required.

6.5.5 Summary

This feasibility study is focused primarily on the development and launch of a DH network within the Kingston Town Centre area. The key stakeholders for the development of this network are the two large new developments in the Town Centre (Eden Redevelopment and the Post Office Development) with the main drivers being the supply of heat prior to completion of the network and the carbon savings the network can provide the developers.

As the financial performance of both schemes have similar payback periods and achieve a 12% IRR (at a 12 % discount rate), the key financial indicator is the required connection charge paid by developers for the ESCo to obtain an IRR of 12%. The financial performance of the scheme is considered greater with a lower connection charge, as the DH network is less reliant on the initial one-off payments.

The carbon emissions for the gas fired CHP are superior considering the current building regulation carbon factors however as the grid decarbonises over time, the WSHP option results in greater carbon savings over the baseline.

Considering the potential future decarbonisation of the electricity network and the target to minimise the use of fossil fuels, implementing a WSHP solution at this stage would provide a comprehensive future proof option as opposed to future retrofitting of a gas fired CHP energy centre.

There is however a higher level risk implementing a WSHP led DH network due to a number of unknown costs surrounding the water abstraction system as well as the efficiency of the scheme currently estimated at the limit for RHI eligibility.

Table 12 Traffic light comparison of the CHP led supply option and WSHP supply option

Characteristic	**Gas Fired CHP**	**Water Source Heat Pump**
Financial		
Carbon Emissions – 3 year emissions factors		
Carbon Emissions – 15 year emissions factors		
Future Proofing		
Risk		

On this basis and the current level of risk associated with the two supply options, the gas fired CHP solution provides the more robust and feasible solution to be developed at this stage.

7 Sensitivity Analysis

The key sensitivities on the demand side include the size of connected heat loads and their phasing while the key sensitivities on the supply side include CAPEX, commodity prices, and heat tariff. Heat tariff for the district heating network includes the variable heat price (£/kWh) and fixed standing charge (£/kW). A detailed table outlining the impacts on the IRR and NPV of the various sensitivities tested below is provided in the Appendix.

7.1 CHP Supply Option

7.1.1 Sensitivity to demand side parameters

The key demand side parameters which will have a material impact on the network are the total connected heat demands and the phasing of the network. The impact of these two demand side factors on the absolute Internal Rate of Return (IRR) of the project are illustrated in Figure 32 below.

The financial performance of the scheme is more sensitive to the bringing the phasing of the heat demands forward by 20% resulting in an increase in IRR from 12% to 26.5% whereas a 20% delay drops the IRR to 9.3%. This is primarily due to the reduced total revenue accrued over the 20 year analysis period whereas bringing the network connections and therefore developer contributions forward has a positive impact on the cashflow of the project.

The DH network phasing has no impact on the overall capital investment required for the project whereas changes in heat demand impacts the required sizes of the generation assets and DH network pipe sizes and therefore the associated costs. A 20% reduction in the connected heat demand results in a small increase in the absolute IRR of 12.4% whereas a 20% increase in the connected heat demand reduces the IRR to 11.1%. The increase in heat demand leads to a consequential increase in CHP engine size along with heat revenues and electricity sales however the increase in revenues does not exceed the associated increase in capital costs and O&M charges.

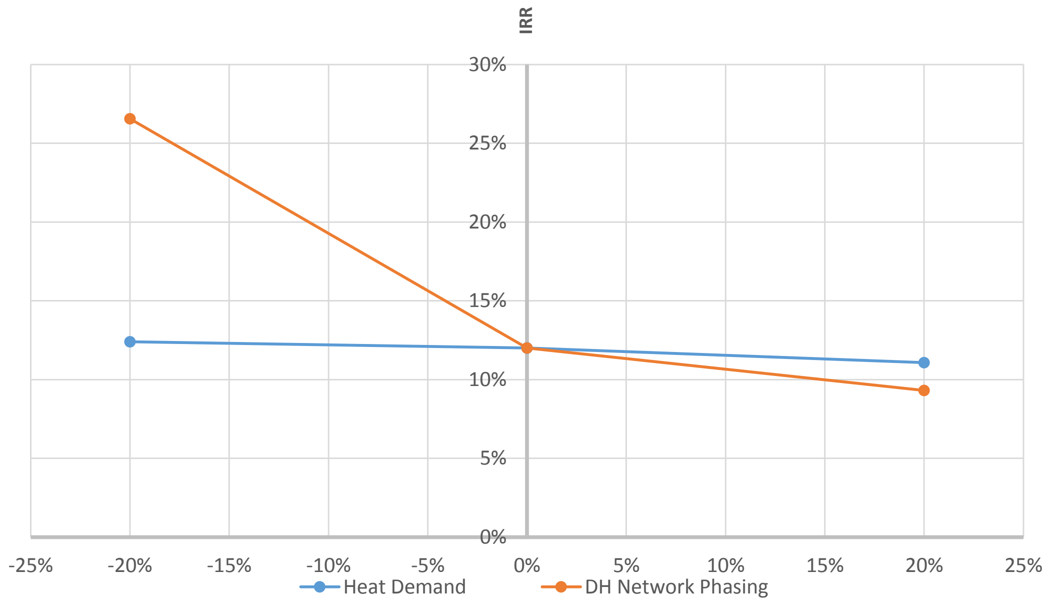

Figure 32 Connected heat demand and network phasing impact on absolute IRR

7.1.2 Sensitivity to supply side parameters

The financial performance of the scheme is dictated by the total revenues and expenditures of the ESCo including the capital expenditure, commodity costs and heat and electricity revenues.

The capital costs of the project are primarily made up of the DH network transmission costs and supply plant (e.g. CHP engine, gas boilers and energy centre construction costs). As expected, decreases in capital costs (see Figure 33) with all other aspects of the scheme remaining constant will increase the IRR of the scheme. Reductions in the pipework size, although still resulting in a beneficial impact has a smaller impact since there is a marginal saving in reducing the pipework diameter since a large portion of the pipework costs are associated with the necessary civil engineering works.

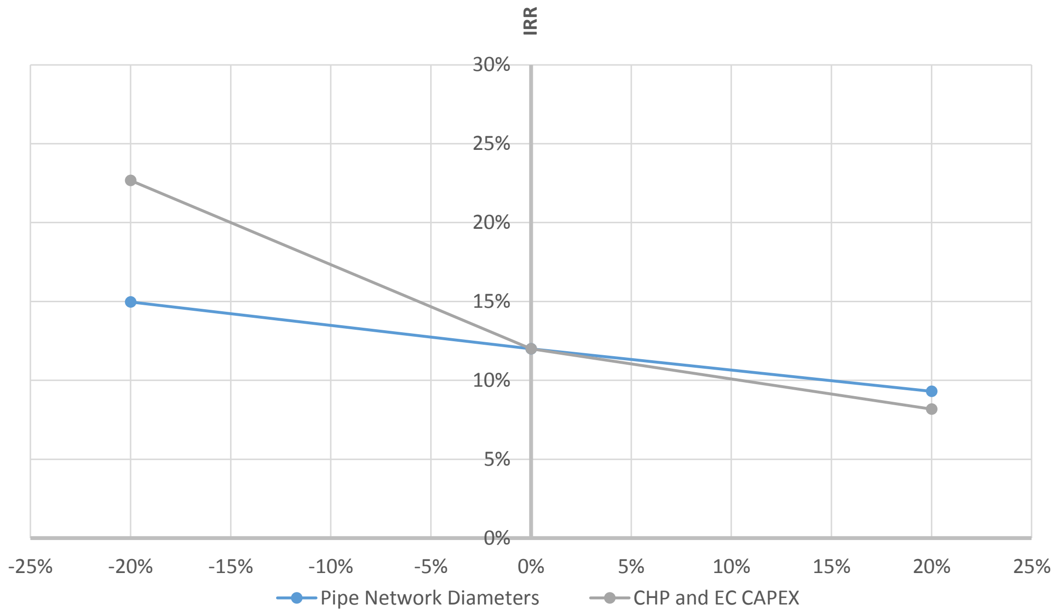

Figure 33 Pipework diameter and energy centre capital cost sensitivity analysis for CHP supply option

The scheme is highly sensitive to the heat price (both standing charge and variable heat tariff elements) and connection charge. Any reduction in the heat price and connection charge would severely impact the financial performance of the scheme with a 20% reduction in heat price and connection charge leading to a drop in the IRR to 0% and 4% respectively.

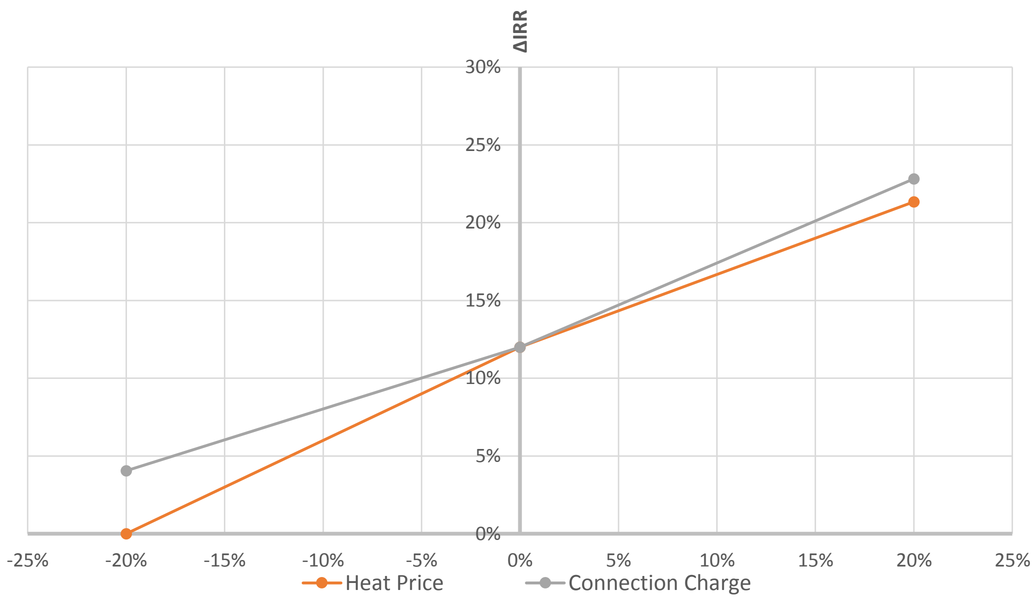

Figure 34 Heat sales revenue sensitivity analysis for CHP supply option

The gas fired CHP supply option is highly sensitive to both the wholesale gas price and the electricity price the ESCo would receive selling electricity to the electricity network. A 20% increase in the price of gas would drop the IRR of the scheme to 0% and a 20% decrease in electricity price would reduce the IRR to 4.7%. The scheme is more heavily dependent on the price of gas than the wholesale electricity price.

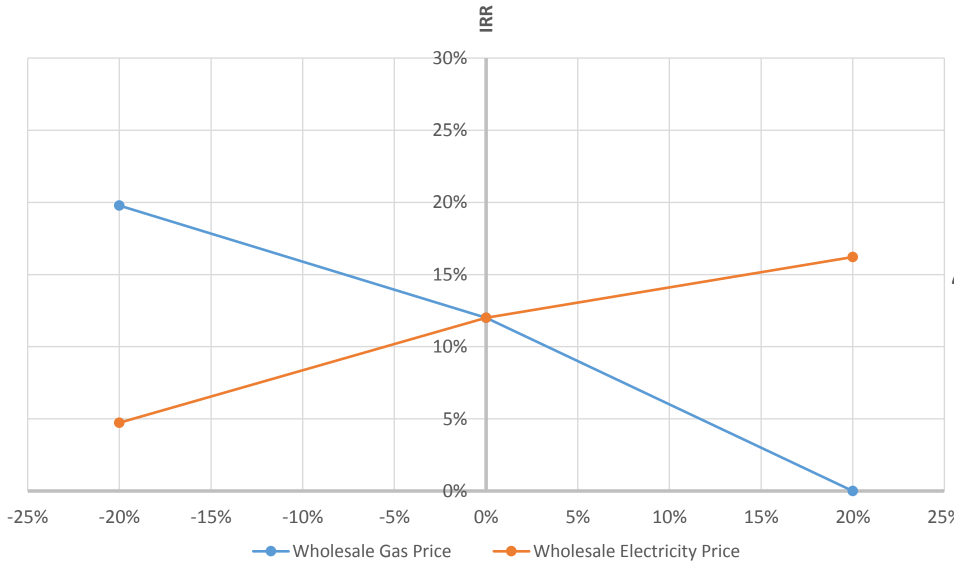

Figure 35 Gas commodity costs and electricity wholesale price for CHP supply option

7.1.3 Developer Contributions

One of the core elements for the feasibility of the scheme in addition to the heat sales revenues are the developer contributions charged to new private residential dwellings. The techno-economic modelling indicates that a developer contribution of £3,500 per dwelling would be required to achieve an IRR of 12% at a 12% discount rate and ensure that there is no funding gap for the development of the Kingston Town Centre DH network.

At a 6% public sector discount rate, with all other aspects remaining constant, the developer contribution required to break even would be £2,990. Preliminary analysis of the potential avoided costs to the developers indicates that is at a similar level to their avoided costs (to provide alternative heating systems and carbon reduction measures) however discussions with developers surrounding the developer contributions should be developed further.

Figure 36 Developer contributions impact on the Net Present Value (NPV) of the project at 6% and 12% discount rates

7.2 WSHP Supply Option

As with the CHP supply option, the key demand side parameters which will have a material impact on the network are the total connected heat demands and the phasing of the network. The impact of these two demand side factors on the absolute Internal Rate of Return (IRR) of the project are illustrated in Figure 37 below.

The financial performance of the scheme is more sensitive to the bringing the phasing of the heat demands forward by 20% resulting in an increase in IRR from 12% to 19.8% whereas a 20% delay drops the IRR to 11.2%.

A 20% reduction in the connected heat demand results in a small decrease in the IRR to 11.9%. A 20% increase in the connected heat demand raises the IRR to 12.1%. The change in connected heat demands directly impacts the RHI revenues payable on the eligible heat generated by the WSHP which represent a greater portion of the annual revenues (excluding the developer contribution) at 30% than the electricity sales generated by the CHP supply option at 24%.

The additional revenues from an increased heat demand for the WSHP scheme are able to offset the increase in capital costs for the scheme.

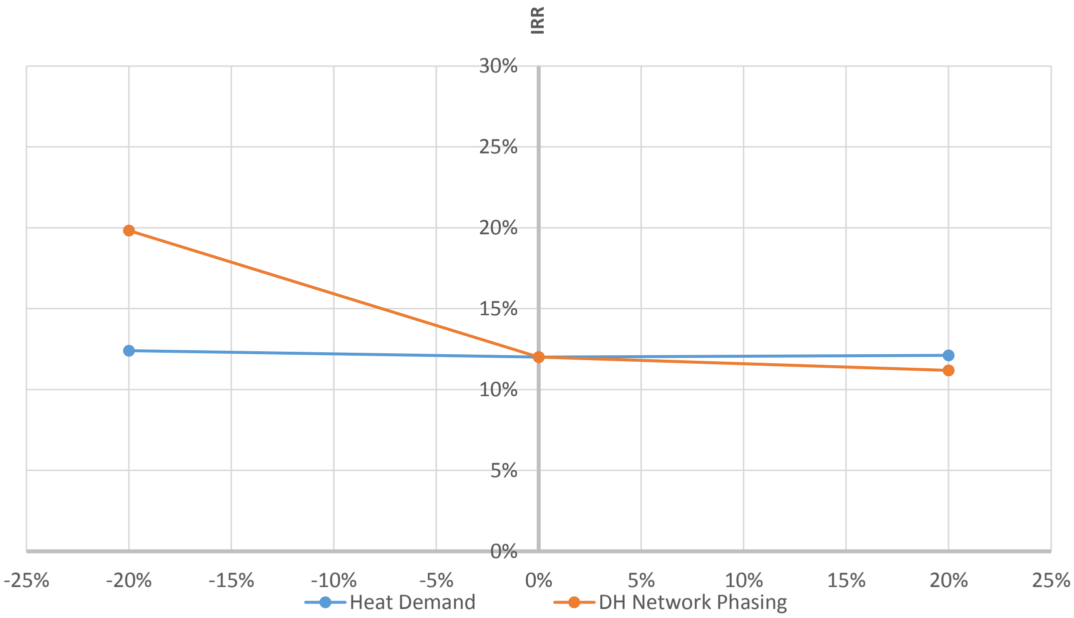

Figure 37 Heat demand and network phasing impact on the IRR of the WSHP scheme

7.2.1 Sensitivity to supply side parameters

The financial performance of the scheme is dictated by the total revenues and expenditures of the ESCo including the capital expenditure, commodity costs and heat and electricity revenues.

