Royal Borough of Kingston upon Thames: Energy Master Plan Final Report

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Royal Borough of Kingston upon Thames:
Energy Master Plan

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Acronyms

AHU	Air Handling Unit
BMS	Building Management System
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
DE	Decentralised Energy
DECC	Department of Energy and Climate Change
DEPDU	Decentralised Energy Programme Delivery Unit
DEN	Decentralised Energy Network
DH	District Heating
DHN	District Heating Network
DHW	Domestic Hot Water
DNO	Distribution Network Operator
EfW	Energy from Waste
EMP	Energy Master Plan
EPC	Energy Performance Certificate
ESCo	Energy Services Company
FiT	Feed in Tariff
GIA	Gross Internal Area
GLA	Greater London Authority
GSHP	Ground Source Heat Pump
HIU	Hydraulic Interface Unit
HVAC	Heating, Ventilation and Air Conditioning
IRR	Internal Rate of Return
K+20 AAP	Kingston Town Centre Area Action Plan
KTC	Kingston Town Centre
kW	Kilowatt (unit of power)
kWe	Kilowatt electricity
kWh	Kilowatt hour (unit of energy)
kWth	Kilowatt thermal
LDF	Local Development Framework
LTHW	Low temperature hot water
MW	Megawatt (unit of power)

MWe	Megawatt electricity
MWh	Megawatt hour (unit of energy)
MWth	Megawatt thermal
NPV	Net Present Value
PHE	Plate Heat Exchanger
RBK	Royal Borough of Kingston-upon-Thames
RHI	Renewable Heat Incentive
STW	Sewage Treatment Works

Capabilities on project:
Building Engineering

Executive summary

Introduction

This report has been prepared by AECOM consulting engineers at the request of our Client, the Royal Borough of Kingston-upon-Thames (RBK). As part of RBK's commitment to addressing climate change, it has developed a specific policy on decentralised energy. Accordingly the Council now requires an Energy Master Plan (EMP) to consider the feasibility of Decentralised Energy (DE) and District Heating (DH) serving two areas: the Kingston Town Centre and Tolworth Regeneration Area. The development of DE schemes in the Borough comprising DH networks could provide a number of benefits:

- Improved fuel security through higher efficiency heat generation and the ability to use alternative forms of energy including "waste" heat.
- A reduction in CO_2 emissions and the ability to change heat supply technologies at a large scale in the future to optimise CO_2 reduction.
- The ability to deliver lower cost heat. This could be used to provide commercial benefits, and help alleviate fuel poverty in residential areas.
- The provision of a low carbon heat source for new development to connect to, helping to reduce the costs of complying with future regulations, and providing a connection-ready solution to developers.

The overall aim of this EMP is therefore to determine the extent of a DE system that has the potential to supply market competitive, low carbon energy to new developments and existing properties.

District heating networks

Our work has built on an earlier report "Royal Borough of Kingston-Upon-Thames Heat Mapping Study", prepared by URS in 2010.This identified a number of opportunities for DH in the Borough, but in particular in the Town Centre area, the main assessment area for this EMP. In addition, AECOM were requested to examine the Tolworth area due to the presence of a large commercial building (Tolworth Tower) and a number of local re-development areas.

Our overall approach has been to consider the nature and scale of the existing and potential future energy demands in Kingston to identify how these might be best served by a DH network in the longer term – in 40 years time, using energy modelling. Working back from this, we have considered the energy loads at existing buildings and likely loads for identified redevelopment sites to inform how an appropriate DH network could be developed in phases over the next 10-15 years – the medium term, and what are likely to be the most suitable heat sources.

The scope of a District Heating network in the Tolworth area appears to be limited. The major 'Tesco site' which includes residential units, and a leisure centre as well as the supermarket already includes a CHP plant sized to serve the whole development. The other major building in the area, Tolworth Tower appears to have an uncertain future and a standalone CHP system is likely to be more suitable for this building in any case. Other sites are either too small or distant to justify connection.

The Kingston Town Centre offers a significant opportunity for a DH network to be established. There is a wide mix of buildings at reasonable density including: Council offices, retail centres, university buildings and a major social housing estate. Further away from the centre is Kingston General Hospital which has its own CHP plant at present but could form a future heat customer. The main emphasis of this EMP is therefore on Kingston Town Centre.

There are a number of potential energy sources for a DE scheme, providing heat, and potentially electricity. Initially it is proposed that gas-fired CHP plant is used to supply the low carbon heat for a DH network. This is a reliable and mature technology which can deliver large CO_2 reductions and efficiency improvements. Gas-fired CHP plant is also the most economic of solutions and hence well suited to developing an early scheme which can attract investment. In the longer term, there is the potential for the use of large-scale heat pumps. One of these could be located near to the river using the river water as a heat source. The other could be located near to the sewage treatment works using the waste water as a heat source. The latter may be more viable as space adjacent to the river for a major energy centre is at a premium. However the ability to access the Renewable Heat Incentive (RHI) will be crucial for either location based on current economic assumptions.

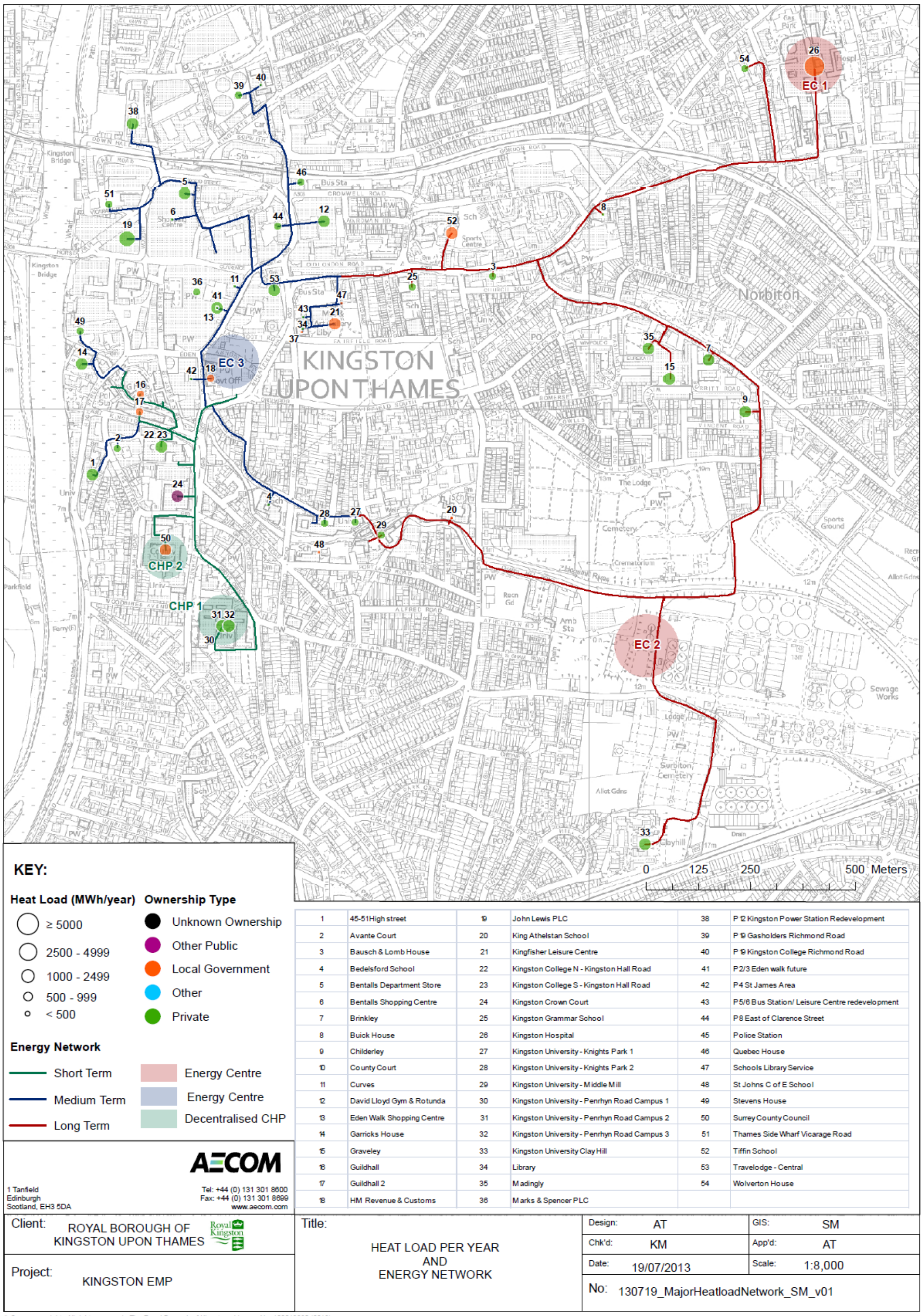
This EMP assesses a number of network options. It proposes that the network is developed in 3 phases:

- The first phase comprising a small group of Council owned buildings, Kingston College, the Courts and police station and part of Kingston University
- The second phase which would comprise an extension into the town centre area supplying mainly commercial and retail property
- A third phase which would extend out to serve local housing areas including the Cambridge Rd estate and forming a ring main from which further extensions can be made and in this phase connection to a more remote heat source at the sewage treatment works for example would become viable

For the each phase a number of combinations of heat mains routes and buildings to be connected were analysed to find an optimal configuration and examine sensitivities.

The map in Figure i below indicates the extent of the proposed scheme and its phasing.

Capabilities on project:
Building Engineering



1	45-51High street	19	John Lewis PLC	38	P 12 Kingston Power Station Redevelopment
2	Avante Court	20	King Athelstan School	39	P 19 Gasholders Richmond Road
3	Bausch & Lomb House	21	Kingfisher Leisure Centre	40	P 19 Kingston College Richmond Road
4	Bedelsford School	22	Kingston College N - Kingston Hall Road	41	P 2/3 Eden walk future
5	Bentalls Department Store	23	Kingston College S - Kingston Hall Road	42	P 4 St James Area
6	Bentalls Shopping Centre	24	Kingston Crown Court	43	P 5/6 Bus Station/ Leisure Centre redevelopment
7	Brinkley	25	Kingston Grammar School	44	P 8 East of Clarence Street
8	Buick House	26	Kingston Hospital	45	Police Station
9	Childerley	27	Kingston University - Knights Park 1	46	Quebec House
10	County Court	28	Kingston University - Knights Park 2	47	Schools Library Service
11	Curves	29	Kingston University - Middle Mill	48	St Johns C of E School
12	David Lloyd Gym & Rotunda	30	Kingston University - Penrhyn Road Campus 1	49	Stevens House
13	Eden Walk Shopping Centre	31	Kingston University - Penrhyn Road Campus 2	50	Surrey County Council
14	Garricks House	32	Kingston University - Penrhyn Road Campus 3	51	Thames Side Wharf Vicarage Road
15	Graveley	33	Kingston University Clay Hill	52	Tiffin School
16	Guildhall	34	Library	53	Travelodge - Central
17	Guildhall 2	35	Madingly	54	Wolverton House
18	HM Revenue & Customs	36	Marks & Spencer PLC		

Figure i: Map indicating proposed scheme and phasing

Assessment of network options

The key economic and environmental results for Phase 1 are:

Phase 1 – Short term	Units	Base Case	Variation 1	Variation 2	Variation 3	Variation 4	Variation 5
Network							
Network length	m	1635	1370	1635	1635	1090	2045
Total network capacity	kW	16,820	16,820	16,820	8,410	10,330	21,803
Economic performance							
Total Capital Cost	£million	7.7	7.6	8.7	5.6	5.7	10.8
CHP capacity	MWe	3.2	3.2	3.2	3.2	2.4	4.5
Energy centre boilers capacity	MW	16.9	16.9	16.9	16.9	10.4	21.9
IRR (indexed) 25 years	%	3.0	4.1	2.3	4.9	2.4	3.7
Environmental Performance							
10 year carbon saving	%	26%	26%	25%	25%	30%	28%

The results demonstrate that the baseline Phase 1 scheme with a central energy centre located in the Eden Quarter on existing RBK land (currently surface car parking) providing all of the schemes heat could provide an IRR of 3%. By locating the energy centre closer to the customers (and therefore reducing the DH network length), the IRR is increased to 4.1%. The highest IRR of 4.9% is obtained when the DH network provides baseload heat only (Variation 3) and peak and back-up heat supply is from the customer's existing boilers.