As described previously, reductions in pipework size and therefore the cost savings result in a small increase in IRR of the scheme to 13.7% however a large part of the pipework costs are made up of the necessary civil engineering works. A reduction in the WSHP and energy costs of 20% lead to an increase in the IRR to 15.3% and conversely a 20% increase reduces the IRR to 9% (see Figure 38). The WSHP scheme is less sensitive to changes in the capital cost of the supply plant than the CHP supply option which had increases of 22.7% (for a 20% reduction in costs) and 8.2% (for a 20% increase in costs).

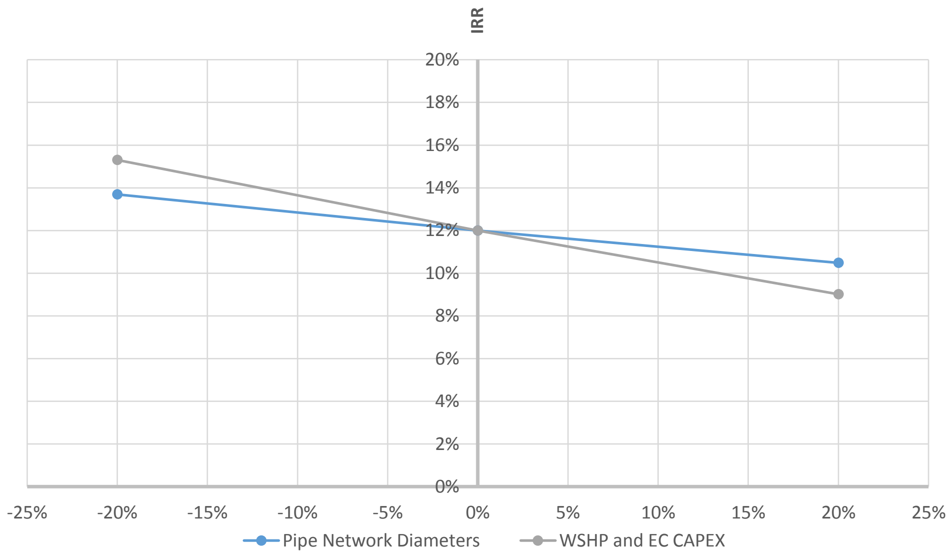

Figure 38 Pipework diameter and WSHP and energy centre capital cost sensitivity analysis for the WSHP option

The scheme is sensitive to the heat price (both standing charge and variable heat tariff elements) and connection charge (see Figure 39). A reduction in heat price and connection charge of 20% would reduce the IRR of the scheme to 5.5% and 8.5% respectively and an increase of 20% would increase the IRR to 16.8% and 16.6%. Although the scheme is sensitive to the heat price and connection charge, it is less sensitive than the CHP supply option being less dependent on heat sale revenues (although more dependent on RHI revenues).

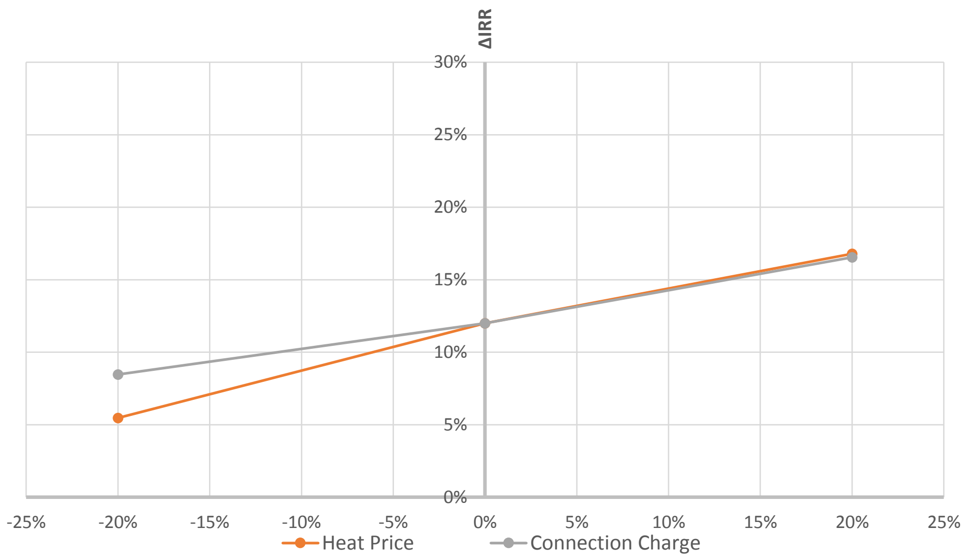

Figure 39 Heat sales revenue sensitivity analysis for the WSHP supply option

The WSHP supply scheme utilises both electricity (for the heat pump) and gas (for the top up boilers) and is much less sensitive to changes in the gas price (see Figure 40). A 20% increase in gas price results in a small reduction in IRR to 11.5% and a 20% decrease results in a small increase in IRR to 12.5%. As expected, the scheme is more sensitive to the electricity price as the heat pump

Figure 41 Developer contributions impact on the Net Present Value (NPV) of the project at 6% and 12% discount rates

8 Commercial and Business Case Analysis

This section reports on the particular commercial delivery options which have been analysed for the scheme.

8.1 Summary of scheme options and economic performance

The results of the technical and economic analysis reported in the preceding sections can be summarised as follows:

- A district heating network serving Kingston Town Centre could be developed to serve planned new and existing developments. The network would begin by connecting to the two planned major development sites of Eden Quarter and the Old Post Office site, with the network growing over four distinct phases.
- Two feasible supply options have been identified, being:
  - a gas CHP-led system with the preferred energy centre location being the Council's Ashdown Road car park site (or other town centre sites); and
  - a water source heat pump (WSHP) system drawing heat from the River Thames, with an energy centre located at the Eagle Brewery Wharf site.
- The economic analysis provides an indication of the likely developer connection charges which would be needed to ensure the scheme is viable over a 20-year period of analysis. In some plausible scheme scenarios, the connection charges are be greater than the developers' likely willingness to pay (based on an estimate of their avoided costs from connection) while in others the charges are less than their willingness to pay. This is a critical issue for the scheme and in particular affects the potential for a market-led delivery route and for growth of the network from its kick-start phase to serve the whole of the town centre and beyond.

8.2 Network development conditions

This section summarises the key conditions of network development that have arisen so far during Arup's feasibility study. These strongly influence the delivery routes for a scheme.

1. There are two significant developments within Kingston Town Centre, the Eden Quarter redevelopment by British Land and the Old Post Office Site development by St. George. The two developments are located adjacent to each other and represent a potential 700 residential dwellings and over 25,000m^2 of non-domestic floor space. The phasing of the two developments is similar with both developments predicted to complete around 2017/2018 both being key anchor loads to the development of Phase 1 of the network.

   Currently, the two developments have each proposed an energy strategy integrating a small-scale combined heat and power (CHP) heating solution with an allowance for future connection to a DH network. Preliminary discussions undertaken with British Land and St. George indicate a strong appetite to connect to a DH network if a network was available and would satisfy their requirements for planning. However, both developers expressed reluctance to hosting large energy centres.

2. There are a number of existing large non-domestic heat loads identified in the surrounding area, primarily John Lewis, Bentalls Department Store and a number of buildings within the council's Guildhall complex. The phasing of the connection to the Guildhall complex is dictated by the current estimate for the boiler plant replacement (an estimated 2025). The phasing for connections to John Lewis and Bentalls Centre are provisionally estimated for 2023 with similar estimated plant replacement date of 2025.
3. There are a number of residential-led developments in the old Kingston gas works site which are also due for completion around 2018 north of Kingston Town Centre (by Berkeley First Homes and the Kingsgate House development by Goldcrest land). Discussions with the developers also indicate a high level of interest to connect to a DH network if available, with the majority of the new developments planning to build in an allowance for a connection to a DH network in the future. If these developments are not connected prior to their completion dates, it is expected that there would be a significant time interval before the developments would be willing to connect, the next opportunity being dependant on the developments' plant replacement cycles. A delayed retrofit connection would also mean a much lower connection charge, or no charge at all, because there would be little in the way of avoided costs from connection at that stage.

8.3 Commercial options

In a workshop held on February 17th 2015 between Arup and the Royal Borough of Kingston, discussions focused on the various roles and responsibilities which are typically involved in the commercialisation of a district heating network (promoter, funder and asset owner for example). The Council discussed where each of the various roles and functions should lie for the development of the scheme in Kingston Town Centre with the preferred structure illustrated below in Figure 42.

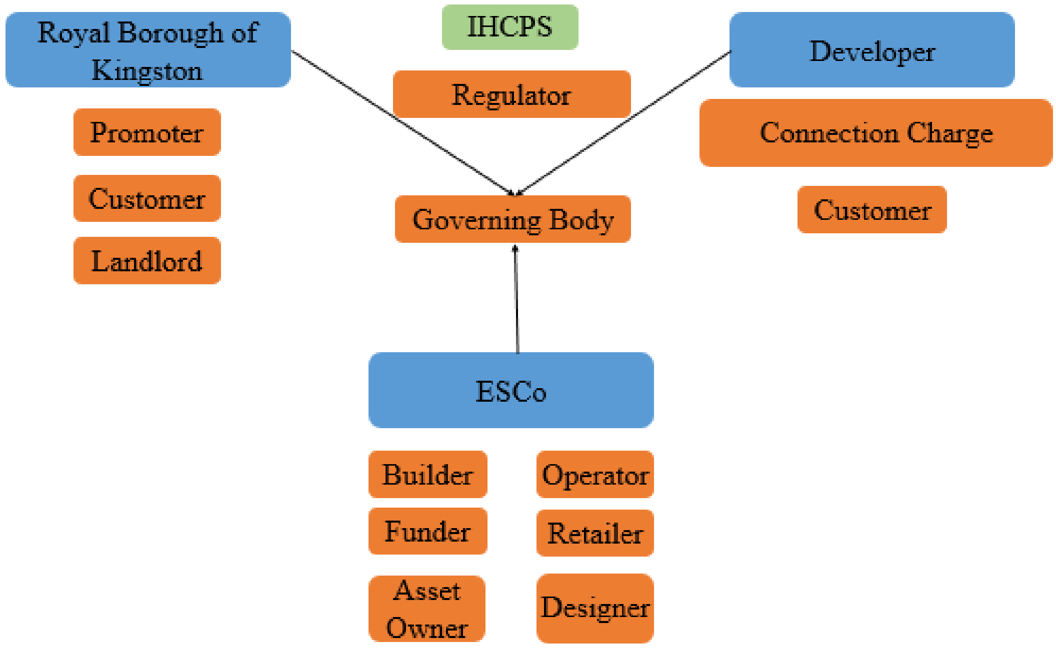

Figure 42 Roles assigned to the development of a DH network

8.3.1 Council roles

By virtue of its client role in commissioning this and the previous decentralised energy studies for the town centre, the Council is currently acting as the **promoter** of a potential of a potential DH network with the commissioning of this feasibility study and previous heat mapping and energy masterplan studies. This role could continue to be performed by the Council, through activities such as convening meetings with potential customers, undertaking soft market testing with potential suppliers (ESCos) or even undertaking a formal procurement process to select an ESCo for the scheme.

The council is also potentially a **landlord** (if the EC is hosted in the Ashdown Road Car Park or other town centre sites) and a **customer** (with the connection of some of the buildings within the Guildhall complex).

8.3.2 Developer roles

The two main developers (St. George and British Land) would act as **customers** and contributors to the scheme through payment of the **connection charge**. Potentially one or both of the developers could act as **promoters** of the scheme, although the absence of a clear leading anchor development for the town centre makes this less likely in the Kingston context. It may be a matter for discussion with the developers.

Other developers and landowners in the town centre would also act as **customers** and **connection charge** contributors.

8.3.3 ESCo roles

The risk averse position of the council, coupled with it not having an existing heat supplier role (i.e. because it is not a residential landlord in this area), lead to a conclusion that an ESCo would be called upon to undertake all the **main delivery roles** for the network and the heat service itself, including **funder**. This would include **asset owner**, even in the event that the assets were sited on the Council's land.

8.3.4 Other roles

Given the likely central importance of the Council and the two main developers, a joint **governing body** role along with the potential ESCo may be appropriate. The council's representation on the governing body could help ensure, for example, that the ESCo continued to apply a strategy of network growth over time.

District heating networks are not subject to national regulations and therefore a bespoke regulatory framework would have to be established for the Kingston Town Centre scheme. While the network might be self-regulating, another option would be for the network operator to register with the Independent Heat Customer Protection Scheme[10] (IHCPS), a national voluntary scheme operated by the Heat Trust. The IHCPS would act as a form of **regulator** for the DH network, thus providing customers with a framework for recourse in the event of a dispute or grievance with the operator of the network.

8.4 Delivery options

Following stakeholder engagement with the Council, three potential options for delivery of a DH network in the Kingston Town Centre area have been identified with different levels of involvement;

- Option A: The council acts as Promoter
- Option B: The council acts as Promoter and the Funder
- Option C: The council exercises only its planning function and leaves the market to provide a solution.

Following the workshop, RBK expressed a preference to proceed as a promoter (Option A) primarily due to the fact that there is little heat demand under direct Council control therefore any Council involvement in ownership of a network would be considered too high risk.

8.4.1 Delivery option A: Council as Promoter only

Acting as the promoter would see the Council invest staff resources and consultants in shaping and procuring the DH network. This would involve:

[10] For more information see: http://www.heatcustomerprotection.co.uk/

- Bringing together and aligning the interests of the key stakeholders in this scheme;
- Using the Council's planning levers to ensure that a coherent network was delivered; and
- Leading the procurement and tendering of the scheme.

Once the tender is successfully completed and an ESCo has been selected, the Council would have a much reduced role in the scheme as the selected ESCo would then engage and contract with the developers and customers directly. The Council may choose to act only as part of the governing body of the scheme to ensure its future development aligns with the Council's wider aspirations for the borough.

If adopted as an option, it is recommended that the Council undertakes discussions with the two key developer stakeholder at an early stage prior to planning approval to allow them the time to progress their schemes and provide assurances that detailed system designs would be compatible with a DH network providing low carbon heat.

These discussions become especially important if the scheme was developed using a split energy centre between within the St. George and British Land developments (discussed below in Section 8.5); such an arrangement would increase the complexity of the commercial agreements among the interested parties.

It is important to note that in this option the Council would not provide any capital investment in this scenario, merely the resources and assistance to procure the necessary services on behalf of all stakeholders.

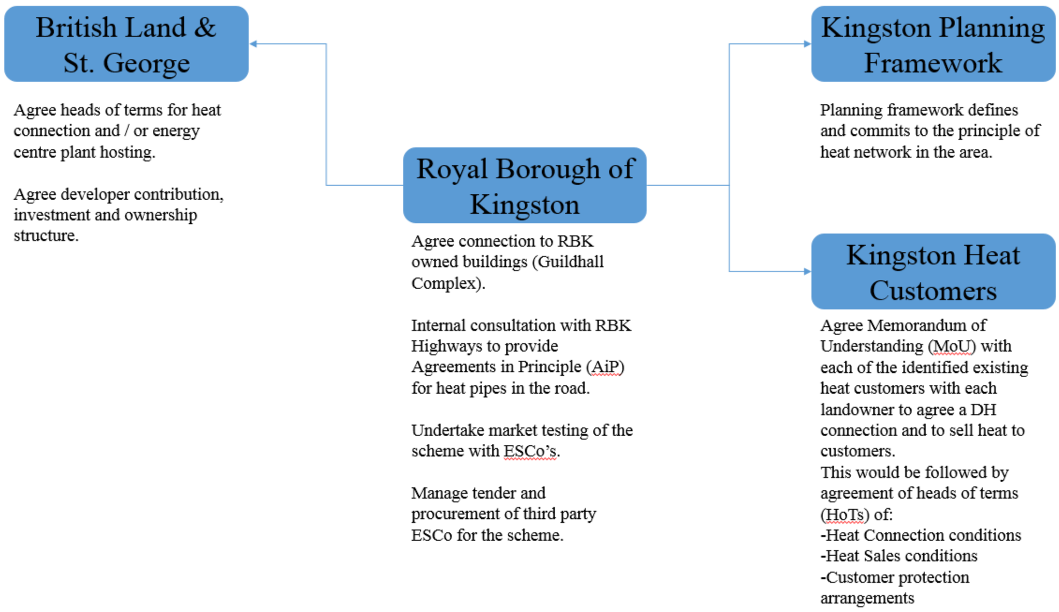

Figure 43 Promotional phase: initial activities for the Royal Borough of Kingston Council

8.4.2 Delivery option B: Council as Promoter and Funder

In this delivery option the Council involvement goes beyond the promoter activities by supplying the investment capital and taking ownership of the main pipe network assets. The Council retains ownership of the transmission pipework, receiving income in the form of an appropriate transmission use of service (TUoS) charge from the ESCo that is procured as before (InfraCo solution), or by buying heat from the energy centre and selling it with a margin to the other sites (TransCo solution).