Whilst these IRRs are not commercially attractive, they could be potentially improved through optimisation at detailed feasibility stage to a level which can attract public sector investment, or even commercial investment. It should be noted that the assumptions used in this EMP are purposely conservative to reflect the high level nature of the analysis, and therefore it is possible that optimisation could be beneficial. Sensitivity analysis on the baseline results shows that:

- a 20% increase in electricity revenue price (equivalent to 1.2p / kWh extra) could increase the IRR to around 7.5% for the baseline Phase 1 scheme. This would attract public sector investment.
- A 20% reduction in capital costs (representing either a real cost reduction, or input of funding from grants of local sources such as CIL) would result in an IRR of 6.6% for the baseline Phase 1 scheme.

A combination of the above would have greater compound benefits.

The CO_2 reduction in heat supply is around 25% in all options. This is calculated based on future electricity grid CO_2 carbon intensity projections from the UK Government. It is believed these de-carbonisation projections are reasonably optimistic and therefore in reality, the CO2 savings for the DE scheme are likely to be higher.

The key economic and environmental results for Phase 2 are:

Phase 2 – Medium term	Units	Base Case	Variation 1	Variation 2	Variation 3	Variation 4	Variation 5
Network							
Network length	m	5245	5245	5250	4675	5380	5245
Total network capacity	kW	42,850	42,850	45,400	39,188	42,850	42,850
Economic performance							
Total Capital Cost	£million	22.2	23.0	23.4	19.7	22.3	19.5
CHP capacity	MWe	7.9	7.9	8.9	7.9	7.9	N/A
Energy centre boilers capacity	MW	43.1	43.1	45.6	39.4	43.1	43.1
IRR (indexed) 25 years	%	3.9	3.4	4.3	4.2	3.9	0 (0.45 with RHI)
Environmental Performance							
10 year carbon saving	%	12%	12%	12%	12%	12%	45%

The phase 2 schemes all provide IRRs of around 4% except for the river water heat pump option which drops to 0.45% even with RHI income. These IRRs include investment in the entire network (including the Phase 1 components), and so if the phase 1 component is considered to be partially paid back, then the effective IRR would increase further. The stability of the IRRs across the variations demonstrates that the Phase 2 options are not critical when defining phase 1 of the network.

The key economic and environmental results for Phase 3 are:

Phase 3 – Long term	Units	Base Case	Variation 1	Variation 2	Variation 3	Variation 4	Variation 5	Variation 5
Network							No CHP	CHP
Network length	m	9,700	10,600	8,500	7,285	9655	9800	9800
Total network capacity	kW	94,500	97,200	50,000	93,400	94,500	94,500	94,500
Economic performance								
Total Capital Cost	£million	49.7	51.0	33.5	45.5	43.1	43.7	45.3
CHP capacity	MWe	20.1	20.1	9.7	20.1	20.1	N/A	3.0
Energy centre boilers capacity	MW	95.5	98.3	50.9	95.5	95.5	95.5	95.5
IRR (indexed) 25 years	%	4.9	4.6	0.5	6.1	6.9	0 (0 with RHI)	0 (1.2 with RHI)
Environmental Performance								
10 year carbon saving	%	-29%	-33%	-34%	-33%	-33%	58%	43%

The IRRs for the long term Phase 3 network improve over the initial 2 phases with up to around 6% for an optimised network (this includes removal of a section of the ring main which is poorly utilised - variation 3). As with Phase 2, some of the capital for Phase 2 and 1 will have been paid off and therefore the effective IRRs of this later phase will be higher – if is assumed that only the network costs for Phase 3 need to be paid off then the IRR increases to 6.9% (variation 5). The heat pump options are not predicted to be cost effective as a single heat source, but with additional CHP generation included in the scheme (a relatively small contribution), an IRR of 3% is achieved with RHI income.

Energy centre locations

Finding land for an energy centre/s will be critical for the development of DE in RBK. In the short term, a phase 1 network could make use of distributed boiler plant, and a central CHP engine either at the Kingston University Penrhyn Road campus, the Surrey County Council buildings, or if completed in time, the redeveloped Kingfisher Leisure centre. An alternative location is on existing surface car parking in the Eden Quarter, which would allow the development of a larger centralised energy centre, which could also be used to power a phase 2 scheme.

The main long-term option for an energy centre is in the Hogsmill Valley area, either on RBK land or on the Thames Water STW site. This provides opportunities for using secondary heat from the STW outlet in a large heat pump for future phases. The location of an energy centre in the Hogsmill Valley, in an area which can potentially connect to the STW outlet, should be seen as a priority for the forthcoming Hogsmill Valley AAP.

If heat pumps are to be a long term strategy taking secondary heat from the River Thames, a location is also required along the river bank. Therefore suitable locations, including potentially as a future addition to the power station site, need to be identified and promoted through planning.

Conclusions

These results all demonstrate that there are potentially viable short, middle, and long term DE options in Kingston Town Centre. Phase 3 demonstrates that the viability of the scheme improves with size, and whilst the phase 1 scheme gives lower IRRs, the assumptions used in this EMP are conservative and it is anticipated that optimisation of the network at the detailed feasibility stage combined with improvements to the electricity revenue (though either on-site electricity sales, or improved licence-lite rates) could increase the IRR to public sector investment levels or better.

A phase 1 scheme is connected to primarily public sector customers which helps de-risk the initial investment and should allow the establishment of long-term heat supply contracts. The scheme could make use of a centralised energy centre providing all heat, potentially based on the RBK owned land in the Eden Quarter which allows for future expansion. Alternatively it could make use of existing boilers for peak and back-up heat supply with a smaller energy centre for the CHP and associated equipment. The latter could be a temporary solution prior to a longer term central energy centre, and have the plant located at potentially the County Hall or Kingston University Penrhyn Road site amongst others.

Future phases of a DE scheme have a number of options which will need further investigation following the establishment of a phase 1 scheme. A key issue to address for future phases is the transition in heat supply technologies from gas-fired CHP to heat pumps. Future work is required to examine in more detail the feasibility of heat pumps taking secondary heat from the Hogsmill outlet and the river Thames, and this will also need to consider the future changes in the electricity grid carbon intensity. Alongside the transition of heat supply technologies, future phases of a network will also need to consider lower temperature regimes to allow the distribution of the lower temperature heat from heat pumps, whilst meeting the customers heating demands.

Recommendations

This report identifies that a DE scheme could be viable in Kingston Town Centre providing environmental and economic benefits. In particular, the report identifies a potentially feasible Phase 1 scheme. Therefore the following recommendations are made:

- The Council review the report’s findings and decide whether there is sufficient evidence for taking the next steps in its development
- If positive the Council should undertake more detailed feasibility studies for Phase 1 and examine the various business structures available to them to implement the project, including the use of their own capital resources or borrowing facilities
- A full business plan should then be established for which backing can be sought from all stakeholders within the Council and outside

A Programme Board should then be established to take the project forward.

1 Introduction

1.1 Background

The Royal Borough of Kingston upon Thames (RBK) has set a 2020 vision within the Kingston Plan that the Borough will be sustainable, prosperous and inclusive, and safe, healthy and strong[1]. The first theme of a sustainable Kingston sets a number of objectives, the first of which commits the Borough to tackling climate change. To help deliver this objective, RBK developed an Energy Strategy in 2009[2]. This addresses energy issues under the Council's varied roles; that of Community Leader; that of Local Planning Authority; and that of Service Provider and Asset Holder. Four ways to deliver the Energy Strategy have been identified:

- Reducing the unnecessary use of energy
- Using energy efficiently
- Using renewable and cleaner energy
- Getting more from conventional supplies, e.g. Combined Heat and Power.

Following the Energy Strategy, a detailed heat mapping exercise (2010) was conducted as part of the GLA's Decentralised Energy Master Planning (DEMaP) programme, aiming to produce heat maps for all London boroughs, and identifying opportunities for District Heating (DH) networks [3]. The heat map study identifies a number of potential clusters of buildings which may be suited to DH development, in particular the Kingston Town Centre Ring (which includes the Hogsmill area and sewage works).

The importance of DH and the benefits it can provide to Kingston in terms of energy security, fuel poverty, and CO_2 emissions reduction is addressed in the latest Core Strategy[4]. Decentralised Energy (DE) features strongly as part of the 2027 Vision, and a number of the policies set out requirements and strategies for the identification and development of DH schemes, including the requirement for new developments to connect where viable:

Core Strategy Policy DM2 Low Carbon Development:

Independent Renewable Energy Generation

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

The development of energy generating infrastructure will be fully encouraged by the Council providing that any opportunities for generating heat simultaneously with power are fully exploited.

District Heating

The Council will seek to develop District Heating Networks in the following areas identified as being suitable for the establishment of a combined heat and power network (as outlined in Figure 15):

- Kingston Town Centre
- The Hogsmill Valley Area

[1] RBK Kingston Plan: Kingston's Vision for 2020. 2008.
[2] RBK Energy Strategy. 2009
[3] Royal Borough of Kingston-Upon-Thames Heat Mapping Study. URS. 2010.
http://www.londonheatmap.org.uk/Content/uploaded/documents/Heatpmap_Report/Kingston_Heat_map_FINAL_resize.pdf
[4] RBK Local Development Framework: Core Strategy. Adopted April 2012.

- 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 there is insufficient heating demand for an efficient connection.

Present: connect to the District Heating Network and make all reasonable attempts to connect existing developments in the vicinity to the network, unless it can be demonstrated that connection of existing developments will not result in CO_2 savings.

The Council is now keen to progress the findings of the Heat Map to support its planning policies and energy strategy and to influence future development proposals, working alongside the Greater London Authority's Decentralised Energy Programme Delivery Unit (DEPDU). To that end, this Energy Master Plan (EMP) study has been commissioned from AECOM by the Council, to consider specifically:

- Kingston Town Centre (KTC), and;
- Tolworth Regeneration Area.

1.2 The benefits of Decentralised Energy

The present system of energy generation in the UK is relatively inefficient. Electricity is generated centrally, resulting in electricity transmission losses, and large amounts of waste heat from power stations which are currently not used. Heat is usually generated at a building scale which means that only small scale technologies can be used (most commonly gas boilers), and limiting the other forms of heat generation technologies which can be incorporated at a building scale. By localising electricity generation and generating and capturing heat at a larger scale for distribution, it is possible to improve efficiencies through the capture of waste heat and reduce electricity losses.

A key component of a Decentralised Energy (DE) scheme is a DH network. This provides opportunities for capturing the heat and distributing to a number of customers. The generation of heat at a larger scale, and linking many buildings, allows alternative and more efficient forms of heat generation to be used which would not be viable at a building scale, the capture and delivery of waste heat, and the simple transition to new technologies (rather than retrofitting to many individual buildings).

District Heating is a system of insulated pipes which distribute hot water from a centralised boiler or other heat generation plant to a number of different buildings to provide space heating and hot water. Schemes can range in size from simply linking two buildings together, to spanning entire cities. In some continental European countries the use of DH is widespread – in Denmark around 60% of the country's heat load (and 60% of homes) are connected to heat networks, including a scheme supplies the whole of Copenhagen.

The use of DE in Kingston, comprising the DH networks and energy generation plants at a district scale offers many potential benefits to the Borough:

- CO_2 savings. The combination of more efficient generation and the ability to use alternative technologies and fuels means that DE schemes can provide large CO_2 reductions to communities.

- CO_2 cost savings. Policies such as the CRC Energy Efficiency Scheme place a value on CO_2 emissions (effectively a carbon tax) and it is expected that such policies may increase in future as the pressure to reduce emissions increases. Therefore a reduction in CO_2 will also provide economic benefits.
- Reduction in energy prices. The efficiencies can allow reduced energy costs for customers. Often the price of heat is linked to gas prices with a discount (see section 7) providing long term cost reductions. This can provide commercial benefits to commercial customers, and fuel poverty alleviation to households.
- Energy security. The higher efficiencies combined with the ability to provide alternative forms of heat generation (for example from large heat pumps or energy from waste) means that DE improves energy security, and reduces reliance and long term lock-in to gas.

The above benefits are at a high level, and could be broken down into sub-levels, for example economic benefits can be realised in a range of forms, and in different ways to different customers.

Whilst a scheme can provide a range of benefits, it is important at the outset when developing a scheme to establish the priorities. This will in turn guide the design and configuration of a scheme, and the commercial versus environmental drivers.

1.3 The purpose of this study

The purpose of this study is to establish an EMP based on DE serving KTC and Tolworth Regeneration Area TRA. The aim is to determine the extent of a DE system that has the potential to supply market competitive, low carbon energy to new developments and existing properties.

As noted above, our work has built on an earlier report "Royal Borough of Kingston-Upon-Thames Heat Mapping Study", prepared by URS in 2010.

Our overall approach has been to consider the nature and scale of the existing and potential future energy demands in Kingston to identify how these might be best served by a DE network in the longer term – in 40 years time, using energy modelling. Working back from this, we have considered the energy loads at existing buildings and likely loads for identified redevelopment sites to inform how an appropriated DE network could be developed and supplied over the next 10-15 years – the medium term.

The project outputs are therefore:

- Proposals for Phase 1 DE scheme, supported by a map showing the location of the Energy Centre and the layout of the District Heating Network
- A set of next steps for the Council, to support the project moving forward

In addition, AECOM will provide additional support to RBK though analysis of the impact of additional sites over the next year.

The supporting work is presented in Sections 2 – 11 as described below:

- Review of existing information to gain an understanding of the existing sources of information in the two target areas – Section 2
- A scoping assessment of the potential customers and sales, network layout options, technology options, potential locations for an Energy Centre/s, and phasing of networks – Section 3
- A review of the available energy producing technologies – Section 4
- An assessment of the potential customers for connecting to a DE scheme - Section 5
- Identification of the energy loads and estimation of the current and future energy[5] demand and supply balance – Section 5
- Assessment of potential energy distribution options – Section 6

[5] Electricity, space heating and hot water

- Consideration of issues and options around the selling of heat and electricity – Section 7
- Analysis of proposed schemes in terms of environmental and economic performance – Section 8
- A high level risk assessment – Section 9
- Indicative project plan and next steps– Section 10
- Conclusions and recommendations – Section 11

2 Review of existing information

2.1 Introduction

This section provides an overview of relevant existing available information which will be used to inform the Energy Master Plan study. This includes information about existing energy uses within the Borough and changes which may affect energy demand. It also includes a review of other factors which may influence the development of a distributed energy network within the Borough. Analysis of these sources of information is provided throughout this report.

2.2 RBK Heat Mapping Study (2010)

A study was conducted in 2010 by URS to develop a heat map of RBK to support the London DEMap programme. The information generated as part of this study was used to input to the London Heat Map to supplement the London-wide mapping work conducted.

The RNK Heat Mapping study makes use of a range of data capture and analysis techniques:

- Analysis of GIS datasets providing information on building location, use, and type.
- Analysis of datasets providing information on energy consumption and CO_2 emissions across a range of buildings.
- Conducting surveys to acquire data from specific buildings relating to energy consumption
- Assessment of energy demand using benchmarks where specific data is not available.
- One to one consultation with key stakeholders

As the most recent and comprehensive assessment of heat demand in RBK, AECOM have used this study as the prime source of data. Alongside the capture and presentation of heat demand data, the study provides an analysis of the potential for DE schemes using a cluster process. By assessing groupings of buildings, and forming these into clusters, each cluster is assessed against a range of metrics to ascertain the suitability of DE in each area. Figure 2 shows a copy of the RBK Heat Mapping study cluster map, and Figure 3 the assessment of suitability of clusters for DE.

The cluster map shows a ring of clusters in the town centre area and the simple assessment of suitability suggests that these clusters may be suitable for a DE scheme. Importantly the cluster map does not indicate a cluster of buildings in the Tolworth area, and only identifies one large heat demand, Tolworth Tower. The selection of Tolworth for inclusion in this study is therefore not based on existing heat demand but future regeneration.

Capabilities on project:
Building Engineering

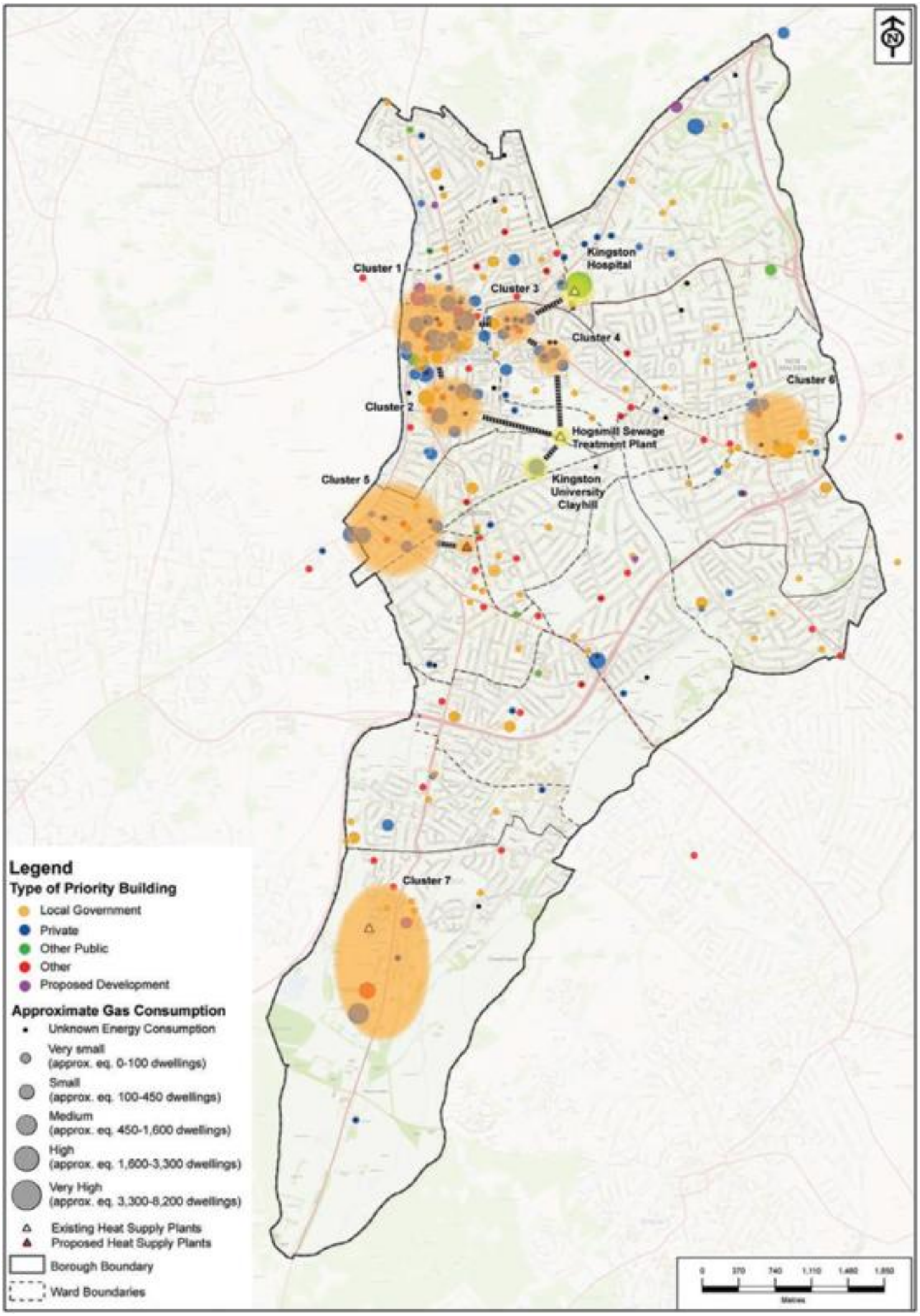


Figure 2: The RBK Heat Mapping study cluster map showing groupings of buildings where DE opportunities may exist.

Cluster Performance

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7
	Town Centre Ring						
Heat Density	High	High	High	Medium	Medium	Medium	Low
Diversity of Consumers	High	High	Medium	Medium	Medium	Medium	Medium
Anchor Loads	High	High	High	High	High	Medium	Medium
Proximity to Strategic Locations	High	High	High	High	High	Low	Medium

Performance

High	(green)
Medium	(amber)
Low	(red)

Figure 3: Assessment of suitability of each cluster for DE schemes (Source – RBK Heat Mapping study)

The data set provided as part of the RBK heat mapping study has been used as the prime data source for this EMP. Further information is given in later sections of this report on how this data have been checked and used.

2.3 The London Heat Map

The London Heat Map has been developed as part of the GLA's DEMaP programme to help promote and provide information for the development of DE schemes in London. The DEMaP programme recognises the complexity in obtaining and forming energy masterplans and by developing a strategic London wide approach, provides a common baseline of information which all Boroughs can make use of, and contribute to. A key aspect of the heat map is the ability to include new data, and so as detailed information is formed at a local level around existing and new heat demands and sources, this can be added to the central data base. As such, this EMP can be used to help input further more detailed information on DE opportunities in RBK.