The advantage of this option is that the Council would have access to a lower cost of capital and potentially a lower investment hurdle rate (as represented by modelling at a 6% discount rate). This arrangement would improve the viability of the overall scheme. The merger of the promoter and funder role would put the Council in a clear position as the network developer, giving the greatest probability of successful delivery of the full town centre network.

The disadvantage of this option is the financial commitment and risk exposure which the Council would incur. Although this investment would be distinctly different from non-revenue investments (such as schools and roads), this risk exposure has been identified by the Council as beyond its appetite. This option has therefore not been considered further.

8.4.3 Delivery option C: Council as Planning Authority only

The most basic option available to the Council represents the “do minimum” case, with the Council taking no role beyond its statutory role as planning authority. In this case the Council would enforce connection to a DH network through planning conditions or Section 106 agreements to connect to a network if one is built.

boundary is indicated by the green dashed line, and includes the individual HIUs in each dwelling but excludes the secondary system pipes and risers beyond the main building or site heat connection. This is one example for ESCo ownership and a number of alternative options exist (for example responsibility may terminate at each building connection or include all secondary pipework).

In this case, the Council would procure an ESCo to manage generation, transmission, distribution and retail of heat for either of the two potential core networks. The ESCo would also be responsible for sourcing the necessary funding and financing for the capital costs of the scheme. The Council would necessarily be required to enter into an agreement with the ESCo to grant either a lease or the use of the Ashdown Road car park (or other RBK owned town centre site). This configuration represents the simplest case with the energy centre being located at the Ashdown Road car park site.

8.5.2 Delivery Option A2: Split Energy Centre

An alternative structure is based around a split energy centre as described previously, with some of the DH network plant located within the Old Post Office development and the remainder located within the Eden Quarter redevelopment by British Land (see Figure 45). It is likely that in this situation, a third party ESCo would still be procured to manage at least the transmission, distribution and retail and potentially to own the generation assets. However, British Land and St. George may be owners of the plant sited within their developments, or may elect to enter into a joint venture with the ESCo.

A split energy centre typically necessitates a greater amount of plant space for a given peak energy demand compared to meeting the peak demand with a single consolidated energy centre due to space efficiencies gained through scale as well as operation and maintenance access. The peak heating demand for the district heating network is also considerably greater than each of the individual development heating demands which would therefore require a greater amount of space within each of the two developments to accommodate the required plant. Therefore consideration is required as to who will bear the costs for the increased plant area. As discussed previously, this option may require greater input from the Council to engage with the stakeholders.

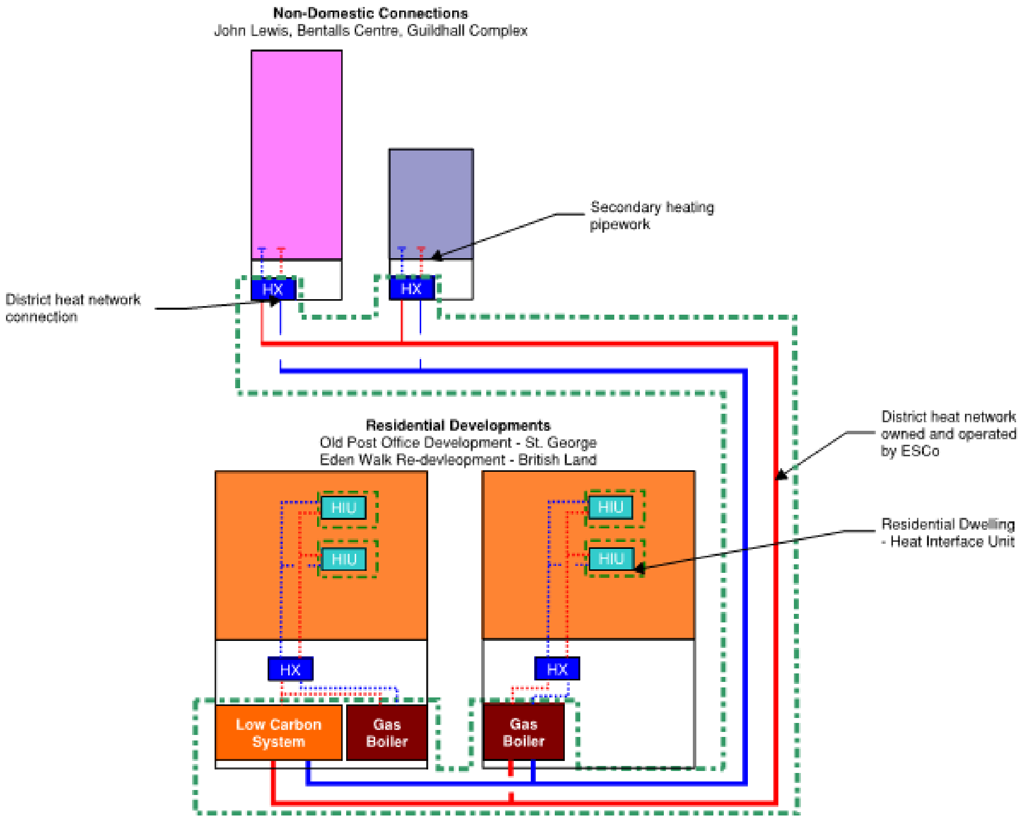

Figure 45 Alternative DH network configuration with a split energy centre

8.5.3 Recommended Council Role

With two large new developments in the Kingston Town Centre each currently planning for individual heating systems for their sites, it is unlikely that a district heating network will emerge in Kingston Town Centre without significant leadership from the Council acting as the promoter to increase the certainty for a third party ESCo that a DH network will be created.

Based upon engagement with the Council and the district heat network development conditions identified previously it is recommended that the Council undertake a promoter role (Option A) to increase the potential of a DH network being developed in the Kingston Town Centre area. The promotion phase activities which the Council are outlined in Section 10.1 of this report.

8.6 Delivery options evaluation

The three delivery options described previously lead to the four exit options displayed in the figure below.

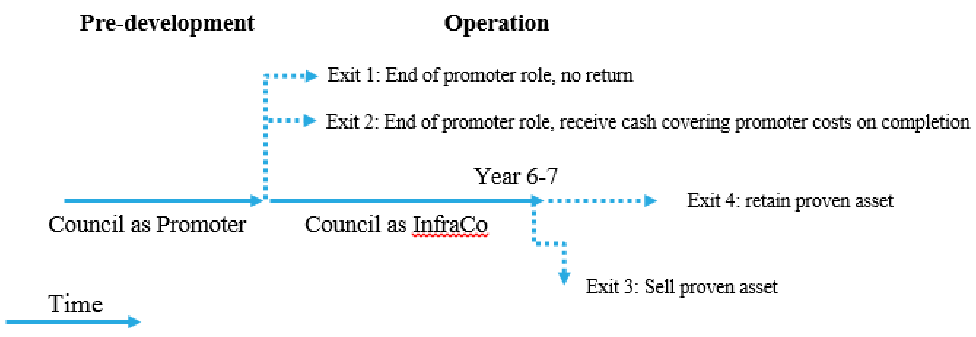

Figure 46 Potential exit routes

Since the Council is considering to act as a Promoter, the Council has two potential ways to exit the scheme, which will be the focus of the subsequent analysis. These are displayed in Figure 47.

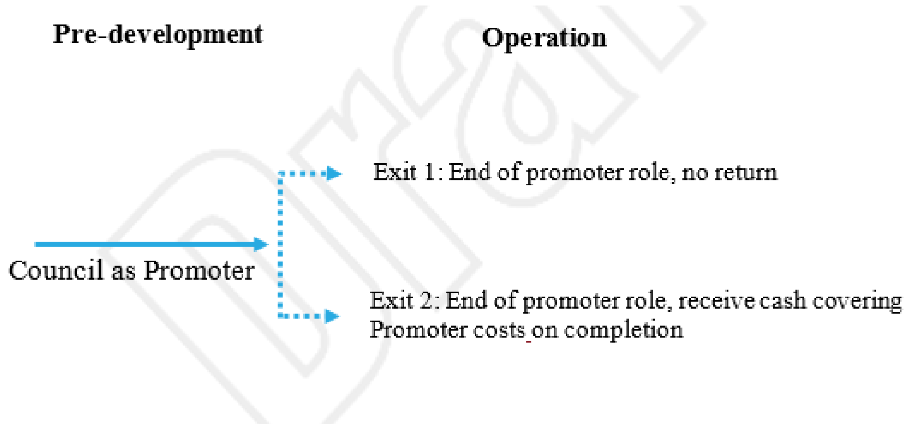

Figure 47 Potential exit routes for the Council as a Promoter

Acting as a promoter, the Council may or may not be able to receive a return equivalent to the resource costs it sank into the scheme in its role as promoter. Depending on its level of engagement, it might not be appropriate to expect such returns. The Council should ensure that the negotiation for a return on the resources invested during the promotion phase are held at an early phase with the ESCo. This could be returned to the Council upon financial close in the form of a payment amounting to the sum of its costs during the promotion phase.

The Council will be providing the resources and assistance to procure the necessary services on behalf of all stakeholders. This role might particularly involve development of the procurement documents (specification, KPIs, incentive structures etc.) and participation in bid evaluation and bidder selection. Therefore, an understanding of the likely investment costs for council resource or funds in this broker / promoter role is necessary to quantify the exit route financially from the perspective of the Council. These costs would include staff resources and spending on consultants, majority of which would be spent in the pre-development promotional phase.

Although there may not be a direct and tangible return on the Council's investment in time and resources spent on the promotion of the district heating network, the Council will benefit by virtue of being connected to the network as a customer. This would provide savings on the current Council expenditure on gas, heating plant O&M, annual gas inspections as well as future capital expenditure for plant replacement.

9 Risk Assessment

The risks highlighted and discussed in this section are those associated with the delivery of a DH scheme at Kingston Town Centre. Depending on the delivery route chosen by the Council, the risk register may be updated to take more fully into account the technical and financial risks. The full current risk register can be found in Appendix A6.

9.1 Market-led scheme

The most apparent risk is the possibility of a market-led solution not being realised within the opportunity window. The time it takes to make a deal may hinder the expansion progress of the scheme or even jeopardise its existence. The responsibility falls onto the Council intervening as the broker. In order to mitigate this risk, the Council acts as the broker in the promotional phase to secure a deal in a timely manner. With no involvement from the Council, our judgement is that it is unlikely that a large-scale heat network will emerge.

9.2 Location of the Energy Centre

Land area must be secured and safeguarded for construction of a standalone Energy Centre on the Ashdown Road Car Park or other town centre site within the Eden Quarter or at the Eagle Brewery Wharf for the WSHP option. The use of the Eagle Brewery Wharf (including the assumed rental price of £5/ft^2) or investigation into alternative riverside locations for the WSHP should be investigated further. The Council expressed that any development on that side could be highly controversial regardless of the rental income and there may also be by-laws protecting public space along the river.

9.3 Fragmented stakeholder landscape

The Council needs to coordinate the developers through its planning powers and its promoter / broker role. Through planning measures and MoUs, it is expected that these developments can be persuaded to commit to connect to a wider area heat network, should one emerge.

9.4 Developer contributions and connection charges

The financial viability of the scheme highly depends on developer contributions and connection charges. These are justified on the basis of the avoided cost of providing heat and carbon emissions reductions from other means. Should these contributions not be set at a suitable level, this could lead to unsatisfactory economics. Therefore the avoided cost value of connecting to the scheme needs to be effectively communicated and the developers should undertake suitable whole life cycle costing as outlined in the GLA Guidance on Preparing Energy Assessments (April 2015). The avoided cost of providing heat from other means should take into account the planning requirements and building regulations regarding carbon compliance of new developments.

9.5 Council commitment of resources

The experience of other schemes in the UK indicate that significant and sustained public sector involvement is normally necessary to deliver a district heating network. If the senior political commitment is not forthcoming to support officer action to promote the network then the Council's role may be under resourced and the opportunity window may pass before a deal can be struck.

9.6 Future proofing a low carbon network

As discussed previously, a CHP-led DH network for the Kingston Town Centre provides carbon savings under the current Part L 2013 Building Regulations, although it is unlikely to continue to provide carbon savings by the 2030s. It would therefore be necessary to implement a switch in the main heat source at the time of major plant replacement (expected to occur around 2030) to for example the alternative WSHP supply solution. The change from the CHP-led solution located at the Ashdown Road car park to a WSHP-led DH network would require a significant amount of investment to build a new energy centre and install the required DH network to connect the new energy centre location. This could however be funded by additional new developments connecting to the network through developer contributions at similar times to the plant replacement date.

There are two key factors to consider in planning and designing the network to allow for the future switch to an alternative supply solution:

9.6.1 System operating temperatures

The network, and the building heating systems which will connect to it, for lower flow temperatures will reduce losses in the network and enable more efficient capture of lower grade and secondary heat sources. The system has been conservatively modelled with a 20˚C flow and return temperature difference for a higher temperature conventional flow temperature of 80°C.
A lower flow temperature could be specified as part of the procurement of the contractor or the ESCo subject to the temperature difference remaining at 20°C. However, existing building systems (such as those in the College) will need to be taken into account, as they will likely require higher flow temperatures. For example, existing radiator systems operating at 82/71°C will have a reduced heat output at a lower supply temperature of 60°C.

We therefore recommend:

- The ESCo procurement specification incentivises the system design towards a lower flow temperature.
- The ESCo engages with existing building owners to explore opportunities to modify the existing secondary heating systems or modify the operating temperatures where possible to achieve secondary return temperatures less than 60˚C.
- The design of building heating systems to be connected take account of a lower temperature system such as through the use of underfloor heating.

9.6.2 Future energy centres

Some low carbon heating systems require greater land take than gas CHP engines, therefore a switch to a lower carbon supply in 2030 may necessitate the expansion of the existing energy centre or adding a second energy centre to the network neighbouring the River Thames to enable the development of a WSHP system.

Alternatively, heat could be injected into the system through multiple heat sources (such as geothermal wells or multiple secondary heat sources). In commercial terms, if the CHP-led solution is developed further, committing now to significant oversizing of the energy centre would erode the viability of the network, the eventual benefit of that investment would remain highly uncertain. Other dispersed heat sources and more suitable energy centre locations might obviate such oversizing or the improvement of building energy management and network management may enable the system to serve its customers with lower peak capacity than was provided at the start.

Given also that the original investment in the pipe network would by that time largely have been paid off, we would expect the commercial case for the additional capital cost of an energy centre to exist in 2030, particularly if the value of carbon has also increased.

We therefore recommend that energy centre oversizing for a future low carbon heat source is not included, but that planning for supply switching is explicitly planned into the ESCo’s business plan from around 2025.

10 Procurement and Delivery Plan

This section provides an initial summary of the typical activities that might be required to be undertaken by RBK in support of the successful promotion and delivery of a DH network at Kingston Activities are based on the currently understood position of the Council and the state of development at Kingston as described in the preceding sections. Estimates are indicative at this point in time.