The London Heat Map is made up of a base layer heat map which has been generated using a large number of GIS datasets to produce a contour map showing heat density. An extract of the contour base map is shown in Figure 4. This shows the largest and highest density of heat demand is over the Town Centre area. The Tolworth area (at the bottom centre of the map at the intersection of the A3 and A240 is on the edge of a moderately high heat demand area but appears to have significantly less potential than KTC.

Capabilities on project:
Building Engineering

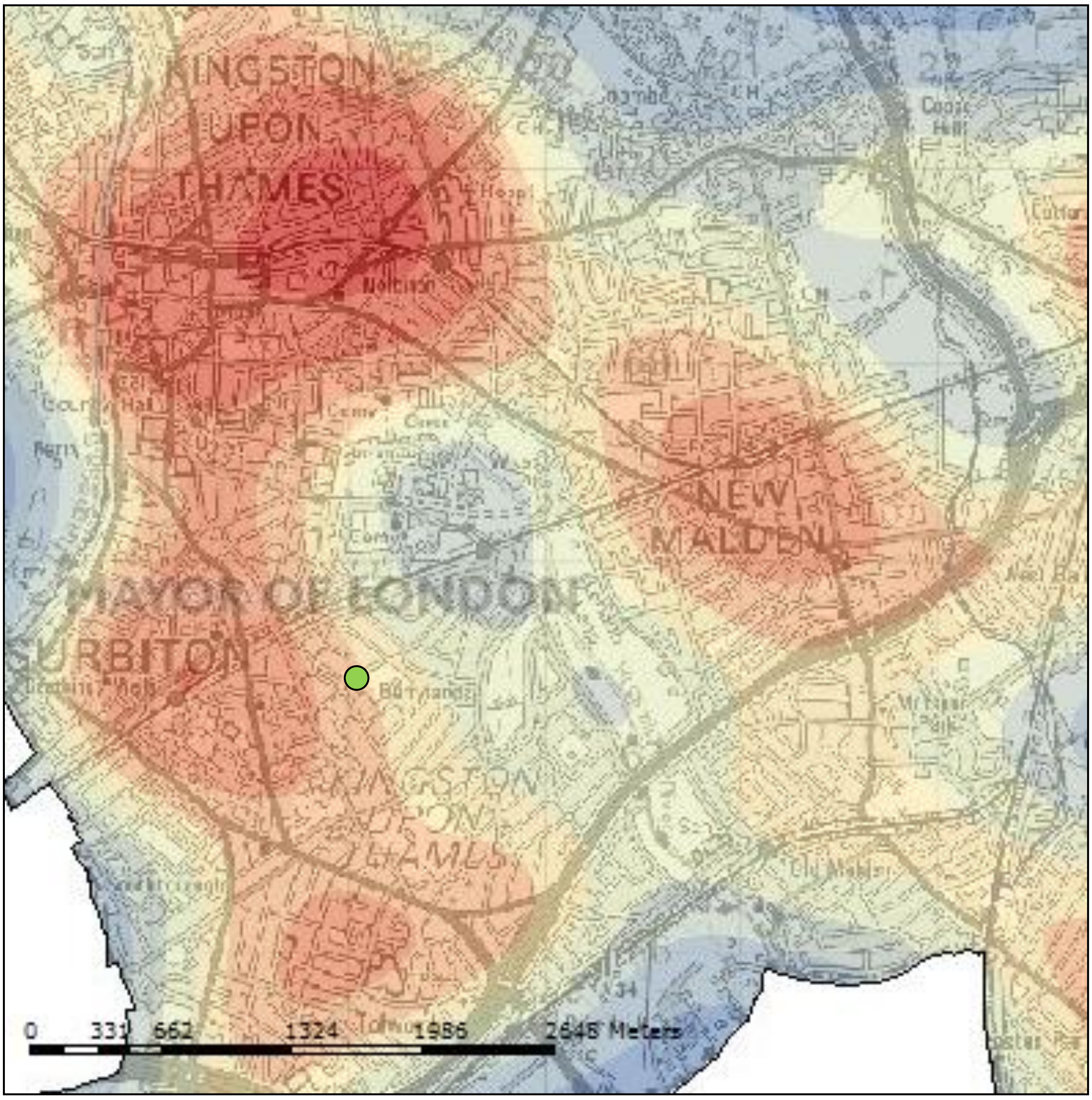


Figure 4: Extract of the London Heat Map showing the contour base map of heat density for the KTC area (top of image) and Tolworth area (bottom centre – green dot).

Figure 5 and Figure 6 show the heat maps with potential anchor heat loads identified – these are primarily based on the information gathered during the RBK Heat Mapping study, and closely mirror the map shown in Figure 2. On first inspection, the KTC area appears to have a large number of opportunities, whilst the Tolworth area appears to be extremely limited. Most significantly, the purple areas indicate those which are deemed to have some form of potential for DE – these are only shown on the KTC map.

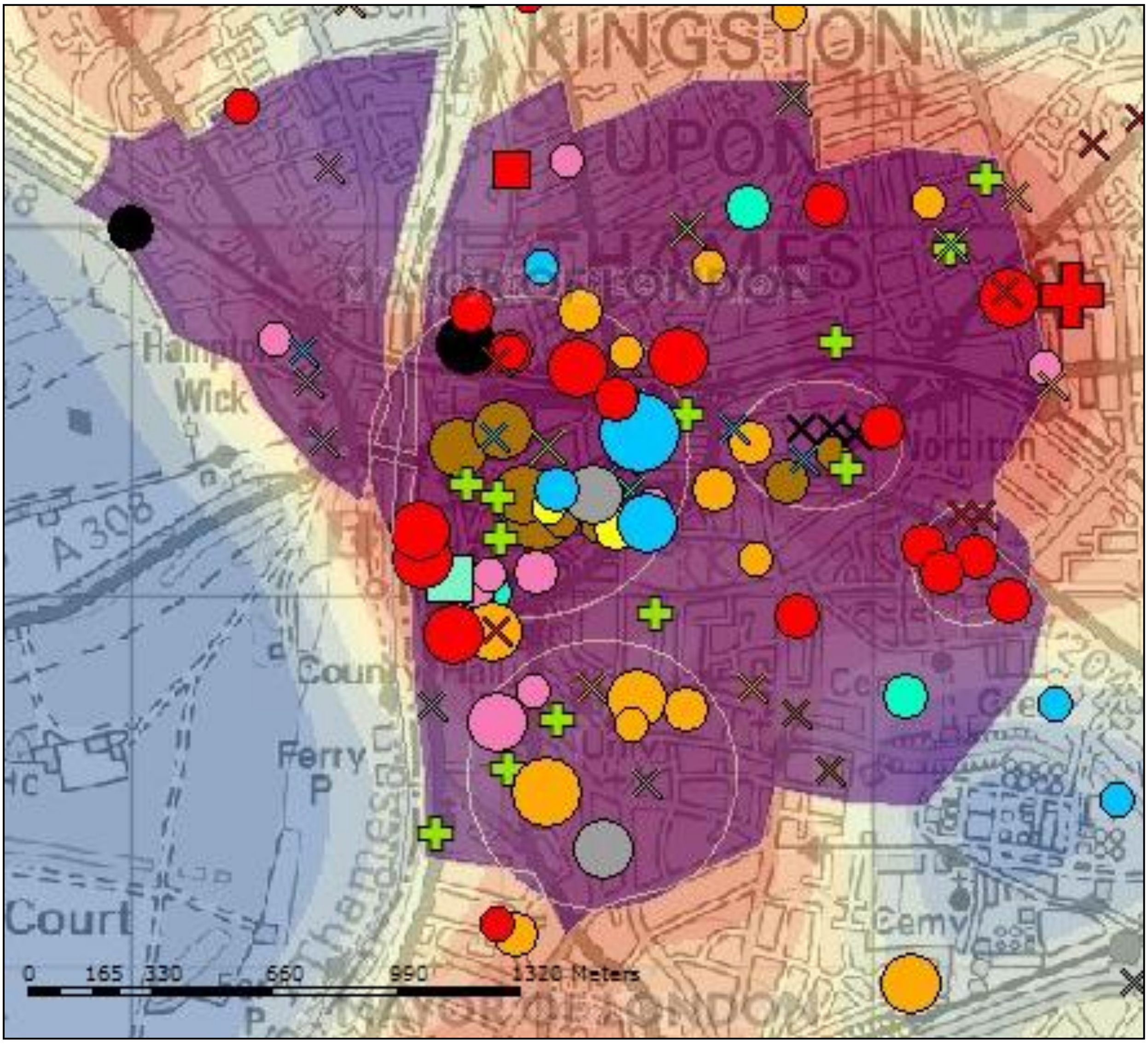


Figure 5: Opportunities in the KTC area. The size of the icon indicates the relative heat demand, and the shape and colour denotes the type and ownership of the building.