10.1 Promotion phase activities

The "promotion" phase coves the activities necessary to bring the various stakeholders in a DH network at Kingston together to secure commitment to delivery, or connecting to the future network.

Due to the short timescales and likely completion of the two large developments ahead of 2018, many of these activities would need to commence almost immediately, but are not expected to take up a whole full-time equivalent (FTE) officer time in the short term at least.

Where an activity includes phrases such as "negotiate with" or secure agreement", this would include formal documentation of the agreement in a "Heads of Terms" or "Memorandum of Understanding." These preliminary agreement documents would be followed at a later date by contractually binding documents appropriate to the particular context and purpose. The later documents might include:

- Section 106 agreement
- Heat Connection Agreement
- Heat Purchase Agreement
- Joint Venture or Development Partnership Agreement

10.2 ESCo procurement support

The developers and the Council (as landlord and customer of the future Energy Centre) can conduct a joint market approach by setting up a Special Purpose Vehicle (SPV) to secure the delivery of the DH network. The partnership's board would be formed by the Council and senior executives from the development companies associated with the DE scheme. New developers would be expected to join when their development comes forward. The Council's involvement in the SPV with the developers will allow the council to retain influence over future delivery. The SPV will facilitate the negotiations by providing a coordinator role, maintaining active engagement throughout to ensure there is an early agreement to adopt the scheme.

The SPV will seek services on behalf of the developers which are committed, and will confer exclusive rights to negotiate with each developer for connection agreements. The SPV aggregates nominally the total number of developers and therefore brings without obligation, the potential for future connections and revenue to the ESCo.

With the input of the developers which form the SPV, the SPV would during the procurement phase provide a guarantee of heat demand to provide certainty to the ESCo on future revenues. A lower or nil guarantee may result in a poor response by the market or higher prices. This would be included as part of the procurement documentation along with the number of dwellings to be connected, non-domestic floor area, metered gas consumption data of existing buildings and an outline of the longer term opportunity for expansion. This will enable the ESCo to design and size the network and energy centre as well as allow it to undertake its financial modelling. The procurement documents can seek to share the benefits of network growth.

During procurement, the selected ESCo would have exclusive right to negotiate with each of the developers by means of SPV. The developers would commit to reasonable endeavours to enter into agreement with the ESCo. The key procurement stages are set out below.

Table 13 Key documents for promotion and procurement process

Item	Detail
Memorandum of understanding	A MoU is to be signed by the developers to demonstrate a working intent to procure ESCo services.
Pre-qualification	A pre-qualification questionnaire (PQQ) is issued jointly by the developers (via the SPV), to shortlist potential ESCOs.
Enquiry Documentation	An invitation to negotiate (ITN) documentation pack is issued jointly by the developers (via SPV) setting out the Master Agreement for the area. This will set out the principles for the scheme, i.e. successful ESCo will gain exclusive rights to negotiate with the named developers to provide heat and energy services, with opportunities for expansion also listed (but not forming part of the core commitment). The master agreement will have schedules which will act as the basis for the individual negotiations undertaken by each of the developers with the selected ESCo. The schedules will form the basis of the individual negotiations between the ESCo and developers during which will be modified to suit the specific needs of each development.
Recommendations Report	Recommendations report prepared by the SPV scoring the responses to the enquiry documentation, with recommendations made to developers.

Following the issue of the recommendations report, the SPV will select a preferred ESCo with whom each developer will enter individual negotiations in Phase 2 of the procurement.

Once appointed, the preferred ESCO negotiates individual heat sale agreements/service level agreements with the developers and signs connection contracts with each independently.

Developers should note that in order to attract an ESCo capable of financing and delivering the services required by the developers, the individual negotiations will commit the developers to a minimum heat take from the network built and operated by the successful ESCo.

Once the ESCo has entered into agreements with the developers, the parties will have a direct contractual relationship with no role for the SPV. The ESCo will continue expansion of the network through negotiation with new developers and landowners.

10.3 Post-delivery

Once the scheme is up and running, the Council could maintain involvement in the area, observing performance and providing planning certainty for future developments regarding the need to connect to this proven network. This role might particularly involve representation on the governing body, which would involve attendance at periodic meetings by a senior member of staff and *ad hoc* involvement in issues outside those meetings.

11 Planning

11.1 Planning policy review

This section considers appropriate policies for securing the opportunity for a decentralised energy network to be developed and for future developments to connect to that network. It reviews RBKC's existing policy framework in relation to DE and identifies any modifications which the Council could consider to strengthen the policies. It also provides a selection of example policies and supporting text from other London local planning authorities, for comparison and reference.

The context for Kingston's policies on DE is the London Plan, which was updated in March 2015. The key policies of relevance are:

- Policy 5.2 Minimising Carbon Dioxide Emissions
- Policy 5.5 Decentralised Energy Networks
- Policy 5.6 Decentralised Energy in Development Proposals

We have provided commentary on each relevant policy and section of guidance, with suggested amendments where relevant.

Policy DM2 Low Carbon Development

The policy contains three main elements:

- General support for renewable energy. We have no comments on this part.
- Support for "energy generating infrastructure" where the heat can be used. We have no comments on the intention of the policy, but it could be made more clear by referring specifically to energy developments which produce heat as a by-product. The policy could also go further by encouraging all developments which generate heat to consider the scope for capturing and using that heat.
- Requirements for new developments within the district heating opportunity areas of Hogsmill, Kingston and Tolworth. We suggest that the requirement to connect should be conditional on a feasibility and viability test, rather than a CO_2 savings test. This is because there can be cases where a development can achieve lower CO2 emissions from a stand-alone solution, but this might preclude the growth of the DH network to serve developments where such savings are not practicable (e.g. connecting to existing development). Furthermore, DH networks create the capacity for the network to achieve further district scale CO_2 savings through large scale supply switches (such as a centralised water source heat pump).

Suggested amendments to the policy are shown below.

The Council will consider all applications for independent renewable energy installations favourably, subject to other Core Strategy policies.

The development of **energy and other infrastructure developments where heat is produced a by-product** ~~generating infrastructure~~ will be fully encouraged by the Council providing that any opportunities for **making beneficial use of the heat** ~~generating heat simultaneously with power~~ are fully exploited.

The Council will **promote the development of** ~~seek to develop~~ District Heating network in the following areas**, which have been identified as being** suitable for the establishment of **such** a ~~district combined heat and power~~ network:

- The Hogsmill Valley Area
- Kingston Town Centre
- Tolworth Regeneration Area

Where relevant, development proposals in these areas should undertake the following when a District Heating Network is:

- Not in place – Major developments should undertake a detailed investigation into the feasibility of establishing a District Heating Network with the proposed development as an anchor heat load or contribute towards such feasibility work.
- Planned – make all reasonable efforts to ensure the proposed development will be designed to connect to the planned District Heating Network without any major changes to the development. When the network is in place, the development should be connected, unless it can be demonstrated that **it is not feasible or viable to do so.** ~~there is insufficient heating demand for an efficient connection.~~
- Present – connect **new developments** to the District Heating Network and make all reasonable attempts to connect existing **buildings within the development site** ~~developments in the vicinity to the network~~, unless it can be demonstrated that **it would not be feasible or viable to do so.** ~~connection of existing developments will not result in CO2 savings.~~

In relation to the "planned" category, guidance should be provided to applicants on the measures likely to make the development "connection ready." A suggested list of measures (adapted from Arup's published guidance document Decentralised Energy Masterplanning Manual[11]) is set out below:

- Installation of pipes connections up to the property boundary to enable future district heating network connection, or at a minimum designation of a safeguarded pipe route to the property boundary;
- Adoption of an on-site network with at least communal heating systems in each building, with the site energy centre or plant rooms located and designed to enable a future network connection;
- Agreeing a planning obligation which imposes a "duty to connect" on the development, which would be triggered by a notice from a district network operator. The duty to connect would be subject to the landowner and that

[11] http://www.theade.co.uk/decentralised-energy-masterplanning-toolkit_644.html

planned (Eden Quarter redevelopment and the Old Post Office development). There is mention that with large development in the area there is an opportunity to implement a district heating network.

11.2 Planning decisions

11.2.1 Planning conditions

The following are suggested model clauses for securing development of or connection to a heat network.

Connection of an on-site heat network

No more than [100] units of the development hereby approved shall be occupied until the proposed CHP plant has been installed and commissioned and all units have been connected to the site district heating network. All units completed thereafter shall be connected to the site district heating network prior to occupation.

Connection to an off-site heat network

The development hereby approved shall not be occupied until a physical connection to the [name of] District Heating Network has been installed and commissioned, unless otherwise approved in writing by the local planning authority.

11.2.2 Planning obligations

The following text is suggested as a form of words for a planning obligation to require a development to connect to a future district heating network. Although it is based on real examples, the form of words set out below has not be reviewed by a lawyer; this should be done prior to its use in a Section 106 agreement.

Interpretation

"Qualifying Heat Network Operator" or "QHNO" means a person currently operating or capable of operating a district heating network with sufficient capacity to serve the Development and the capability to connect to the Development. For the avoidance of doubt, the Council or its nominee may qualify as a QHNO.

"Qualifying Heat Network" or "QHN" means a network currently operated or planned to be operated by a QHNO.

1 Right to Connect Clause

1.1 In the event of a Qualifying Heat Network Operator being identified by the Council, the Council may serve notice upon the Developer to connect the Qualifying Heat Network to the Development to enable the QHN to supply the heating and hot water requirements of the Development.

1.2 The right of the QHNO to connect to the Development shall be subject to the following conditions being satisfied:

(a) the proposed tariff structures must protect the interests of the Developer and occupiers, in that total levelised costs for delivery of the service shall be no more than would have been the case if a stand-alone heating system had been provided. Tariffs include unit consumption charges, standing charges, management fees and plant replacement funds;

(b) connection charges to the network are reasonable and economically viable; and

(c) a service level agreement can be entered into to protect the interests of the Developer and occupiers by way of a guarantee of system availability.

1.3 The right to connect shall also be subject to any regulatory changes governing the communal supply of energy.

1.4 The Developer shall use reasonable endeavours to agree the tariffs, charges, service level agreement and all other commercial terms necessary to enable the QHN to connect to and supply heat to the Development.

1.5 In the event that the network is available to the development prior to completion of construction, and the Developer connects to the network, the developer will be released from obligations to install on-site low carbon heating equipment.

1.6 In the event that the network is not available to the development prior to completion of construction, the developer will remain obliged to connect to the network at any economically viable opportunity, but it is recognised that this opportunity may not arise until the end of the economic life of the on-site heating plant.

Appendix A

Additional Supporting Information

A1 Demand Analysis

A1.1 Full list of demands considered in the immediate area

The heat demand characterization table below outlines the various technical and commercial findings from the feasibility study and highlights the aspects which should be considered in further detail for future scheme development. Each of the customers is considered in isolation against a baseline scheme connecting all of the identified customers below. Each customer is removed from the network individually to indicate its impact on the overall network. The baseline supply energy solution is a CHP and gas fired boiler energy supply solution. The baseline DH network scheme performance has an Internal Rate of Return (IRR) of 4.3% and a Net Present Value of -£409,000 at a 12% discount rate.

The heat demand characterisation of individual connections in relation to the wider network provides insight into their impact on the wider network however it is important to consider the impact of the various network clusters and branches.

The key findings from this analysis was a number of non-domestic connections which were found to be commercially unviable for connection to the DH network including Surrey County Council, Kingston College and Kingston Crown Court. The additional revenue (through heat sales and increased CHP electricity generation) was not sufficient to offset the estimated cost of the transmission and distribution pipework of £1,130,000. These connections represent large heat demands therefore should be considered in the future development of the network however are not considered viable during this feasibility in the initial development of the DH network with a negative impact on the overall scheme IRR of over 7%. Along with further issues related to the network routing (discussed in further detail in Appendix A3) the demands have been removed from this analysis. The

The priorities in developing a DH network in the Kingston Town Centre area are primarily to develop a commercially viable scheme to attract private investment with a target IRR of 12% and maximise the carbon savings of the network. Taking into consideration the various individual aspects and risks with a number of the connections (for example plant replacement cycles for Primark and Marks and Spencer) the final core scheme of customers is outlined in Table 14.

Table 14 Heat demand characterisation table

Customer	Connection Confidence	Connection Importance	Core Scheme Connection
Bentall Department Store	**Medium / Low:** Known communal boiler heating system although interest for connection and plant replacement date currently unknown.	**Medium:** The Phase 3 of the network (the connection to Bentalls and John Lewis) has a minor negative impact on the overall performance of the scheme. However, considering the heat demand from the store and potential carbon savings the connections to Phase 3 have been retained in the feasibility study as the minimum target for the scheme's IRR of 12% is still possible with these connections while increasing the overall carbon savings provided by the DH network by increasing the connected heat demands.	**Yes**
Bentall Centre	**Medium:** Small common boiler heating system although interest for connection if there is a business case. Plant replacement estimated 2020 ahead of current 2023 connection date in analysis.	**Medium:** The connection to the small Bentall Centre heat demand has a small positive impact on the overall IRR of the scheme as the connection to the Bentall Centre and associated heat demand through the network does not result in an increase in transmission pipe size.	**Yes**
David Lloyd Gym & Rotunda	**Medium:** Known communal heating system although plant replacement date and interest for connection is unknown.	**Medium:** The connection to the gym during Phase 1 has a positive impact on the IRR of the scheme.	**Yes**
Guildhall	**High**: Communal heating systems suitable for connection and high interest for connection to low carbon network.	**Medium:** The connection to Guildhall and Guildhall 2 has a small negative impact on the IRR of the scheme (reducing it by 0.2% and 0.4%). Despite the negative impact on the IRR of the scheme; the interest for connection to the network as well as the aim to increase the carbon savings of the DH network in the borough	**Yes**
Guildhall 2			**Yes**
John Lewis PLC	**Medium:** Communal heating system however current plant replacement estimated 2025 with a current connection date of 2023.	**Medium:** Currently, the connection to John Lewis (along with the Bentalls connections) have a negative impact on the overall scheme IRR. As mentioned previously, although the connection to John Lewis has a negative impact on the scheme, the connections in Phase 3 are retained to increase the overall connected heat demands and associated carbon savings for the DH network.	**Yes**

Customer	Connection Confidence	Connection Importance	Core Scheme Connection
Kingston College	**Medium**: Communal heating system although plant replacement cycle and interest level currently unknown.	**Low:** The connection to the Kingston College in Phase 1 has a negative impact on the IRR of the scheme reducing it by 1.4% against the baseline. To be considered in future expansion of scheme when plant replacement dates are known.	**No**
Kingston College North (Kingston Hall Road)	**Medium**: Communal heating system although plant replacement cycle and interest level currently unknown.	**Low:** The connection to both Kingston College buildings to the South of the DH network has a negative impact on the IRR of the scheme decreasing it by 1.5%. Potential additional network routing costs due to river crossing are currently unknown and should be considered for connection.	**No**
Kingston College South (Kingston Hall Road)			**No**
Kingston Crown Court	**Medium**: Communal heating system. Connection interest and drivers unknown.	**Low:** The connection to the Crown Court has a negative impact on the IRR of the scheme reducing it by 1.1% against the baseline. As per Kingston College North & South, there are unknown costs associated with the river crossing.	**No**
Kingston Police Station	**Medium**: Communal heating system although plant replacement date unknown. Connection interest and drivers unknown.	**Low:** The connection to the Kingston Police Station in the Guildhall complex has a slight negative impact on the IRR of the scheme, reducing it by 0.4%. The connection to the police station is retained in the core scheme for the moment however this should be reviewed following further information regarding estimated plant replacement dates.	**Yes**
Marks & Spencers Ltd	**Medium:** Communal heating system although plant replacement date is unknown. Connection interest unknown although known sustainability drivers may motivate connection.	**Low:** The connection to Marks & Spencers would result in a reduction in the scheme IRR by 1.2%. The precise point of connection to the communal heating plant is unknown and the reduction in IRR is in part due to the cost of DH connection to Marks & Spencers. This should be investigated further as Phase 1 of the network is developed but currently connection is removed from the core scheme.	**No**
Primark	**Low:** Heating system, plant replacement dates and connection interest and drivers unknown.	**Low:** The connection to Primary along the DH network in Phase 1 towards the gas holders site would result in a marginal negative impact on the IRR of the scheme reducing it by 0.3%. The connection has been removed from the core scheme due to the small minor impact along with a	**No**