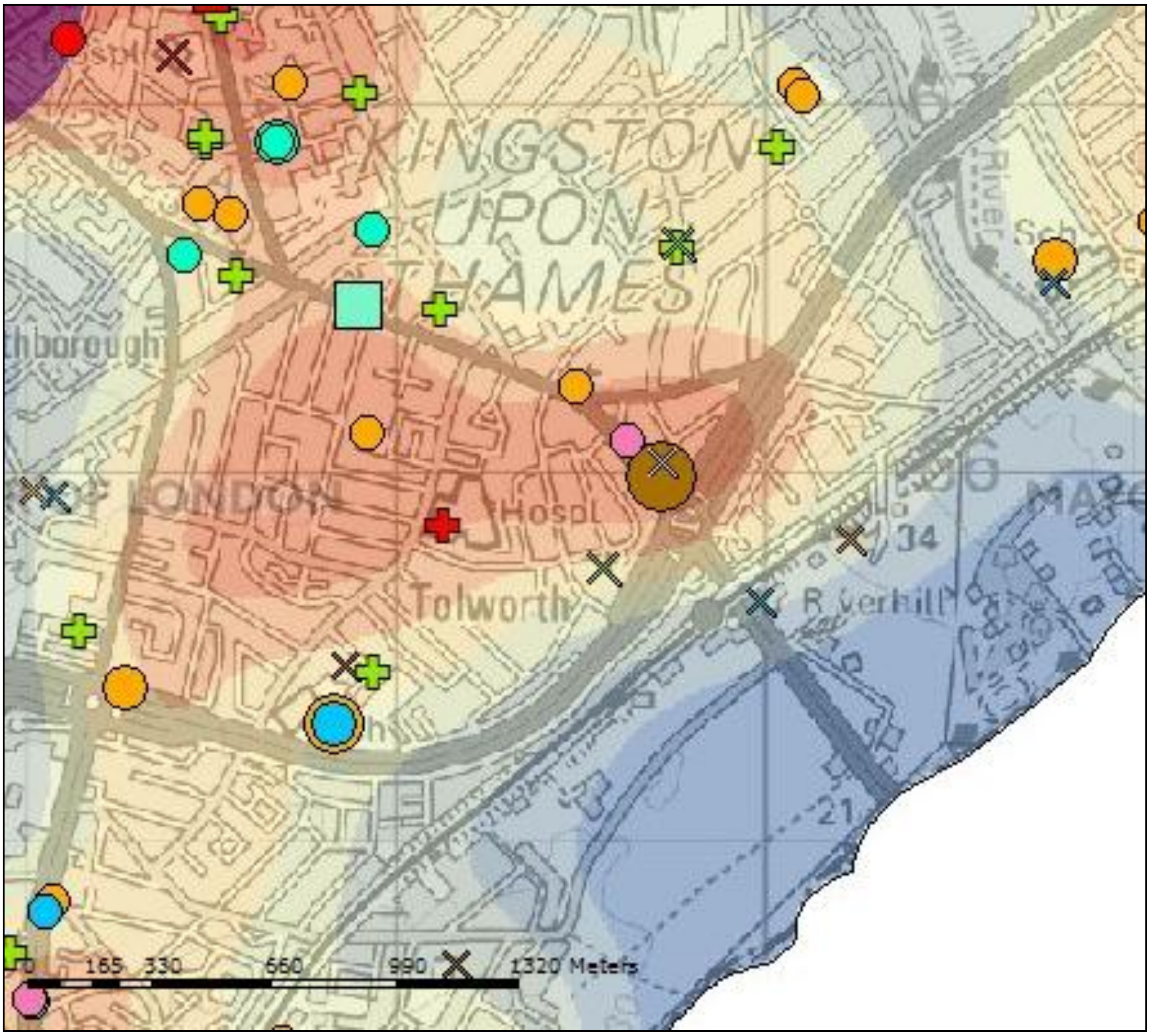


Figure 6: Opportunities in the Tolworth area. The size of the icon indicates the relative heat demand, and the shape and colour denotes the type and ownership of the building.

2.4 Kingston Town Centre Area Action Plan

The Kingston Town Centre Area Action Plan (K+20 AAP) is part of the Local Development Framework and was adopted in 2008, and sets out planning policy for KTC to 2020[6]. From inspection of the K+20 AAP, it is clear that there are ambitions for extensive re-development over the next decade, with new homes, retail, and student accommodation, including a range of other infrastructure and landscaping modifications. These opportunities could provide the catalyst for developing a DH scheme, by providing initial anchor loads and networks from which the main network can extend. Redevelopment may also open up opportunities for identifying land suitable for hosting an energy centre; something which can act as a constraint on network development. It is also possible that other infrastructure works (such as roads) offer opportunities for combining works and minimising disruption.

[6] RBK K+20 Kingston Town Centre Area Action Plan. Adopted July 2008.

An important component of the K+20 AAP is the 2020 vision which identifies key development and re-development opportunities in the town centre area (see Figure 7). This is used in this study to inform both the new development opportunities which may connect to a DE scheme, and land for locating an energy centre. Accompanying the K+20 AAP, AECOM have been provided with a schedule of opportunity sites relating to the sites in the Vision diagram – this provides updated information on the status of each site.

Overall the information provided in the K+20 AAP and the schedule of sites is either of relatively detailed nature (due to either completion or planning application received or imminent), or very high level with quantum and type of development very uncertain.

Capabilities on project:
Building Engineering

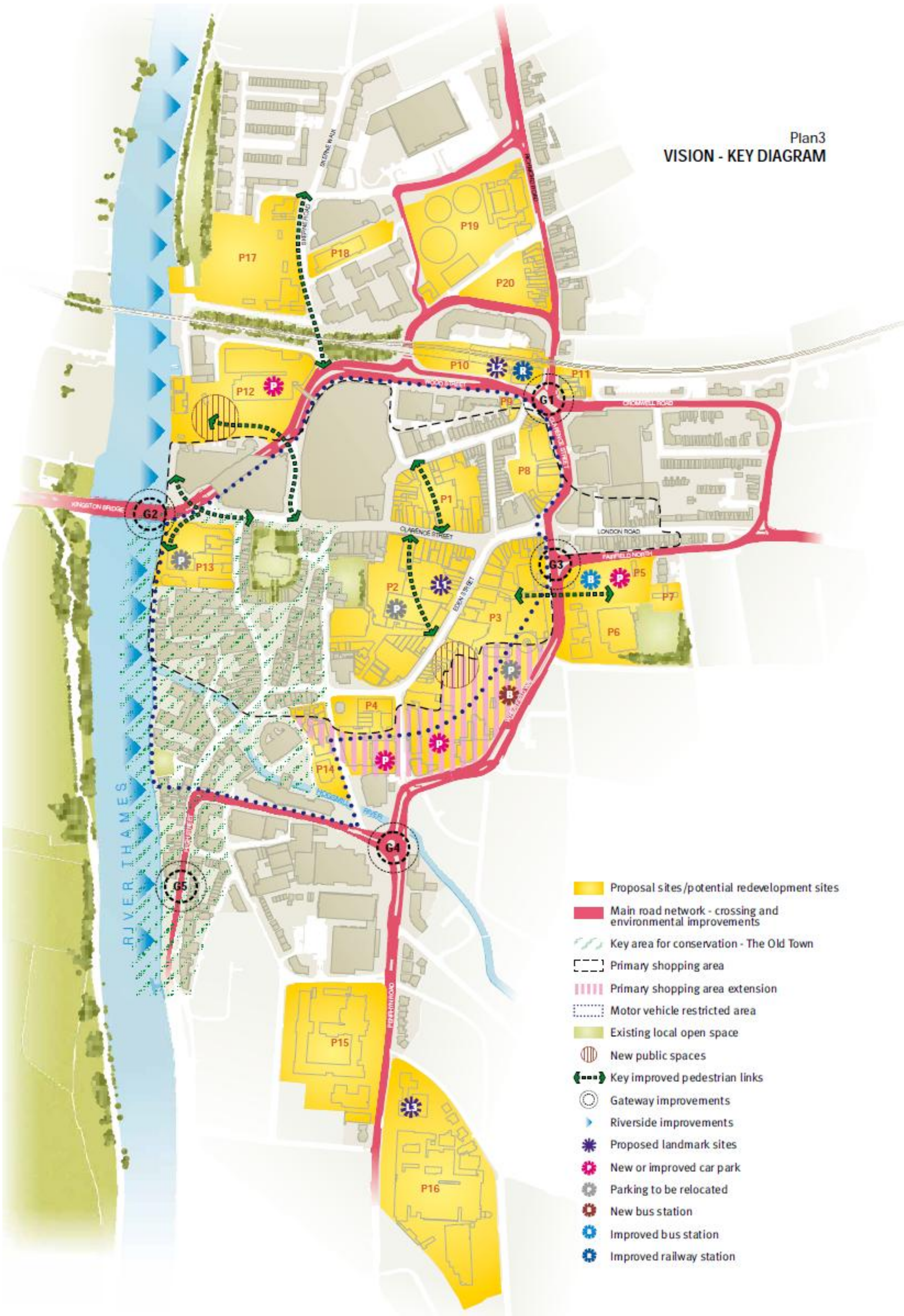


Figure 7: Kingston Town Centre Area Action Plan Vision diagram.

2.5 Kingston Infrastructure Delivery Plan

The Infrastructure Delivery Plan has been developed as part of the LDF to identify existing and planned infrastructure and assess the need for further infrastructure to meet the needs of the Borough with new development.

In relation to this study, it provides information on:

- Sustainable Energy networks (although it does not make recommendations due to the need to conduct an EMP study)
- Waste Management
- Water treatment
- The Hogsmill Valley open areas
- Healthcare

Further information on the last four items has been obtained with consultation.

2.6 Tolworth Regeneration Strategy

The Tolworth Area is dominated by Tolworth Tower which is a 1970 building 22 storeys tall and comprising commercial and retail space. This sits at the junction between the Tolworth Broadway (A240) and the main A3 into central London. The Tolworth Regeneration Strategy was developed to set a vision for improving and enhancing the area, and realising social, economic, and physical regeneration.

Figure 8 provides an overview of the strategy. Many of the proposals are based around the improvement and re-development of open and public spaces to improve biodiversity, reduce transportation impacts, and generally increase the amenity benefits to residents. Most significant of these are the Tolworth Broadway Greenway project which is currently under construction and is introducing new pedestrian and cycle routes along the Broadway and across the A3 to improve the Broadway for users, reduce the impact of cars, and improve access to open land to the South of the A3.

Of interest to this study, the strategy makes reference to the following sites:

- Tolworth Tower (Site 1). Reconfiguration and additional development
- Red Lion Public House (Site 2). Mixed use re-development including ground floor commercial and circa 50 flats. This is now under construction.
- Tolworth Hospital (Site 4). Some redevelopment.
- Former Government offices, Toby Jug PH, and Marshall House sites (Site 5). Redevelopment into mixed use comprising Tesco supermarket, hotel, and residential.
- 12 Kingston Road (Site 9). A 142 bedroom hotel and conference facilities.
- Jubilee Way / Kingston Road (Site 10). Indoor leisure facilities and potentially a hotel.

Apart from a planning application for the Tesco development (Site 5), and knowledge that the Red Lion PH site is under construction / completed, no further information has been obtained on the other sites, and there is no certainty over their delivery outside of the strategic vision.

Further discussion of these sites is provided in section 3.3.2.