Customer	Connection Confidence	Connection Importance	Core Scheme Connection
		number of additional unknowns with the connection. This should be investigated further as Phase 1 of the network is developed.	
Surrey County Council	**Medium:** Interest in connection with key focus on heat price and connection business case. Plant replacement cycle within next few years against current connection date of 2029.	**Low:** The connection to the Surrey County Council building has a negative impact on the IRR of the scheme reducing it by 2.3% against the baseline. This is primarily due to the length of DH pipework required to connect the Surrey County Council plantroom located off Penrhyn Road down The Bittoms Road. As per Kingston College North & South, there are unknown costs associated with the river crossing.	**No**
Travelodge Central	**Low:** Heating system, connection interest and drivers unknown.	**Medium:** Without a connection to the Travelodge along the DH network to the north of Kingston Town Centre the IRR of the network would be reduced by 4%.	**Yes**
Kingsgate House – Goldcrest Development	**Medium:** Planning consent granted and proposed heating system unknown.	**High:** The connection to Kingsgate House in Phase 1 of the network is crucial for the development of the DH network. Without a connection to the development, the IRR would be -8.2% with a negative NPV of £-885,000. The developer contributions are key for the commercial viability of the scheme.	**Yes**
Eden Walk – British Land Development	**High:** High level of interest and communal heating system proposed.	**High:** The Eden Walk redevelopment (along with the Old Post Office Development) is the key anchor load for the development of a DH network in Kingston Town Centre. Without a connection to the Eden Walk the scheme would not be commercially resulting in a negative IRR of -14.6% and a negative NPV of -£1,317,000. The developer contributions are key for the commercial viability of the scheme.	**Yes**
Old Post Office – St. George Development	**High:** High level of interest and site wide heating system proposed.	**High:** As per the Eden Walk, the Old Post Office development is the key anchor load for this DH network. Without a connection, the scheme would not be commercially viable resulting in a negative IRR of -14.7% and a negative NPV of -£1,430,000. The developer contributions are key for the commercial viability of the scheme.	**Yes**

Customer	Connection Confidence	Connection Importance	Core Scheme Connection
Kingston Gala Bingo Development	**Medium**: Planning consent granted although CHP system proposed therefore connection possible.	**Medium:** The connection to the Gala development has a very minor negative impact on the IRR of the scheme reducing it by 0.2%. The Gala development is considered to connect to the core scheme at this stage and should be revisited as the development develops and revised heat demand information might be available.	**Yes**

Fuel consumption data converted to heat demand (in MWh/year) based on assumed efficiency of existing heat generation systems (e.g. gas boilers). See section A9 for details of assumptions.

A1.2 Demand mixes at full build-out

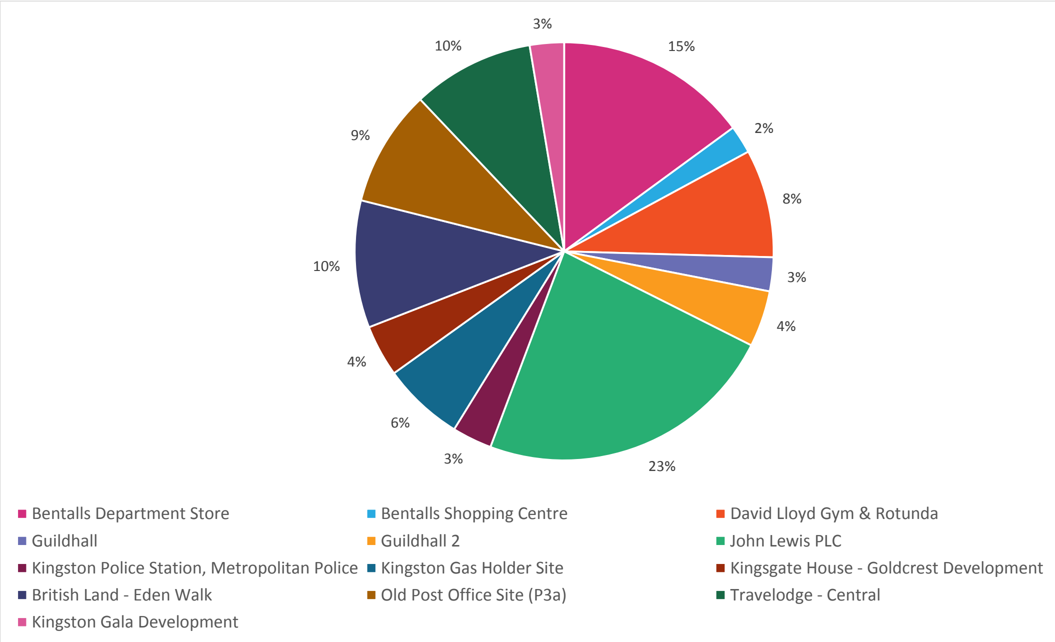

Figure 48 Kingston Town Centre DH network heat demand split

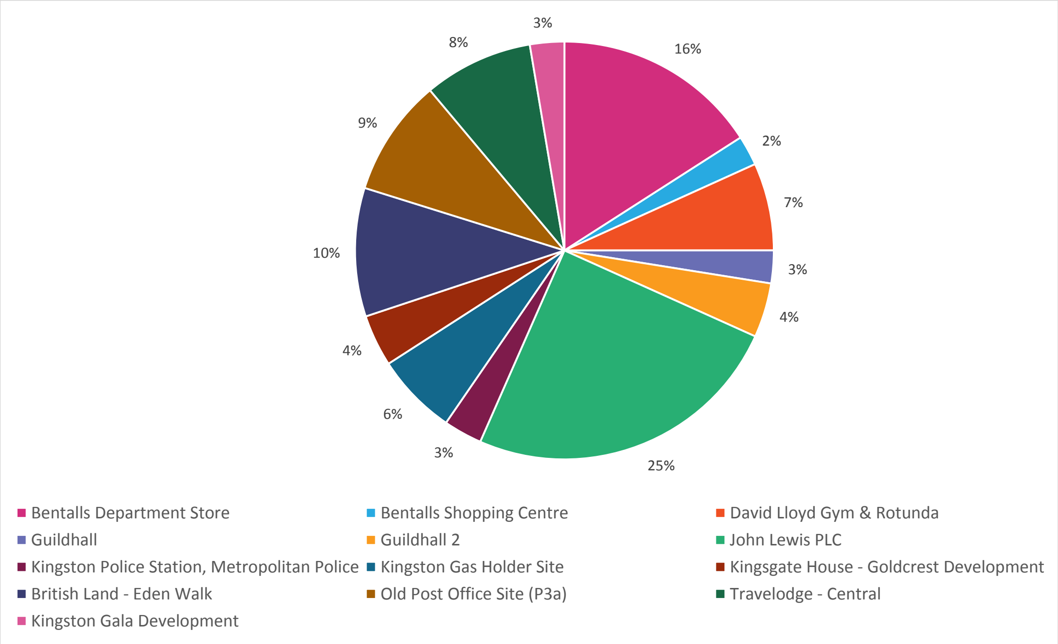

Figure 49 Kingston Town Centre peak heat demand split

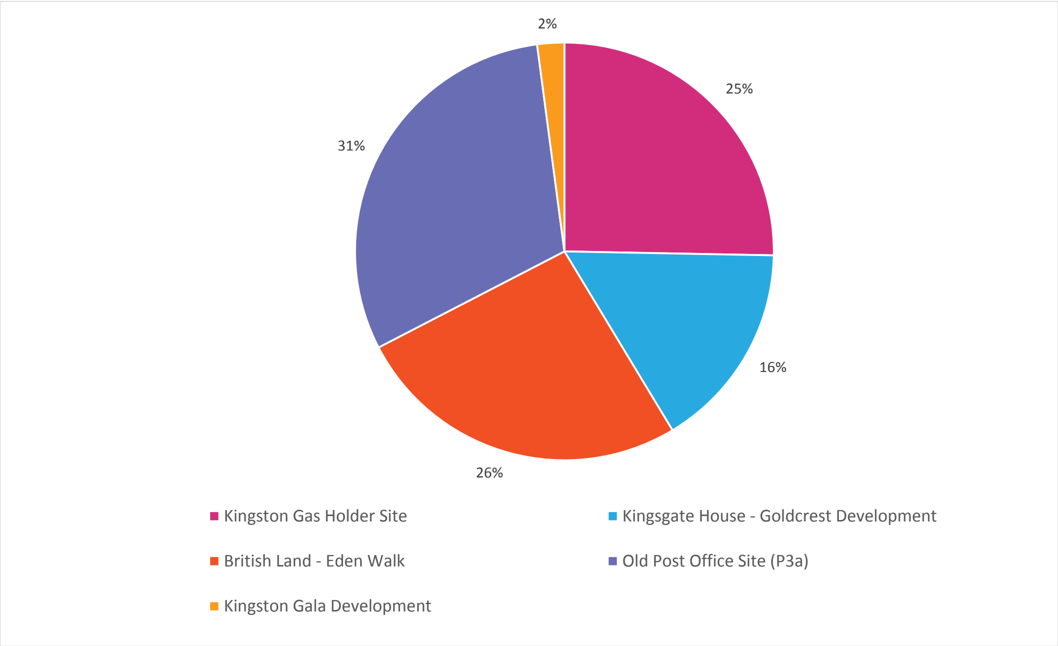

Figure 50 Kingston Town Centre DH network dwellings mix at full build out

Figure 51 - Hourly heat demand profiles for the Kingston Town Centre network for all 3 phases

A2 Energy Centre

The following sections provides further information regarding the energy centre location selection summarised in the main body of the report.

A2.1 Private Land Ownership

A2.1.1 Kingston Gas Holders – Berkeley First

The Kingston gas holders site is a significant area of redevelopment as part of the North Kingston Development area (site P19 from the Kingston Town Centre Area Action Plan) with a number of developments in the area including a scheme by Berkeley First developing a residential led mixed use scheme with a proposed 315 dwellings (site P19d). The energy strategy proposes a communal heating system powered by a 70kWe Combined Heat and Power (CHP) system on site with gas fired boilers providing the top up. The 70kWe CHP engine is too small to export heat to a district heating network since it has been designed to provide the base load heating demand of the development through the summer months.

The scheme submitted a full planning application in April 2014 and was permitted in November 2014. As the scheme has been given permission, it is unlikely that the site will be able to host an energy centre capable of serving a wider district heating network although it is capable of connecting to a site wide network in the future.

Not considered to be a viable location for the energy centre.

A2.1.2 Kingsgate House – Goldcrest Development

The Kingsgate house development is located adjacent to the gas holders site in the North Kingston Development area (site P19c) which is currently in planning. The development is a mixed use site comprising of student accommodation (up to 210 bedrooms) and commercial space.

Currently, no energy statement has been submitted as part of the planning application. At the time of writing, the planning submission is awaiting approval and a decision has not yet been made on the development. The Royal Borough of Kingston through planning should ensure that connection to a district heating network is required as a minimum. There is potential to utilise space on the development to host an energy centre through the use of Kingston planning

The development site floor area is an estimated 2,300m^2 from the planning application site plan therefore there may not be sufficient space in the current development plans to host a large energy centre for a DH network serving the Kingston.

As discussed previously, the location of the energy centre at the north end of the Kingston Town Centre is not the optimum location for the energy centre with a consequential increase in pipe diameters and cost to supply the peak heat demand required south of Kingston Town Centre.

Not considered to be a viable location for the energy centre.

A2.1.3 Kingston Gala Development

The Gala development is the redevelopment of the old Kingston Gala Bingo hall in the North Kingston Development area providing commercial, office and 14 residential units. The current energy strategy is for a small CHP engine to provide the base hot water and heating demand along with air source heat pumps to provide space heating. The proposed development received has received planning permission therefore it is unlikely that the development will be able to or have the space to host an energy centre.

Not considered to be a viable location for the energy centre.

A2.1.4 Eden Walk Shopping Centre Redevelopment

The Eden Quarter in Kingston is undergoing significant redevelopment with currently two large developments in planning one of which is the redevelopment of Eden Walk shopping centre by British Land. This will be a mixed use scheme with up to 324 residential units and 20,000m^2 of retail development. The redevelopment is currently at the time of writing has yet to submit a planning application for the scheme however consultation with British Land indicated that the proposed heating system for the redevelopment will be a gas fired CHP system with gas fired boilers providing additional heat with a plant area of approximately 500m^2. Consultation with British Land also indicated an extremely high level of interest and willingness to connect to a DH network if a network was available.

The plant area indicated by British Land is unlikely to be sufficient to feed the wider Kingston Town Centre DH network however there is an opportunity to collocate an energy centre within the Eden Walk redevelopment and the Old Post Office development discussed below.

Kingston should seek to ensure that the provision for connection to a DH network is incorporated into the Eden Walk redevelopment as a minimum and begin discussions with British Land to host part of the energy centre.

Considered to be a potential location for an energy centre. Further stakeholder engagement required.

A2.1.5 Old Post Office Development

Adjacent to the Eden Walk redevelopment, there is a large new residential led development undertaken by St. George which will include 380 new dwellings as well as in excess of 4,000m^2 of non-domestic (retail and commercial space). Consultation with St. George indicated a high level of interest and willingness to connect to a DH network if a network was available. The energy strategy put forward as part of its planning application which was submitted in December 2014 incorporates a 195kWth gas fired CHP engine in a centralised plantroom (estimated to be 300m^2) supplying heat to the entire Old Post Office development with provision included to connect to a future DH network.

With its close proximity to the Eden Walk redevelopment there is an opportunity to utilise plant area within the Old Post Office development to host the remaining heating plant required to supply a wider Kingston Town Centre development.

Kingston should seek to ensure that the provision incorporated into the Old Post Office development plan for connection to a wider DH network is located in a suitable area on the potential DH network route and begin discussions with St. George to host part of the energy centre.

Considered to be a potential location for an energy centre. Further stakeholder engagement required.

A2.1.6 Kingston University Penrhyn Road Campus

The University has progressed a scheme for a site wide heating scheme on the Penrhyn road campus with the recent completion of a Stage D study either serving the main building on the campus with a 238kWe CHP engine, or a number of other buildings with a larger 600kWe engine. The study revealed that there was not a strong commercial case for the installation of a CHP engine on the campus therefore a number of discussions were held with Kingston University to explore how the campus could be linked or host the required energy centre.

The available space on the campus (part of the existing car park on campus) was deemed to be too small to host the single energy centre required for the wider own centre area. Following a review of the study undertaken for Kingston University, it showed that there was a large amount of heat rejection partly limiting the run time of the CHP engine therefore it presented an additional energy supply option to the wider Kingston DH network. High level techno-economic modelling was undertaken to determine the potential of purchasing waste heat from the campus CHP to feed the network in addition to a large energy centre providing the remaining heat demand on the site. The analysis illustrated that there was not a commercial case for the wider Kingston DH network to connect to the Penrhyn Road campus and utilise the waste heat.

Not considered to be a viable location for the energy centre.

A2.2 Royal Borough of Kingston Ownership

The Royal Borough of Kingston has a number of freehold ownerships in the Kingston Town Centre area including the Guildhall complex, several surface car parks and open spaces.

A significant opportunity which should be investigated is the use of land and surface car parks which are owned by the Royal Borough of Kingston therefore providing a much greater degree of control over the use of the land as well as the installed energy centre capacity. The use and associated costs of use of land owned by the Council will need to be taken into account during the techno-economic modelling of the scheme since in the case of car parks this represents a revenue to the Council which will need to be replaced.

A2.2.1 Kingfisher Leisure Centre (Eastern Approach, P6)

It was previously assumed in the Kingston Energy Masterplan (July 2013) that the Kingfisher Leisure Centre would undergo redevelopment allowing for the incorporation of a decentralised CHP plant. Following consultation with the leisure centre and Royal Borough of Kingston council there are currently there are no plans for any significant redevelopment. In addition, space within the existing leisure centre plant rooms would likely be limited and insufficient to incorporate a large centre energy centre without therefore it is likely that any plant located at the site will provide only a proportion of the overall heat required.

Not considered to be a viable location for the energy centre.

A2.2.2 Ashdown Road Car Park (P3 Eden Quarter)

The Ashdown road car park is located close to the Kingston Town Centre and adjacent to the two largest future developments in this area (Old Post Office and Eden Walk redevelopment) as well as centrally between the numerous developments and potential heat customers around the Kingston gas holders site. The location provides savings in DH network transmission costs through the reduction in transmission pipework sizing due to its central location and proximity to the two large new developments and heat customers. Although the site is currently being used as a Royal Borough of Kingston car park, there are two areas in the centre of the site which the Council do not own the freehold dividing the site into two sections as outlined in the Figure 55 below. Despite this, the Council own an estimated 5,500m^2 of area which could be utilised for an energy centre.

As part of the Eden Quarter Development Brief (SPD) adopted by the Royal Borough of Kingston council in March 2015, there are potential development plans for this site with proposals for a new multi-storey car park in this area between Lady booth Road and Ashdown Road. The future development plans for this area should consider the potential for integrating a large DH network energy centre to serve the wider Kingston Town Centre.

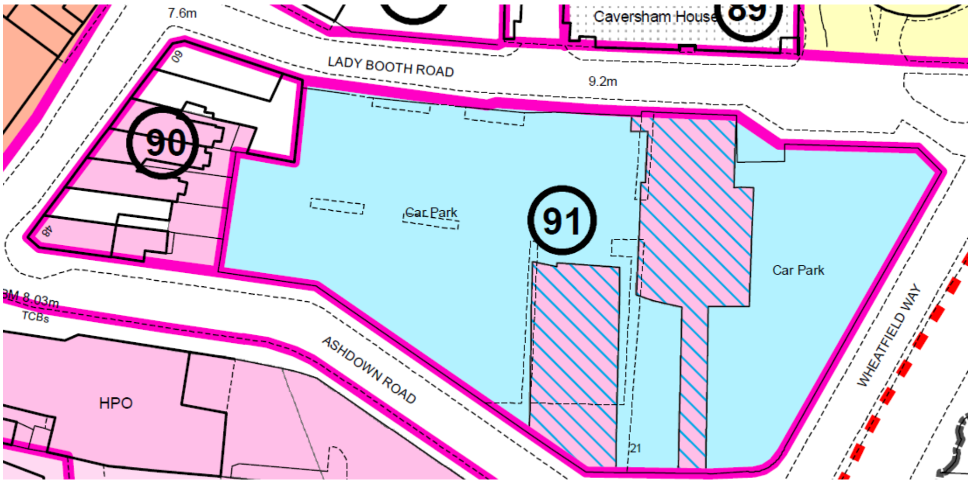

Figure 52 Royal Borough of Kingston ownership outlined in blue with private freehold ownership in pink

As there is currently a car park on the site operated by the Royal Borough of Kingston, the incorporation of an energy centre utilising car park space would result in lost revenue which is taken into account in this feasibility study.

This is considered to be the preferred location for the energy centre due to its location, ownership and control by the Royal Borough of Kingston. Further consideration of the location and incorporation of the energy centre into future development plans of the car park should be taken into account.

A2.2.3 Bus Station & Car Park (Eastern Approach, P5)

Located to the North - East of the Ashdown Road car park is an existing bus station and surface car park the freehold of which is owned in the large part by the Royal Borough of Kingston (with the bus station owned by Transport for London). Currently, there are no significant redevelopment proposals for this area although it is understood discussions are taking place. This redevelopment area is large and owned by the Royal Borough of Kingston with high potential to incorporate the energy centre in this area. This location is located further east than the current preferred location (Ashdown Road Car Park) therefore requiring longer transmission pipework with associated increases in cost. The redevelopment area is large therefore the location of a potential energy centre on this site will need to be carefully coordinated to ensure that it is not located on the East end of the site towards Albert road requiring longer transmission pipework.

Considered to be a potential location for an energy centre. Further stakeholder engagement required.

A2.2.4 Kingston Riverside Sites

As part of the supply analysis, a potential energy location along the river front was sought after to consider the use of Water Source Heat Pumps and its full potential within the Kingston Town Centre area. The Royal Borough of Kingston provided an overview of land ownership within the Kingston Town Centre from which a plot of open space (Eagle Brewery Wharf) which was owned by the Royal Borough of Kingston was identified (illustrated below in Figure 53 and Figure 54). A further site was identified and proposed by Kingston University located within the basement of the Riverhouse building located on the waterfront however the available plant space of an estimated 200m^2 is deemed to be insufficient to accommodate the required plant for the wider Kingston Town Centre DH network.

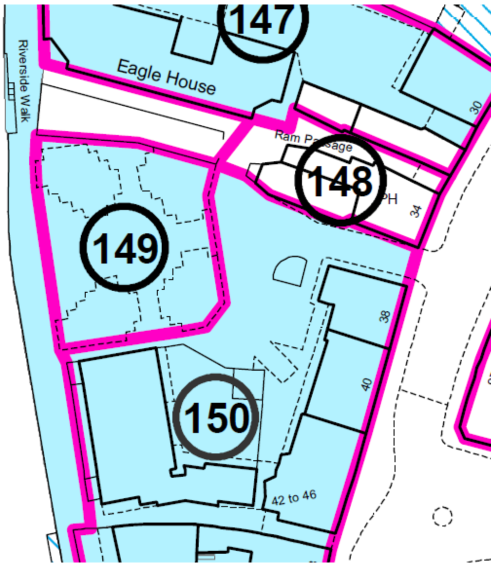

Figure 53 Royal Borough of Kingston land ownership, plot 149 identified as potential location

Figure 54 Satellite image of Eagle Brewery Wharf

The use of this area to host an energy centre for the Kingston Town Centre area is currently uncertain due to its location and surrounding commercial and retail uses. The land value for the use of this area is taken into consideration in the techno-economic modelling at a rate of £5/ft^2 following guidance provided by the Royal Borough of Kingston however this is likely to be considered too low for the loss of public space adjacent to the river. An energy centre in this area would likely be required to be below ground or across two levels to reduce the impact on the surrounding commercial properties which would increase the overall construction cost of the energy centre.

Although technically a potentially viable location for an energy centre it is unlikely that development would be permitted in Eagle Brewery Wharf without considerable cost. It is considered in this feasibility study to determine the potential for the water source heat pump solution.

A2.3 Energy Centre Location Summary

A number of energy centre locations have been identified on both private development as well as Royal Borough of Kingston owned freehold. The four identified below are all considered to be technically viable although there is some uncertainty regarding the various Royal Borough of Kingston owned sites and their future development potential as well as the use of the Eagle Brewery Wharf open space. The Ashdown Road car park is identified as the preferred option due to its ownership, location within the Kingston Town Centre and adjacent to the two key new developments in the Town Centre.

- Ashdown Road car park
- Collocated energy centre with British Land and St. George
- Bus Station and car park
- Eagle Brewery Wharf (Kingston riverside site)

A3 Route Walk Study

A3.1 Introduction

Following initial desk studies for more detailed DH network routing through the Kingston Town Centre area building on previous route studies undertaken for the Kingston Energy Masterplan in 2013. A number of route walks were undertaken to establish physical barriers along the route and evaluating potential connection locations to customers.

A3.2 Kingston Town Centre DH Network

The DH network is broken down into a number of distinct pipework routes (indicated by “T”) illustrated on Figure 55 below. This section will look at each of the key sections of the route individually highlighting key areas of potential difficulty or areas which may require further investigation or analysis to determine any potential cost impacts.

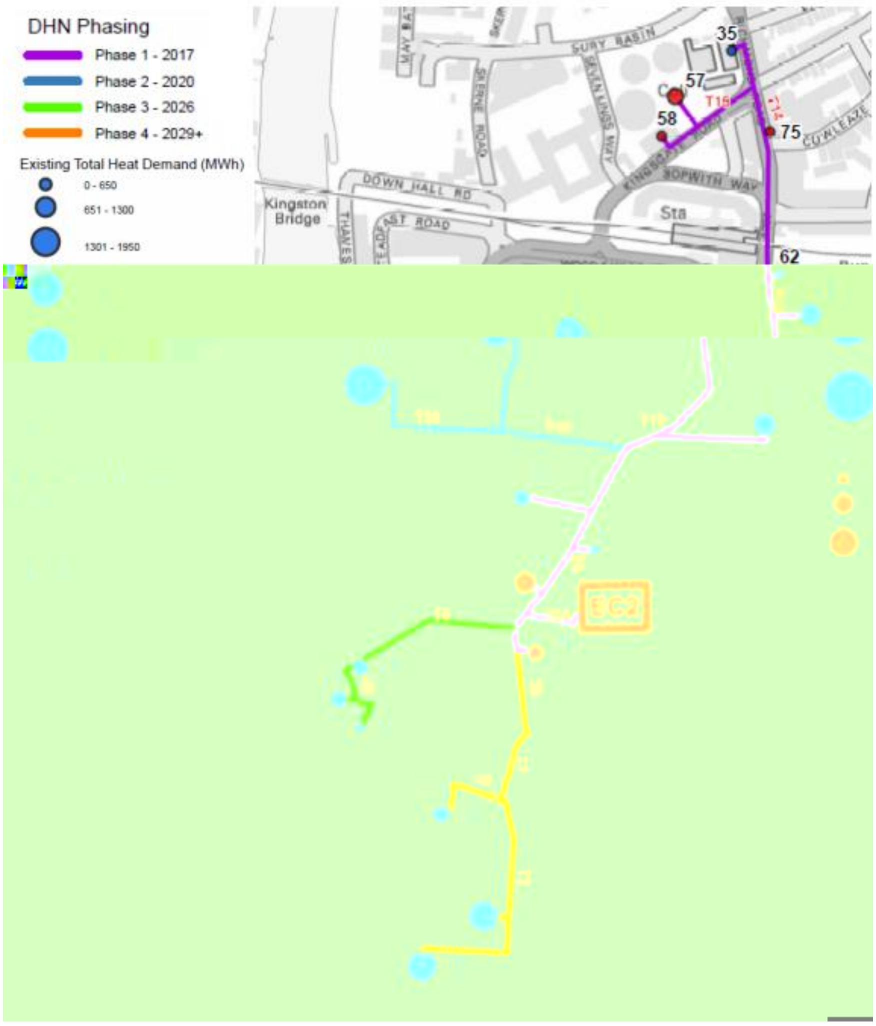

Figure 55 Overview of the DH network for Kingston Town Centre and pipework sections

A3.2.1 Eden Street, Bath Passage – T4

The connection to the Guildhall complex follows Eden Street and passes along the junction of St. James road and is proposed to pass along a pedestrian path which leads to the Guildhall. The pedestrian route provides an opportunity to minimise the pipe length as opposed to running along Eden Street to access the Guildhall complex however there is a reduced width for access, excavation and installation of district heating pipework as well as there being access to residences along Bath Passage.

Figure 56 Indicative pipework route through Bath Passage

A3.2.2 Hogsmill River Crossings: T7

Following the route walk, two key areas of interest were the two bridge crossings over the Hogsmill River across St. James Road and Wheatfield Way.

A3.2.2.1 St. James Road

The bridge crossing at St. James Road is the older of the two with no obvious external utility routing across the bridge. The Royal Borough of Kingston provided utility drawings for the area surrounding the bridge and along St. James Road which indicated that there is a 24 inch gas pipeline which runs along St. James road and crosses Hogsmill River along with a 132kV electrical utility and a number of smaller electricity cables (Figure 57). The 24 inch gas pipeline indicates that there is likely sufficient depth to pass the district heating network pipes which would be shallower than the gas pipeline.

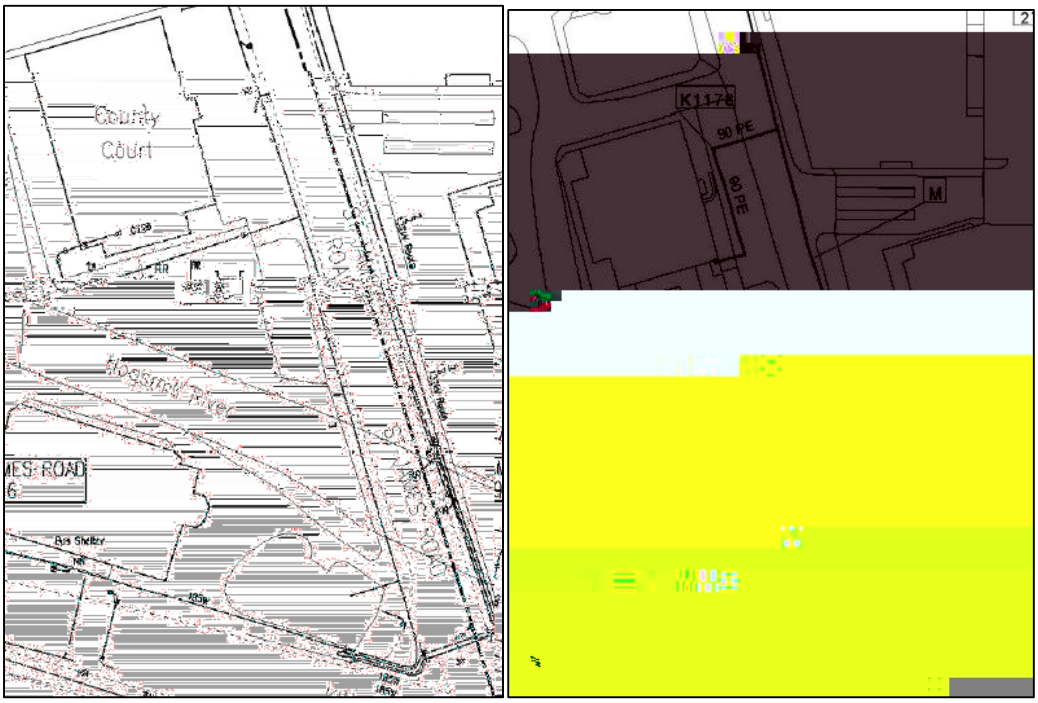

Figure 57 Electrical utilities (left) and gas utility (right) crossing Hogsmill River

Further investigation would be required to determine the precise location of the district heating network pipes however with for example Ground Penetrating Radar (GPR) and trial holes at a later stage.

Figure 58 Hogsmill river bridge crossing

A3.2.2.2 Wheatfield Way

An alternative crossing of Hogsmill River to bring the district heating pipework south of Kingston Town Centre towards the Surrey County Hall is along Wheatfield Way. The bridge across Wheatfield Way is more recent than the crossing at St. James road and the Royal Borough of Kingston provided available utility drawings for this road and crossing. The utility drawings indicate that there is a 6 inch water supply which crosses the Hogsmill river (see Figure 61) and a number of electrical utility cables which cross the bridge however there is no indication that any larger utilities (e.g. gas pipeline) cross at this location.

The bridge is a relatively large crossing and a more recent bridge, it is possible there are utility allowances within the bridge construction which could be used to pass the district heating pipework main although further information is required (for example details on the bridge construction) to determine whether this can be used as a pipework route and mitigate the risk.

Figure 59 Wheatfield Way Hogsmill river crossing

Figure 60 Wheatfield Way Hogsmill river crossing side view

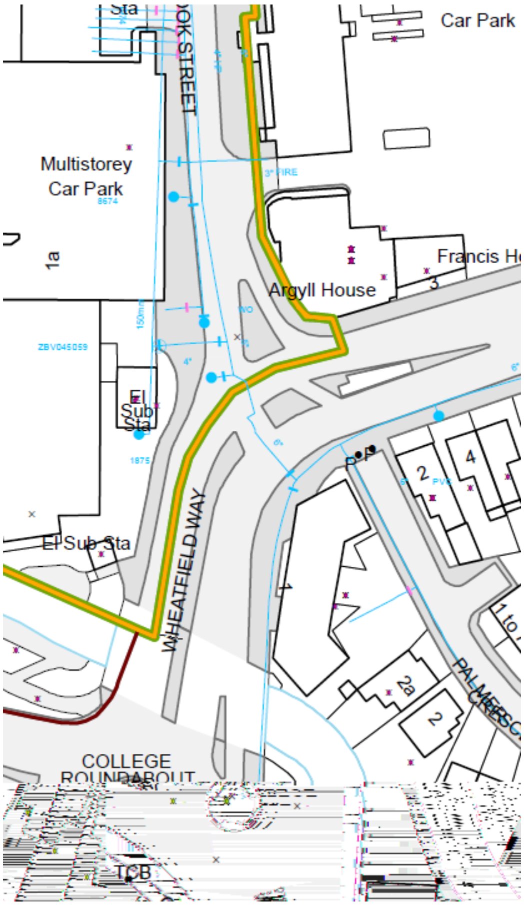

Figure 61 Water utility drawing indicating 6 inch water pipe crossing Hogsmill River

The preferred network routing across the Hogsmill River is across Wheatfield Way as opposed to St. James road. Firstly, it allows the design for Phase 4 of the network to be more independent of the initial phases with only the key transmission pipework requiring to be sized to accommodate the future connection (T24 from Ashdown Road car park and the section of pipework required to connect to the Old Post Office). The crossing over St. James's Road would require part of the T4 section of network to be oversized to accommodate the Phase 4 heat demands increasing the required pipe size and therefore cost of the network. In addition, the connection via Brook Street would result in a shorter section of network (~200m compared to an estimated 220m along St. James Road).