Capabilities on project:
Building Engineering

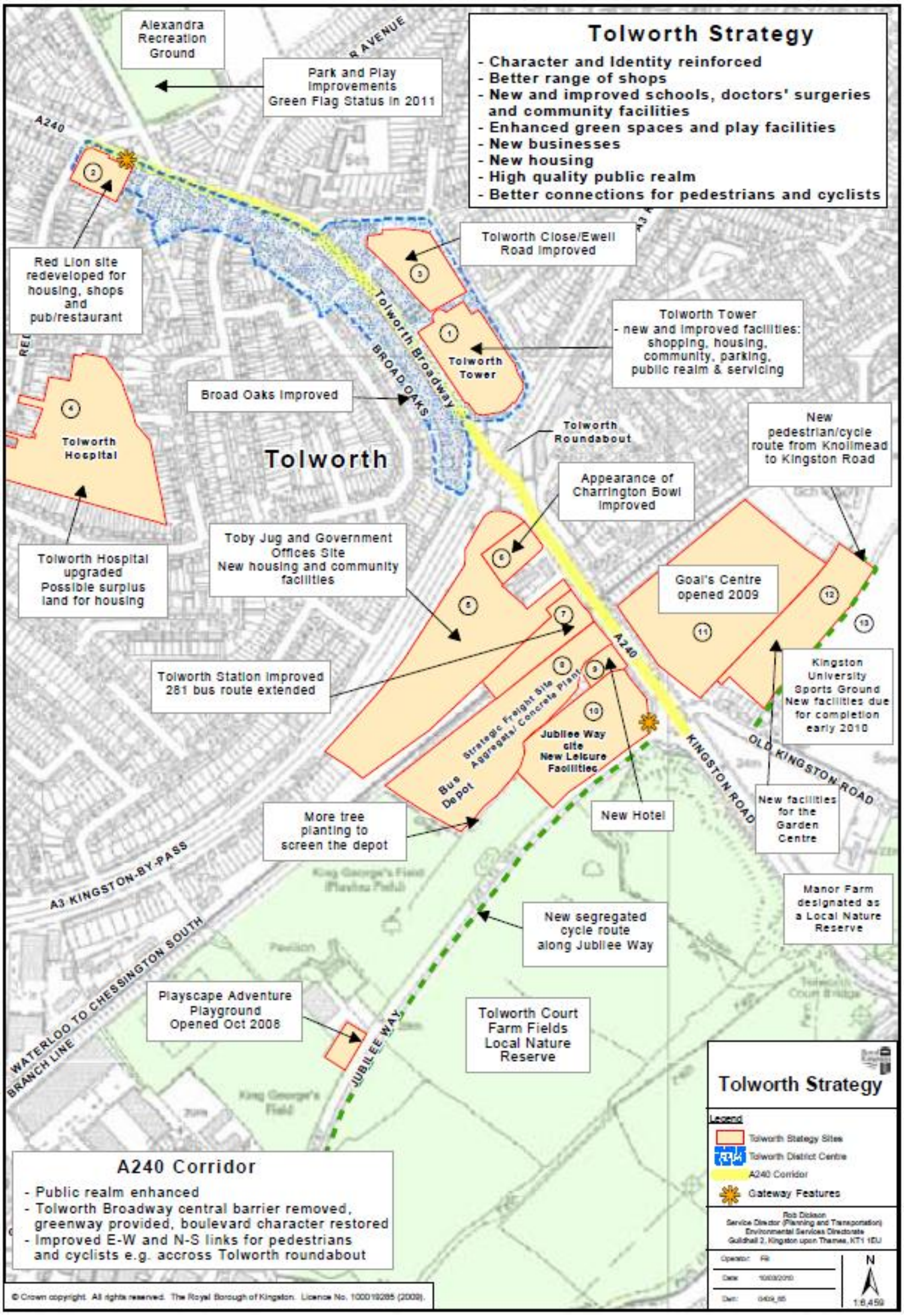


Figure 8: The Tolworth Strategy

2.7 Summary

This section provides an overview of existing work and potential sources of information which can inform the EMP. The most significant report and datasets are from the RBK heat mapping study which is being used as the basis for this EMP. This identifies the key loads, and proposes areas of interest for DE scheme development, mainly the KTC area. The datasets from the RBK study are assessed later in this study with updates and amendments where required.

The K+20AAP outlines a number of redevelopment opportunities and proposals in the KTC area. These may provide opportunities for connecting to a DE scheme, or opportunities for the development of an energy centre. Land is at a premium in Kingston and so important strategic decisions will need to be made for energy centre provision.

The Tolworth Regeneration strategy shows that whilst there are a number of opportunities in the area for redevelopment, these are relatively small, and in some cases dispersed. These are assessed later in this report.

Further information of relevance which has been obtained for the purpose of this EMP is described later in this report and Appendices.

3 Scoping assessment

3.1 Introduction

This section provides an overview of the opportunities and constraints present in the Borough. Using this information, some high level scheme concepts have been developed covering the potential for DE development across the Borough, the extent of early phase networks, and energy supply options. This analysis is used to inform the feasibility assessments set out later in this report.

3.2 Scoping assessment

The development of short-term, medium-term and long-term visions for DE within the Borough requires the consideration of a number of factors which will help inform the nature of schemes proposed. It is impossible to state, at the feasibility stage, how DE schemes will develop across the Borough over the next 40 years, or indeed whether any schemes will develop. Nevertheless it is possible to develop high level concepts from the assessment of a number of factors which influence the viability of schemes.

The scoping study of the opportunities and constraints, which enables the development of a framework against which the more detailed analysis and development of the EMP can take place, needs to consider:

- The size and type of potential customers including their energy demand characteristics, energy purchasing characteristics, and location within the Borough.
- Potential changes to the customers, including removal of existing customers and the creation of new customers, through development and regeneration.
- The presence of existing potential heating infrastructure, including DHNs and heat sources, and their location.
- Opportunities for routing DH pipework, with a view to identifying those routes which may be less disruptive and have a lower cost.
- The availability of land for an energy centre.
- The phasing of the network taking into account the size of the scheme and the period over which it will operate.

As outlined in the introduction, this EMP study is primarily examining opportunities for DE development in the Town Centre and Tolworth regeneration areas. However it also makes reference to a wider vision for DE in terms of future phasing.

3.3 Customers and sales

The size and types of customer can have a significant impact on the development of DE schemes. In general, ideal customers have a large heat load factor and large annual demand, have an existing heating system which is compatible for connection to a DHN, are willing to sign long-term heat supply contracts to purchase heat, and are in a location suitable for connection in an economic and technically viable manner. The mix of customers is also important and whilst the heat demand profile of any one building is not critical, the scheme will benefit from a diversity of demands which when combined will result in a more continuous requirement for heat throughout the day and throughout the year.

Private sector customers will usually require a commercial incentive for connection, based on an attractive heat tariff. They will also be less comfortable with long-term contracts, and the potentially transient nature of commercial organisations means that they can present a risk to the network if they move. In addition the relation between landlord and tenants needs considering: the landlord may make decisions over heating systems and sources, whilst the tenant pays the bills, therefore the incentive for lower cost energy does not act on the decision maker unless this improves the rental value of the property. Therefore the commercial sector is not ideally suited to the first phase of DHN scheme when future certainty over revenue is important.

Public sector and quasi-public sector organisations, such as local authorities and colleges, are more suited to connection in the early phases. They will generally take a less commercial approach, and whilst an attractive tariff will be important, they will probably accept a lower level of benefit compared with their baseline solution as they will also factor in the benefit of CO_2 savings. They will also be more willing to enter into long-term supply contracts, providing sufficient guarantees can be provided.

The longevity of public sector and quasi-public sector clients and their buildings also provides security for DHN development – in general organisations such as Councils, Universities, and Colleges retain buildings and sites over a long period of time.

3.3.1 Town Centre customers

The RBK Heat Mapping study identifies a number of clusters, with Clusters 1 – 4 and intermediate loadsmaking up the Town Centre area in the form of a ring (see Figure 9). The clusters can be characterised as follows:

- Cluster 1 covers the main retail centre. It is predominantly made up of large private retail consumers, in particular the Eden Walk shopping centre, Bentalls (and the neighbouring Bentalls shopping centre), the David Lloyd Gym, John Lewis, and Marks & Spencer. The study also identified some high heat demand residential units at Regents Court to the north of the area. To the south of Cluster 1 are the RBK Guildhall Offices (including blocks 1 and 2), and Kingston College. The cluster also includes a number of other smaller loads, predominantly private sector owned. clusters
- Cluster 2 lies south of Cluster 1, and primarily consists of County Hall, and two Kingston University sites (Penrhyn Road and Knights Park).
- Cluster 3 is to the east of Cluster 1 and contains mainly smaller loads, predominantly Bausch and Lomb House (UK headquarters) and Tiffin School.
- Cluster 4 lies to the east of the town centre ring and consists of RBK housing on the Cambridge Road Estate which has 600 social housing units.

The Town Centre ring presents a large number of potentially significant customers from both the private and public sector, and therefore potentially a good customer base for developing a DHN. However the majority of the large loads in Cluster 1 are privately owned existing retail units, and unless a very attractive commercial proposition could be provided with low cost heat, there will be significant challenges in ensuring these customers sign long-term purchase contracts. Furthermore, the RBK Heat Mapping study does not include detailed information on the nature of the existing heating systems, and in general, shopping centres such as Bentalls and Edenwalk have separate (usually electric) heating systems in each retail unit, with relatively little heating demand for the shopping centre communal areas. The retail element of Cluster 1 therefore suggests that the best potential lies in the RBK Guildhall Offices and Kingston College to the south, and potentially the David Lloyd Gym if a suitable heating system exists.

There is a large public sector and quasi-public sector concentration of loads to the south in Cluster 2, and the RBK housing at the Cambridge Road Estate in Cluster 4. The co-location of Cluster 2 to the Guildhall and College could provide a strong opportunity for early DHN development in the Penrhyn Road and Kingston Hall road area. Whilst the Cambridge Road Estate is further away, the addition of the residential heat load provided by 600 units could be beneficial to the scheme performance, providing summer DHW and evening space heating loads.

The other smaller loads identified in all clusters and outside the clusters are likely to be too small to significantly impact on the EMP, and therefore unlikely to influence the DHN layout. However if the existing heating system is connectable and located in a convenient area, other buildings may be suitable for connecting in Phase 1 or future phases.

In addition to the existing heat loads, a number of areas have been identified for future redevelopment in the town centre. These are primarily the Gas Works site to the north of Cluster 1, and the Eden Walk site to the south east of

Cluster 1. Whilst the exact nature of these two sites is uncertain, planning requirements could be used to encourage these to connect to a network where demonstrated to be viable.

Outside of the clusters and the main town centre area, low rise residential housing is the predominant land use.