A3.2.3 Penrhyn Road – T3

Following the Hogsmill River crossing the pipework section to connect to the potential Kingston College, Kingston Crown Court and Surrey County Hall passes along Penrhyn Road. The utility drawings obtained along Wheatfield Way and surround the College roundabout indicate that the 132kV electrical utility and 24inch gas pipeline continue South along Penrhyn Road. Although these are large utilities, there is likely to be sufficient space along Penrhyn Road to coordinate and route the pipework to avoid any clashes.

Further investigation would be required to determine the precise location and route of the district heating network pipes however with for example Ground Penetrating Radar (GPR) and trial holes at a later stage.

Figure 62 Penrhyn Road looking South towards Kingston Crown Court (connection indicated)

A3.2.4 Kingston Train Station: T13 – T14

The roads and areas adjacent to the train station are very busy being one of the key transport junctions for the Kingston area. The DH network passes along Richmond road under the railway bridge towards the gas holders development. There is insufficient space to pass the DH pipework along the pavement adjacent to the train station or on the opposite side to the station.

Based on the available utility information provided by the Royal Borough of Kingston, there are a number of utilities passing along Richmond Road under the railway bridge crossing including gas, two sets of water pipework and sewers as well as a high probability of electrical utilities although they are not indicated on the drawings provided.

There is likely to be pipework route constraints because of the number of utilities and represents a technical risk to network route although no depth or pipeline sizes are provided there is not sufficient information to be confident of the pipework route.

There is however, a significant amount of space available in this area with three lanes of highway as well as a cycle path therefore it is likely that space is available to pass the district heating pipework mains. It is provisionally suggested the suggested the pipework will pass adjacent to the pavement along the cycle route therefore minimising traffic disruption although a lane closure would still be required.

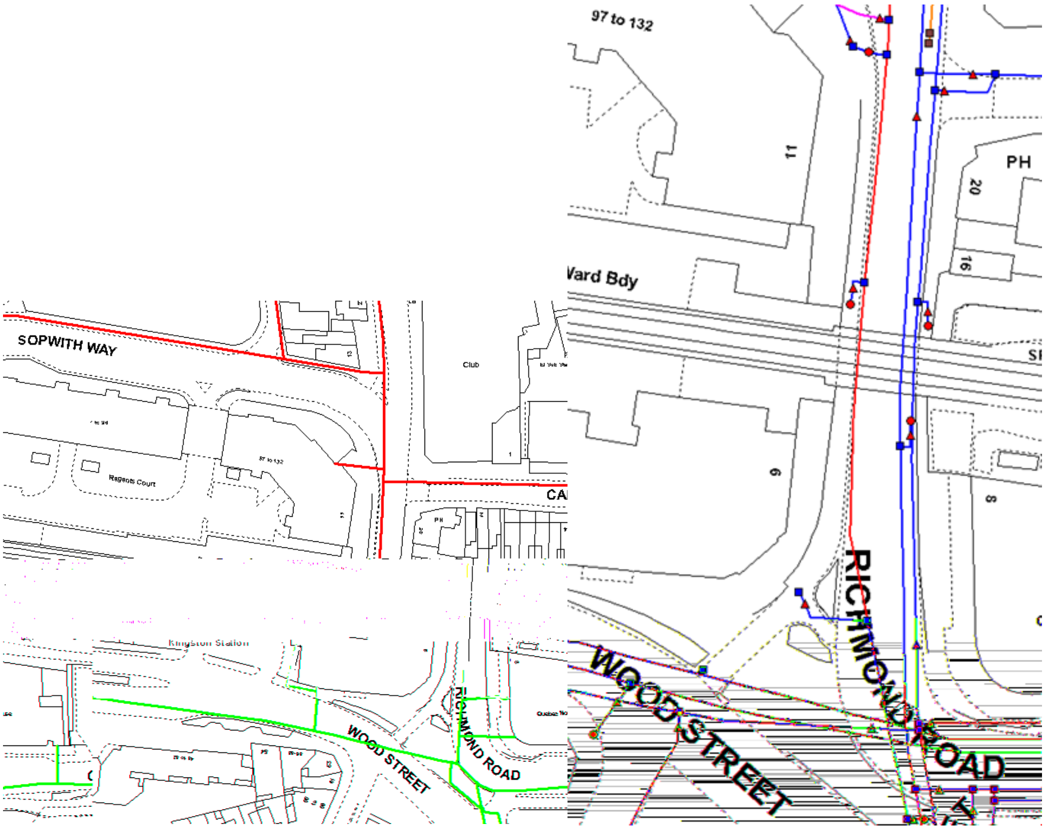

Figure 65 Gas pipeline utility information (left) and water pipeline utilities (right)

A3.2.5 Kingston Gas Holders Connection – T15

The pipework section T15 connects the future gas holders development. There is a large amount of space in the existing carriageway with two lanes of one way traffic available to pass the required pipework and implement the necessary lane closures and traffic diversions.

Figure 66 Pipework route along Kingsgate Road towards gas holders site (looking East) at the construction of the new Kingston College building.

A3.2.6 Kingston Train Station: T13 – T12

The pipework route (section T13 – T12) must pass through a busy carriageway junction adjacent to the train station although there is a significant amount of space in the existing carriageway. Visual inspections did not reveal a significant number of utilities crossing the area. Crossing the junction and pedestrian crossings in the centre of the junction would minimise the pipework length or alternatively the pipework may divert the pedestrian area and remain in the carriageway (dotted line indicated in Figure 67 below).

Figure 67 Pipework route adjacent to the train station South towards Kingston Town Centre

A3.2.7 Clarence Street – T10 & T23

The section of pipework along Clarence Street to connect the large non-domestic loads (6, 7 and 32) passes primarily along the pedestrianized Clarence Street as indicated in Figure 70 below. There are no indications of any potential utility restrictions in this area with sufficient space likely available to negotiate any buried services encountered. This section may incur additional costs depending on the amount of space which is required for the installation of the pipework (e.g. for pipework storage and excavations) due to the local retailers along Clarence Street.

Excavations along Clarence Street may result in higher costs for the T10 and T23 sections of pipework due to the time required to remove and reinstate the paving along the street. The commercial and retail nature of Clarence Street with a significant number of commercial frontages may incur additional costs with the potential for retail units to claim compensation if there is a loss of trade during the construction period.

Figure 70 DH pipework along Clarence Street

The precise location for the DH connection into John Lewis has yet to be identified, however the location of the boiler flues for the building as shown in Figure 71 below indicate that the plantroom will be accessed along Clarence Street through the carriageway. There was no evidence of significant utility constraints in this area with the carriageway being primarily used by local bus routes.

potential crossing locations which will have a consequential impact on the location of the network to connect to Phase 4 whether it is through Brook Street or St. James's Road.

The other key area which should be further investigated due to the likely presence of a high number of utilities is the area surrounding Kingston train station with further utility ground surveys required to determine the precise location of the utilities. This can typically be undertaken by an ESCo or Contractor of the scheme prior or during the construction of the network.

The Kingston Town Centre area is busy with a large commercial and retail centre therefore there will be disruption during the works which should be taken into account and managed. The management of retail premises along Clarence Street is important since poor management of the works may result in a loss of earnings for retail premises and subsequent compensation claims.

A4 Sensitivity Analysis

The impact on the IRR and NPV of each of the sensitivities tested and described previously in Section 7 is outlined in the table below.

Table 15 Sensitivity analysis results for the WSHP and CHP scheme

Scenario	**Range**	**CHP Option**	**WSHP Option**
Heat Demand	+20%	IRR: 11.1% NPV: -£73,400	IRR: 12.1% NPV: £23,500
	-20%	IRR: 12.4% NPV: £28,400	IRR: 11.9% NPV: -£17,500
Network Phasing	+20%		

CHP & purchase price for WSHP)	-20%	IRR: 4.7% NPV: -£376,800	IRR: 14.4% NPV: £453,700
RHI Revenue	+20%	n/a	IRR: 14.5% NPV: £490,100
	-20%	n/a	IRR: 9.0% NPV: -£490,100
Heat Price (variable & standing charge)	+20%	IRR: 21.3% NPV: £967,900	IRR: 16.8% NPV: £967,900
	-20%	IRR: Below 0% NPV: -£967,900	IRR: 5.5% NPV: -£987,900

A5 Avoided Cost Estimate

An avoided cost calculation was undertaken for the Old Post Office St. George development utilising information provided by the developer during consultation and information from their planning submission.

The items included in the avoided cost calculation are outlined in Table 16 below. These include the heating plant which would otherwise be required, plantroom excavations and additional low carbon measures which might be required to meet the required energy and carbon targets as part of planning.

The costs are based on unit rates provided in Spon's Mechanical and Electrical Services Price Book (2015) and Spon's Architects' and Builders' Price Book (2015). Developers should ensure that they undertake accurate avoided costs and business case calculations to determine their suitability for connection to a DH network.

Table 16 Old Post Office development avoided cost calculation

Item	Capacity	Rate	Total
PV Installation	609m^2	£300/m^2	£182,700
CHP Installation	195kWth / 120kWe	£1,030/kWe	£123,600
Heating Plant Installation	700kWth	£90/kWth	£63,000
Thermal Storage	30m^3	£2000/m^3	£60,000
Plate Heat Exchanger	700kWth	£5/kWth	£3,500
Flues	150m (estimated height)	£24/m	£3,600
Basement Excavations	1890m^3 (estimated excavation)	£17/m^{3+}	£32,130
Basement Slab	150m^2	£180/m^2	£27,000
Heat Interface Units	380 (1 per dwelling)	£1,500 per dwelling	£570,000
		Total	£1,065,530
		Total per dwelling	£2,800

The cost rates above include controls and associated testing and commissioning of the required plant.

The basement excavations include costs for disposal of materials off site, breaking out obstructions and dewatering.

A6 Risk Register

This document contains an active risk register to accompany the Kingston DE feasibility study, highlighting risks to the delivery of the scheme, their likelihood, and proposed mitigation methods. It is updated and reviewed as key milestones in the study are reached. Risks are broken down into Commercial (Financial and Stakeholder related) and Technical considerations.

Risks are graded out of five for likelihood and severity, with five representing the highest.

A6.1 Risks: Commercial

ID	Risk / Description	

ID	Risk / Description	Likelihood	Severity	Recommended Actions and Mitigation
C3	**Securing the location of the Energy Centre – Eagle Brewery Wharf** Land area must be secured and safeguarded for construction of a standalone Energy Centre for a WSHP in the Eagle Brewery Wharf. There is also the risk that this space is unavailable due to by-laws protecting public space along the river and the land lease costs exceed £5ft/sq.	4	5	Begin internal RBK dialogue to determine feasibility of land use.
C4	**New development heat loads do not come forward as early or as high as expected** This would reduce the potential heat sale revenue for the scheme and impact on the financial performance.	2	2	Monitor development process and the impact of connection deferrals to the financial performance of the scheme if the network is complete ahead of the development and awaiting connection.
C5	**Securing the location of the Energy Centre – Ashdown Road or other town centre site** Land area must be secured and safeguarded for construction of a standalone Energy Centre on the Ashdown Road Car Park or adjacent site within the Eden Quarter. There are also the risks that adequate space is unavailable which may limit the size of the potential network and the land lease costs exceed £5ft/sq.	3	5	Begin internal RBK dialogue to ensure required land is available and at a suitable price
C6	**Development of the District Heating network** Development of the district heating network and the energy centre falls behind the completion of new developments therefore requiring temporary heating solutions or will not connect to the network	2	3	Ensure plans and procedures are outlined in the requirements of the district heating network to any potential third party Energy Services Company (ESCo) that temporary heat supplies must be guaranteed to potential developments until connection.

ID	Risk / Description	Likelihood	Severity	Recommended Actions and Mitigation
C7	**A market led solution is not realised within the opportunity window** A DH network may never materialise if the Council fails to act as a Promoter. This may result in DH network missing the opportunity to connect to the two core heat loads	4	5	The Council needs to coordinate the developers through its planning powers and its promoter / broker role. Through planning measures and MoUs, it is expected that these developments can be persuaded to commit to connect to a wider area heat network, should one emerge.

A6.2 Risks: Technical

ID	Risk / Description	Likelihood	Severity	Recommended Actions and Mitigation
[redacted]	**Richmond Road poses a significant geographical constraint.** Trenching will result in traffic disruption across the key junction adjacent to the Kingston train station which will require significant traffic management.	5	2	Investigate if there are planned works (highway or utilities) that will require the closure of Richmond road or key junctions. Space available with several lanes of highway for appropriate traffic management measures to be implemented
T2	**Flue Stack Height** There are potential issues arising with minimum air quality standards for the local area if a gas fired Combined Heat and Power heat source is selected. The flue stack height, its location and visual impact may lead to difficulties in obtaining planning consent. A flue dilution system may be required adding increased cost and complexity to the scheme as well as reducing its overall efficiency.	5	3	A flue dispersion model should be undertaken to determine the preliminary stack height and that the proposed design meets the Royal Borough of Kingston requirements.

ID	Risk / Description	Likelihood	Severity	Recommended Actions and Mitigation
	increase the carbon intensity of the CHP heat supplied under the current calculation methodology therefore requiring developers to implement additional carbon mitigation measures			
T4	**Utility Routing – Richmond Road Train Station** The location and routing of existing utilities and services have not been including during this study therefore there may be parts of the DH route which require diversion from the current proposed route.	4	2	The route walk identified key coordination areas which may be required for utilities including the Hogsmill River crossing. Utility information for Richmond Road past the train station indicate a large number of utilities although there is a large amount of space which should allow district heating pipes to pass under the railway bridge. Ground penetrating radar and trial holes at a later stage of the project are recommended to determine the exact pipework location.
T5	**Utility Routing – Hosgmill River Crossing** The district heating network in both current route options require a crossing either along St. James road or Wheatfield Way across two existing bridges. Space may not be available to allow for district heating pipework to pass the existing bridges.	3	2	The route walk identified key coordination areas which may be required for utilities including the Hogsmill River crossing. Utility information provided by the Royal Borough of Kingston revealed existing large utility crossings along St. James road (gas pipeline) indicating district heating pipework should have sufficient depth to pass cross along St. James. A significant number of utilities cross Hogsmill River along Wheatfield Way although no large utilities which do not provide an indication of depth. Further details required on the bridge construction to mitigate this risk. Further analysis is required for both the crossings to determine the additional cost at a later stage of the project. At present there is no requirement to cross Hogsmill River as part of the core network.
T5	**Utility Connection**	2	3	Begin preliminary discussions with the relevant utility companies to discuss local network restrictions, requirements and difficulties.

ID	Risk / Description	Likelihood	Severity	Recommended Actions and Mitigation
	The requirement to draw a significant level of either gas of the local gas network or electricity for an electric heating supply may not be possible without significant gas network reinforcement at additional cost. Similarly, exporting a large amount of electricity to the local electricity network may not be supported by the local network without reinforcement therefore potentially limiting the amount of electricity and therefore revenues or requiring a private wire.			
T6	**District Heating Connections** Technically or financially not feasible for customer connection due to inappropriate existing building systems or upgrade requirements reducing total connected heat demand and total revenue for the scheme or incurring additional costs for conversion.	2	3	Ensure technical evaluation for the final connections is undertaken to ensure that all customers can be connected and the business case of the district heating network updated. Route walk and initial building investigations reduced the number of potential viable connections (due to all electric heating systems or individual gas boiler systems for example).
T7	**Water Source Heat Pump Water Abstraction** Water abstraction systems from the River Thames require high levels of filtration which can incur significant additional costs. Although an allowance has been made within the capital cost of the WSHP system the total system costs may exceed the allowance made in the techno-economic modelling.	2	3	Ensure technical study and evaluation of the water abstraction system is undertake for a more detailed breakdown of the abstraction system costs.
T8	**Water Source Heat Pump Efficiency** Current COP of the system modelled at the supply and return temperatures of 80˚C and 60˚C respectively is 2.90 at the limit of the RHI eligibility. The economics of the WSHP scheme would be significantly impacted if it falls below this threshold and the project does not receive RHI revenues.	2	5	Further detailed system modelling throughout the course of the year and further engagement with heat pump manufacturers to develop the system should be undertaken.

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A7 Drawings

A8 Funding Options Review

A8.1 Funding Options

A project such as this involves significant capital outlay and therefore may require alternative funding options to be considered. There are various funding options available to the Council; a brief summary of these has been included below for review.

A8.1.1 Public Sector Sources

A8.1.1.1 Public Works Loan Board

The Public Works Loan Board (PWLB) is a statutory body of the UK Government that provides loans to public bodies from the National Loans Fund. The PWLB provides loans to local authorities of all types in Great Britain, primarily for capital projects, but also as a lender of last resort.

A few years ago this source of capital was very cheap for local authorities, but its cost has recently been rising compared to other sources of funding as the economy in Europe has improved.

A8.1.1.2 London Green Fund

The London Energy Efficiency Fund (LEEF) is managed by Amber Infrastructure and can fund private and public sector energy efficiency investment, including investment in District Heating.

Often the rates that can be offered are better than Public Works Loan Board (PWLB), depending on the credit rating of the organisation asking for capital from this low interest loan facility. Further details can be found at www.leef.co.uk.

For the purposes of full disclosure, Arup is the technical advisor to LEEF. This role includes introducing potential clients and technical due diligence on the client’s proposed use of the loans.

A8.1.1.3 Green Investment Bank

The GIB has been set up under the auspices of the Department for Business Innovation and Skills (BIS). Currently the GIB is in the process of sourcing its project pipeline which could include DE projects.

Funding from the GIB could be in the form of debt or equity instruments however it is mostly likely to be debt. Indicative costs of capital are likely to be marginally lower than the market rate of 2 to 3 per cent above LIBOR.

A8.1.1.4 European Investment Bank

The European Investment Bank (EIB) grants medium to long term loans to energy efficiency and renewable energy projects. It can provide project finance to projects over EUR 25m in value or intermediate loans through credit lines to banks or other financial institutions if projects are less than EUR 25m in value.

The EIB can lend at rates lower than the commercial market: technically, they can lend at the country-specific reference rate to avoid State aid issues.

Generally the EIB can only finance 50 per cent of project costs. In rare cases the EIB will finance 100 per cent of a loan granted by an intermediary bank.

A8.1.1.5 Project and municipal bonds

Legislation passed in 2004 allows local authorities to issue bonds for capital projects without permission from central government. However, to date there has been little issuance because bond finance generally has high transaction costs. That said, the finance itself can be cheaper than other types of debt if at sufficient scale because it is secured on typically high credit.

One option for bond finance is to pool multiple investments into a single bond, either as multiple different projects within a single city or a single type of project (e.g. district heating networks) across multiple cities. This is a topic of active discussion among global cities networks (e.g. ICLEI[13] and C40), but there is limited experience in delivery of multi-city bond financing.

A8.1.2 Private Sector Sources

A8.1.2.1 Senior Debt secured against the Council

The project sponsor could take out senior debt from a commercial bank secured on the organisation’s assets. Senior debt is generally long term (in excess of 20 years) and interest is generally higher than the public sector loans.

A8.1.2.2 Refinancing

Pension funds and insurance companies are interested in providing very long term finance secured on the assets of district heating networks, for example the primary pipe network, once they have been installed and have a secure income stream. Such a facility can be used to refinance a scheme after it has started operations.

A8.1.2.3 Climate Change / Green Investment Funds

There are some investment funds such as Triodos, Climate Change Capital and Earth Capital Partners that have been established with a specific remit to invest in projects that contribute to climate change reduction such as energy efficiency and renewable energy projects.

These funds tend to be interested only in projects that have relatively high returns (10-20 per cent) and with short investment periods (5-10 years). In addition, they will be looking for projects or project portfolios with a large scale investment potential rather than individual small-scale projects.

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[13] http://issuu.com/resilientcities/docs/rc2014__congressreport_2014_final

For these reasons they may not be appropriate for the majority of DE projects where returns are less certain and scale is small.

A8.1.3 Grants, incentives and subsidies

A8.1.3.1 Allowable Solutions

The UK Government has recognised that achieving actual zero carbon in new development on site is unlikely to be viable in most cases and indeed may not be technically achievable in many cases. It has therefore proposed to implement a system of “allowable solutions” to deliver carbon reductions to offset residual emissions in new development.

Allowable solutions would include low carbon measures away from a new development, for example, standalone renewable energy installations, a district heating network or building retrofit.

It is likely that limited funds will be collected through such a system before 2016. For the time being, the most likely route for developer contributions to be available to fund DE schemes will be through Section 106 agreements or through CIL payments.

A8.1.3.2 Enhanced capital allowances

Tax incentives like ECAs are focused on providing incentives to the private sector to encourage the delivery of energy saving plants, low carbon generation and infrastructure. ECAs will enable a private sector organisation to write off the whole of the capital cost of an investment against taxable profits for the period in which they make the investment.

A9 Technical and Financial Assumptions

A9.1 Technical Assumptions

Equipment Lifetimes		
CHP		10 years
Gas Boiler		15 years
HIU		15 years
WSHP		15 years
Efficiency		
CHP (< 800 kW)	Thermal	40%
	Electrical	39%
CHP (> 800 kW)	Thermal	43%
	Electrical	36%
Gas Boiler - New		90%
Gas Boiler- Existing		75%
WSHP		2.90

System Losses	
Energy Centre	0.5%
Distribution	9%
Heat Substations	0.5%
TOTAL (Heat Loss Factor)	10%

CHP Sizing Criteria	
Runtime	6000 hours/year

Heat Benchmarks	
Residential	3,247 kWh/unit
Office	50 kWh/m^2
Retail	80 kWh/m^2
Restaurant	324 kWh/m^2
Hospital	148 kWh/m^2
Education	108 kWh/m^2
Hotel	260 kWh/m^2
Leisure	206 kWh/m^2
Public	50 kWh/m^2
Warehouse	50 kWh/m^2

Peak Heat Load Factors (diversified)	
Residential	0.03801%
Office	0.04991%
Retail	0.04039%
Restaurant	0.02941%
Hospital	0.02633%
Education	0.06394%
Hotel	0.03399%
Leisure	0.03069%
Public	0.03672%
Warehouse	0.03702%

District Heating Network Specifications	
Flow Temperature	80°C
Return Temperature	60°C
Max. Allowable Flowrate	1.5 m/s
Max. Pressure Drop	100Pa/m

Emissions Factors	
3 – Year Grid Electricity Emissions Factor	0.519 $kgCO_2/kWh$
3 - Year Mains Gas Emissions Factor	0.216 kgCO2/kWh
15 – Year Grid Electricity Emissions Factor	0.381 $kgCO_2/kWh$
15 – Year Mains Gas Emissions Factor	0.222 $kgCO_2/kWh$

A9.2 Financial Assumptions

Inflation & Discounting	
Gas Inflator	0%
Electricity Inflator	0%
RPI Inflator	0%
Discount Rate	6%

Commodity Pricing	
Wholesale Gas	£25/MWh
Wholesale Electricity	£45/MWh
Retail Electricity	£90/MWh

Renewable Heat Incentive Tariffs	
Tier 1	£88.4/MWh
Tier 2	£26.4/MWh

Standing Charge	
Existing Residential - Public	£220 per dwelling
Existing Residential - Private	£220 per dwelling
Existing Non-Resi - Public	£10,000/MW
Existing Non-Resi - Private	£10,000/MW
New Residential - Public	£220 per dwelling
New Residential - Private	£220 per dwelling
New Non-Resi - Public	£10,000/MW
New Non-Resi - Private	£10,000/MW
Heat Price	
Existing Residential - Public	£44/MWh
Existing Residential - Private	£44/MWh
Existing Non-Resi - Public	£38/MWh
Existing Non-Resi - Private	£38/MWh
New Residential - Public	£44/MWh
New Residential - Private	£44/MWh
New Non-Resi - Public	£38/MWh
New Non-Resi - Private	£38/MWh

Connection Charges	
Existing Residential - Public	-
Existing Residential - Private	-
Existing Non-Resi - Public	£22,000/MW
Existing Non-Resi - Private	£22,000/MW

Developer Contributions	
New Residential - Public	Connection charge specified in techno-economic analysis of each supply option
New Residential - Private	Connection charge specified in techno-economic analysis of each supply option
New Non-Resi - Public	£22,000/MW
New Non-Resi - Private	£22,000/MW

Service Charge	
Existing Residential - Public	£170/dwelling
Existing Residential - Private	£170/dwelling
Existing Non-Resi - Public	-
Existing Non-Resi - Private	-
New Residential - Public	£170/dwelling

New Residential - Private	£170/dwelling
New Non-Resi - Public	-
New Non-Resi - Private	-

Operational Expenditure	
CHP Maintenance	£5/MWhe
Boiler Maintenance	£2.5/MWh
WSHP Maintenance	£18,000/MW
Management Fees	£10,000/EC/year
Network Maintenance	£7,000/year
Energy Centre Land Lease Cost	£5/ft^2
Service Fees	£152/dwelling

Capital Expenditure		
CHP		£780,000/MW
Gas Boilers	[0.15, 0.5] MW	£35,000/MW
	[0.5, 1] MW	£30,000/MW
	[1, 4] MW	£22,000/MW
WSHP*		£1,100,000/MW
Energy Centre (EC)		£500,000/EC
HIU		£1,500/dwelling

*Including allowance for the water abstraction / intake system

A10 Other London DE Planning Policies

The table below provides extracts of relevant planning policies of three other London local planning authorities: Camden, Islington and Enfield.

Document	**Extract**
Camden Draft Local Plan 2015	Policy CC1 Climate change mitigation The Council will require all development to minimise the effects of climate change and encourage all developments to meet the highest feasible environmental standards that are financially viable during construction and occupation. We will: a. require all development proposals of five or more dwellings and/or 500m sq of any floorspace to show in an energy statement how the energy hierarchy has been applied; b. ensure that the location of development and mix of land uses minimises the need to travel by car and help support local energy networks; c. support and encourage sensitive energy efficiency improvements to existing buildings; and d. ensure that developments maximise resource efficiency. We will promote local energy generation by: e. working with our partners and developers to implement local energy networks in the parts of Camden most likely to support them;

	f. protecting existing local energy networks where possible (e.g. at Gower Street and Bloomsbury) and safeguarding potential network routes (e.g. Euston Road); and g. requiring all major developments to assess the feasibility of establishing a decentralised energy network or connecting to an existing network. We will have regard to the cost of installing measures to tackle climate change as well as the cumulative future costs of delaying reductions in carbon dioxide emissions.
Camden Draft Local Plan 2015	8.23 New developments are considered to be the most effective catalysts for decentralised energy network growth. The Council will therefore require all new major developments to assess the feasibility of establishing new or connecting to existing or planned decentralised energy networks. Developments will be required to follow the steps below, in the order listed, to ensure energy from an efficient source is used where possible: • where feasible, development will be required to connect immediately to existing networks; • where networks do not currently exist, developments will be required to provide on-site infrastructure for connection to any planned future decentralised energy network in the vicinity of the site, having regard to opportunities identified on the map below and area specific energy plans and site allocations; • major development proposals that cannot immediately connect to an existing heating or cooling network should evaluate the feasibility of combined heat and power (CHP) systems and, where appropriate, examine the feasibility of extending the system beyond the site boundary to establish a new network.
Camden Planning Guidance CPG3: Sustainability	What are developments expected to do? 5.11 Once a development has been designed to be as energy efficient as possible (Energy hierarchy - Stage 1), developments will be required to consider the following steps, in the order listed, to ensure energy from an efficient source is used, where possible: 1. investigating the potential for connecting into an existing or planned decentralised energy scheme and using heat 2. installing a Combined (Cooling) Heat and Power Plant (CHP or CCHP), including exporting heat, where appropriate 3. providing a contribution for the expansion of decentralised energy networks 4. strategic sites are to allow sufficient accessible space for plant equipment to support a decentralised energy network 5. designing the development to enable its connection to a decentralised energy network in the future
	Financial contributions 5.28 In line with the flow diagram above, if your scheme does not connect to a decentralised energy network or have a secure agreement to do so within 3 years, and does not include combined heat and power, a financial contribution will be expected to enable expansion of the network and future connection. The financial contribution should be in line with the

<table>
<tr><td></td><td>following table (or as updated in CPG8 Planning Obligations):
<table>
<tr><th>Size of development</th><th>Residential (per dwelling) or
Per 300sq m of non-residential floorspace</th></tr>
<tr><td>Over 20 stories</td><td>£2,800</td></tr>
<tr><td>8-20</td><td>£2,500</td></tr>
<tr><td>5-7</td><td>£2,800</td></tr>
<tr><td>3-4</td><td>£4,100</td></tr>
<tr><td>2-3</td><td>£5,300</td></tr>
<tr><td>Single dwelling houses or single storey commercial developments</td><td>£8,600</td></tr>
</table>
Source: Community energy: Urban planning for a low carbon future.</td></tr>
<tr><td>Islington Development Management Policies, Adopted June 2013</td><td>Policy DM7.3
Decentralised Energy Networks
A. All major developments are required to be designed to be able to connect to a Decentralised Energy Network (DEN). Minor new-build developments should be designed to be able to connect wherever reasonably possible.
B. Major developments located within 500 metres of an existing DEN, and minor new-build developments located within 100 metres, will be required to connect to that network, including provision of the means to connect to that network and a reasonable financial contribution to the connection charge, unless a feasibility assessment demonstrates that connection is not reasonably possible.
C. Major developments located within 500 metres of a planned future DEN, which is considered by the council likely to be operational within 3 years of a grant of planning permission, will be required to provide a means to connect to that network and developers shall provide a reasonable financial contribution for the future cost of connection and a commitment to connect via a legal agreement or contract, unless a feasibility assessment demonstrates that connection is not reasonably possible.
D. Where connection to an existing or future DEN is not possible, major developments should develop and/or connect to a Shared Heating Network (SHN) linking neighbouring developments and/or existing buildings, unless it can be demonstrated that this is not reasonably possible.
E. Where connection to an existing or future DEN is deemed possible under the above policy, major developments are required to detail a preferred energy strategy and an alternative energy strategy within their Energy Statements. The preferred energy strategy shall be based on connection to a DEN and shall be enacted, unless it is not reasonably possible to connect to a DEN, in which case the alternative energy strategy shall be enacted.
F. The council will support the development of decentralised energy networks and energy centres in principle, subject to meeting wider policy requirements, including on design (Policy DM2.1 and Policy DM2.3) and air quality (Policy DM6.1).</td></tr>
<tr><td>Enfield DM Document, November 2014</td><td>DMD 52
Decentralised Energy Networks
Proposals for the development of decentralised energy network infrastructure and related apparatus in the borough will be supported. The Council will support, and in some cases facilitate, the provision of infrastructure to support new and expanding networks including safeguarding routes and land for such use where necessary.</td></tr>
</table>

Proposals for major developments which produce heat and/or energy should contribute to the supply of decentralised energy networks unless it can be demonstrated that this is not technically feasible or economically viable.

Connection to a decentralised energy network

All major developments should connect to or contribute towards existing or planned DE networks supplied by low or zero carbon energy.

1. Where the proposed development is adjacent to an existing DE network, it should:

a. Secure the direct connection of all units to that network; and

b. Contribute as necessary to the increased capacity of the DE network to

[redacted]

2. Where [illegible]
to supply the proposed development, proposed developments should:

[redacted]

b. Secure the direct connection of all units to the extended network; and

[redacted]

[redacted]