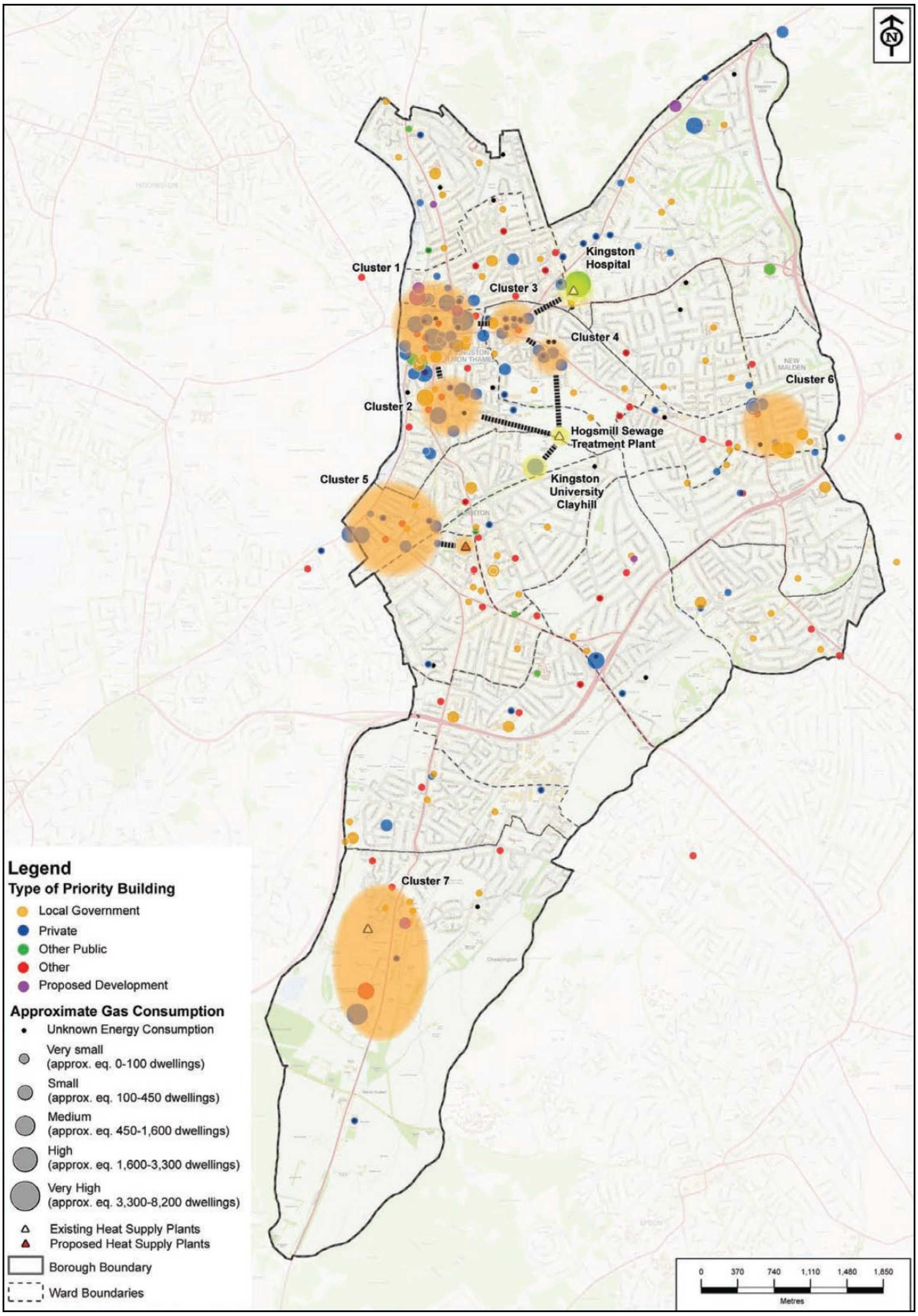


Figure 9: Map of the Borough showing the heat loads and clusters identified in the RBK Heat Mapping study. Source – RBK Heat Mapping Study

3.3.2 Tolworth customers

The Tolworth area is around 4 km to the south of the town centre and is divided by the A3 and A240 main roads (see Figure 8). Tolworth was not identified in the RBK Heat Mapping study as a cluster, neither does it appear to have potential from the London Heat Map, and has only one large energy consumer identified, Tolworth Tower. This is a 22-storey mixed use development comprising office space, retail, a hotel, and entertainment facilities. The surrounding area is predominantly low rise semi-detached and terraced housing, but there is also a small NHS hospital specialising in mental health owned by South West London and St George's Mental Health Trust.

The Tolworth area has been identified for inclusion in this EMP due to a number of re-development opportunities in the area and the need to invest here to attract new business. The re-development opportunities include (see section 2.6):

- The Tolworth Tower complex, to provide increased residential, commercial, retail, and entertainment facilities.
- Re-development of the former Government Offices, Toby Jug Public House (PH) and Marshall House site which sits to the south of Tolworth Tower on the other side of the A3 / A240 intersection. This will include a new 3400m^2 Tesco store, 275 flats and houses, a leisure centre, and hotel (hereafter referred to as the 'Tesco site').
- Re-development of the no. 12 Kingston Road site with a new hotel and associated facilities.
- Re-development of the Red Lion PH site with 50 flats and commercial and entertainment facilities.
- Re development of Jubilee Way for indoor leisure facilities
- Re-structuring of the A240 to provide a central green corridor and pedestrian and cycle links over the existing A3 roundabout.

With respect to the existing buildings, any potential for DE centres on Tolworth Tower due to the absence of other large heat demands at present. An extension of DE from Tolworth Tower will require DHNs to be developed in low density areas linking relatively small sites, and predominantly low rise housing. If DE in low rise residential areas becomes viable, this could provide a large potential for connection, but this is unlikely in the shorter term. Nevertheless, the scale of Tolworth Tower suggests a DE scheme could be developed solely for the building, justifying the development of a building scale CHP scheme. However this would not be a community project, but a commercially-led scheme by the Tower owners, Stevenor Investments.

The new development sites may increase the opportunity for DE development, in particular the Tesco site and the hotel, and leisure centre. However at present no information is available on when and if the hotel and leisure centre will be delivered, and whilst they are adjacent to each other, they are distant from the Tower. The Tesco site development proposals already include a site-wide DHN and gas-fired CHP system (300kW) which has been sized for meeting the baseload heating demands[7]. There is therefore little benefit in linking a scheme at Tolworth Tower to the Tesco site, and the Tesco site system will be significantly smaller than would be needed to justify a connection to Tolworth Tower. The opportunity provided by the Tesco site is therefore perhaps a future opportunity with a link at a later date, should a DE scheme be developed in the vicinity, potentially as part of a wider scheme from outside of Tolworth.

The other sites identified in the Tolworth Regeneration strategy are all small in scale and too distant from the Tower area to justify connection to a scheme, unless a scheme is developed which is viable in low density areas in the future.

Overall the potential in the Tolworth area appears extremely limited with any scheme being based around the two key sites of Tesco's, and Tolworth Tower, but with seemingly little benefit to each for connecting these sites together with a DH network. Other sites are either too small, or uncertain/unknown to be viable for connection.

[7] Hook Rise, South Tolworth. Environmental Sustainability Statement: Appendix 4 Energy Statement. URS for Tesco Stores LTD. 2012.

3.3.3 Identification of customers through mapping

In addition to the use of existing mapping from the RBK Heat Mapping study and the London Heat Map, AECOM have conducted some additional mapping to inform this EMP. Using GIS datasets from national statistics, the following attributes have been mapped across the Borough:

- Dwelling density. Using national statistics dataset "Dwellings, Household Spaces and Accommodation Type (KS401EW)", the density of dwellings at Output Area level has been mapped. The density of dwellings can be used as a proxy for DHN suitability, with high density areas showing where DHNs are likely to be mode viable. (see Figure 10)
- Percentage of flats. Using national statistics dataset "Dwellings, Household Spaces and Accommodation Type (KS401EW)", the percentage of flats within each Output Area level has been mapped. As with dwelling density, this can be used as a proxy to identify areas where a DHN may be more viable. (see Figure 11)
- Percentage of social rented dwellings. Using national statistics dataset "Tenure (KS402EW)", the percentage of dwellings in each Output Area which are social rented has been mapped. This can help identify areas where higher uptake of connections to a DHN could be achieved through a small number of landlords. (see Figure 12).

The mapping as expected closely mirrors the London Heat Map (which will also make use of these datasets). However it provides a clear and transparent set of metrics which can be used to help identify the potential opportunities for developing DHNs.

In all of the maps, the Cambridge Road estate is apparent with a high density, large number of flats and high levels of social rented tenure (all in RBKs ownership). However other areas can also be observed which may be of interest to future phases of a network including:

- Flats located to the north of the Borough on Kingston Hill, at Kingsnympton Part Estate showing high density and moderately high levels of social rented tenure. These may be of interest if the hospital becomes part of a wider scheme or if excess heat is available at the hospital for a smaller localised network.
- Parts of Surbiton (including one area with very high social rented tenure around School Lane off Red Lion Road).
- Part of New Malden at Newhouse Close (although with low levels of social rented tenure).

Capabilities on project:
Building Engineering

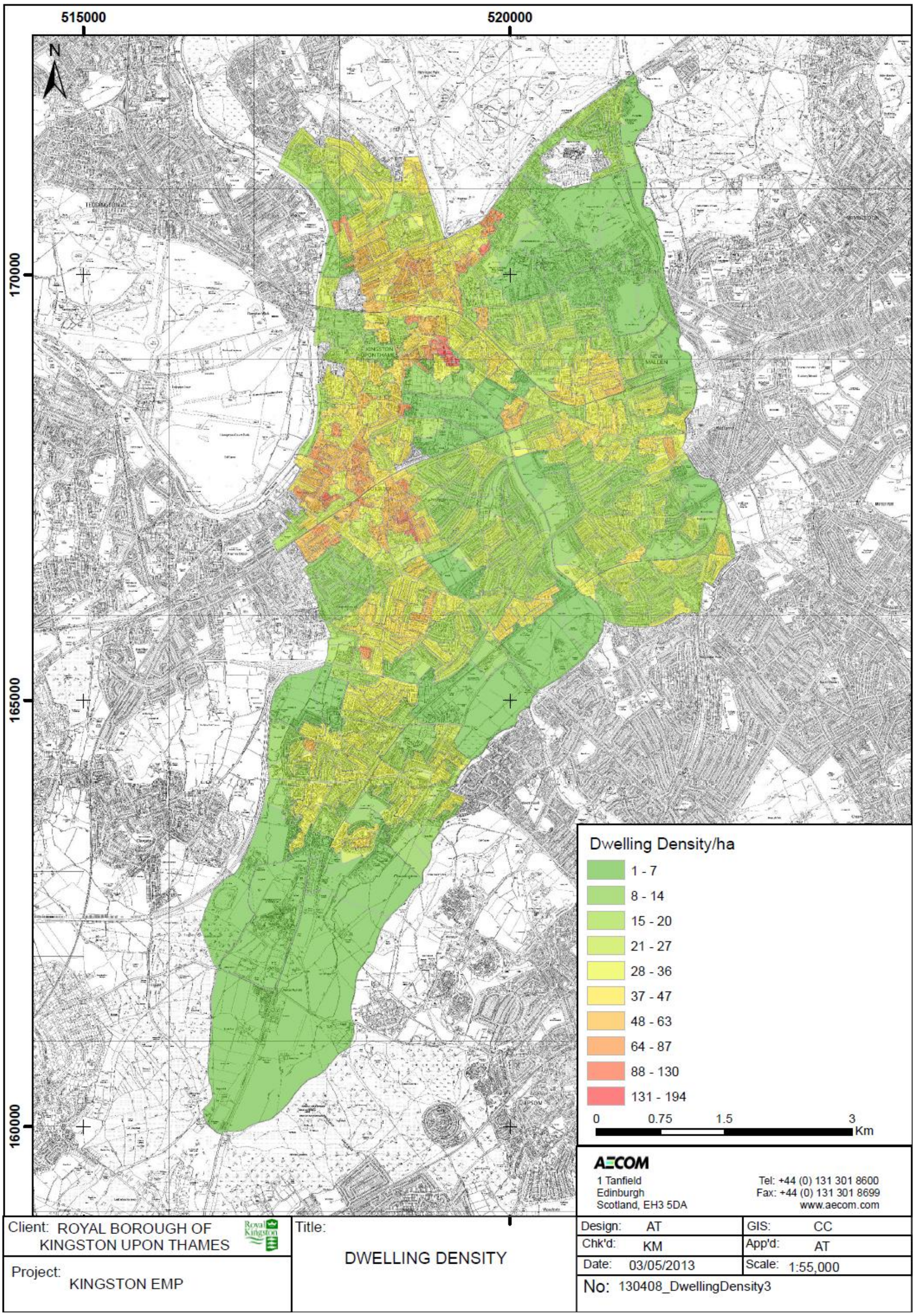


Figure 10: Density of dwellings

Capabilities on project:
Building Engineering

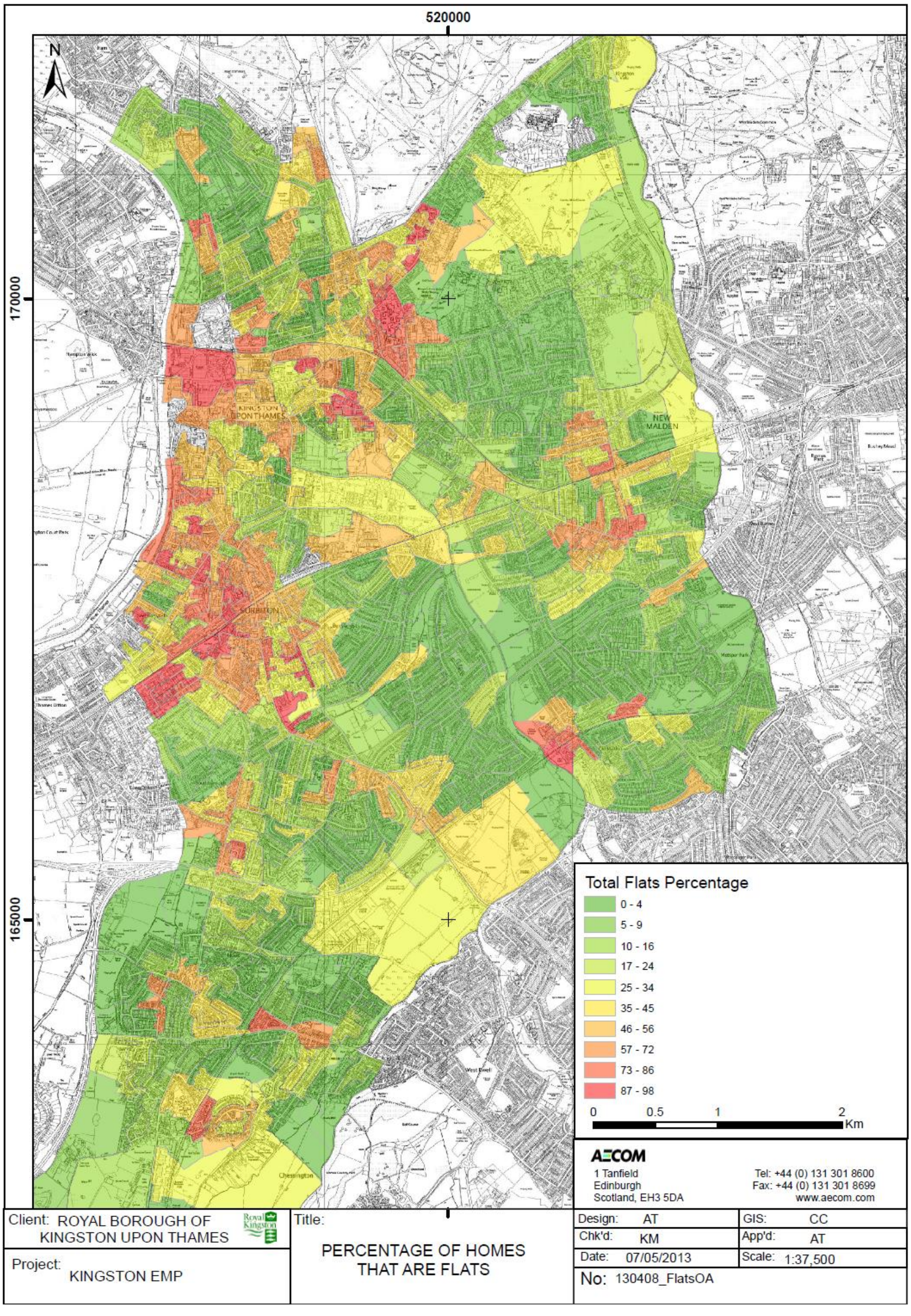


Figure 11: Percentage of flats per output area

Capabilities on project:
Building Engineering

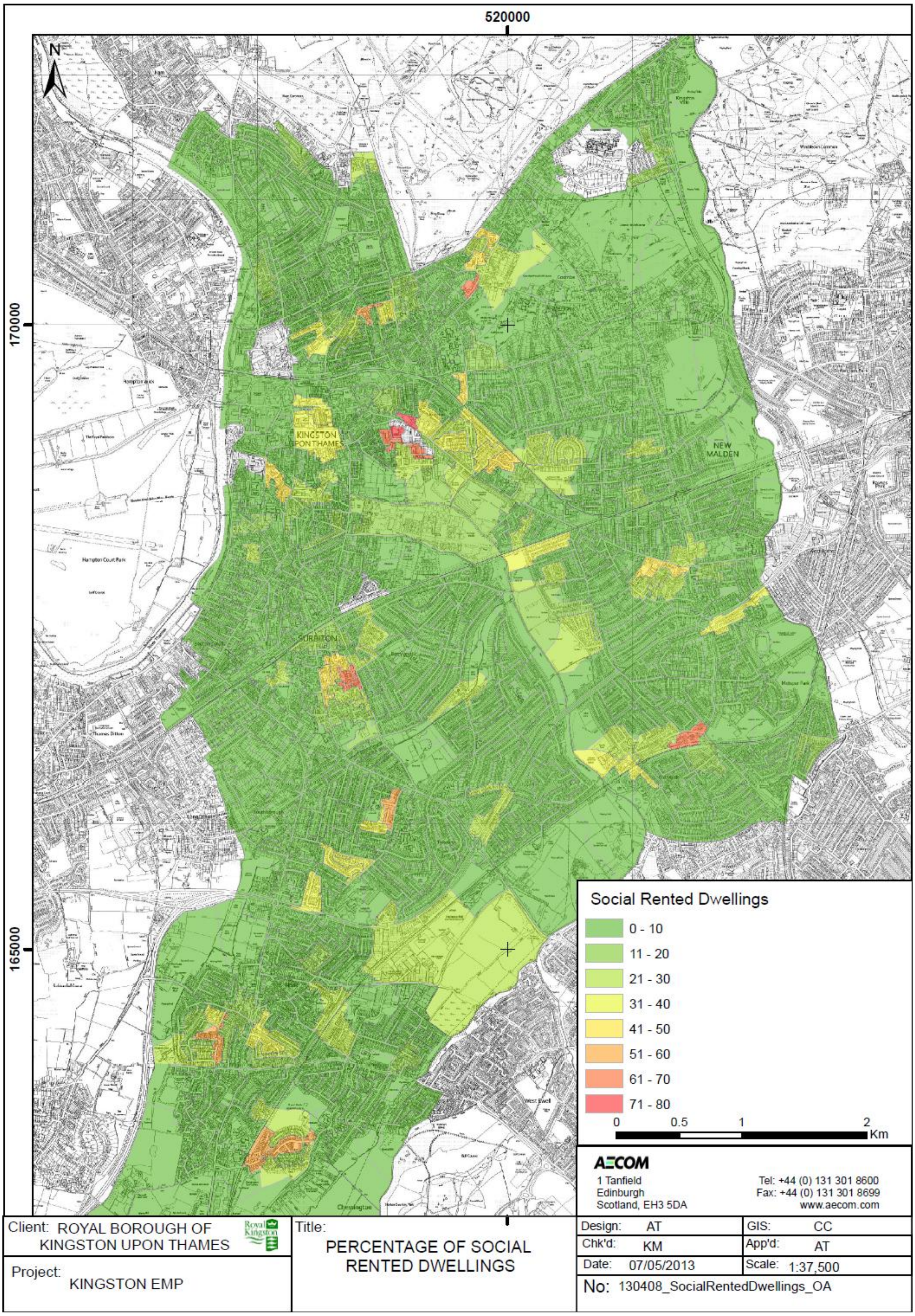


Figure 12: Percentage of social rented dwellings per output area

3.4 Network layout options

DHNs require suitable routes to be found to install the pipework. Installation of pipes and associated equipment is expensive and disruptive and therefore the routing needs to be carefully considered to ensure the network is as efficient as possible; the largest amount of heat needs to be sold over the shortest length of pipework.

Key considerations for the network routing include:

- The use of existing 'corridors' such as roads and pathways where public ownership enables development.
- The use of soft landscaped areas such as verges and parkland to reduce civil engineering works and disruption to transport routes.
- The use of existing utilities infrastructure such as service tunnels.
- Making use of above-ground routing where practical. This could be achieved in more industrial areas, or when pipes can be installed within buildings, such as within blocks of flats, basement car parks etc
- Integration of DHN pipework installation with other utilities works to prevent additional digging and associated disruption and cost.

Alongside the opportunities, some key constraints need to be considered:

- Strategic transport routes and intersections where the installation of DHN pipes may cause significant disruption.
- Natural barriers such as rivers, where the network would need to make use of an existing crossing point.
- Railway lines which would require the involvement of Network Rail or Transport for London (TfL), and the associated time delays and costs of crossing or tunnelling under tracks.
- Existing major utilities infrastructure which may prevent pipework being installed. In general major infrastructure elements, such as sewers, are sufficiently deep to not be a problem.
- Land ownership. When DHN pipes are routed through private land, agreements will be required with the landowners, and easements needed for future maintenance and repairs.

At the stage of detailed design for DHNs, the location and routing of existing utilities infrastructure needs to be considered, and this may impose some constraints on the exact routing of the network. However the mapping of utilities within roads is of limited accuracy and completeness and their position can only be reliably ascertained through survey work and extensive examination of available maps. In this EMP, therefore, existing utilities are not considered as a specific constraint and would need to be considered at design stage.

3.4.1 Town centre network considerations

The town centre of Kingston is largely pedestrianised in the retail areas, with plans for further changes outlined in the Area Action Plan - K+20 AAP. Using pedestrian routes may result in lower installation costs through a reduction in the requirement for traffic management and extensive civil engineering works, but it may cause disruption to retail activities and may attract cost penalties for loss of income. The routing of a DHN to large retail units will need to consider the installed HVAC plant, which is most likely to be located adjacent to delivery access routes. Therefore pedestrian routes are unlikely to present a significant opportunity. Parts of the town centre are due for renewal of the surfacing with new granite setts being installed. Therefore any future network installation in these areas should aim to minimise disruption to these new surfaces, making use of other utilities works as an opportunity, and exploring alternative routes.

Around the town centre, the A308 and A307 ring road effectively cuts off the central retail area, and therefore any DE scheme extending into the main retail centre (including the Guildhall complex) will need to be installed in, or across, these busy major routes.

To the south of the town centre, in cluster 2 (see Figure 9) Penrhyn Road offers the most obvious route, linking the Guildhall complex with the College, County Hall, and Penrhyn Road University site. However, alternative minor roads may also be used through residential areas which would limit disruption to traffic on the major routes. These routes may even be more efficient from a network layout perspective, but may also limit the long term development and expansion capacity of the network, as well as causing disruption to residents. Figure 13 shows these southern town centre locations.

Sites to the north of Cluster 1 will need to consider how to cross the railway around Kingston Station. The road crossings all pass under the railway through bridges and so crossing the railway may not be a major constraint. However any infrastructure works close to the foundations of railway bridges require the collaboration of Network Rail and these routes may be already congested with existing infrastructure. An alternative option could be to route a network under or over the railway as part of future railway upgrades. The complexities of crossing the railway may mean this is only considered as part of a strategic DHN route, not simply to connect to a small number of customers as part of a first phase.

Opportunities for making the railway crossing in combination with other works may include:

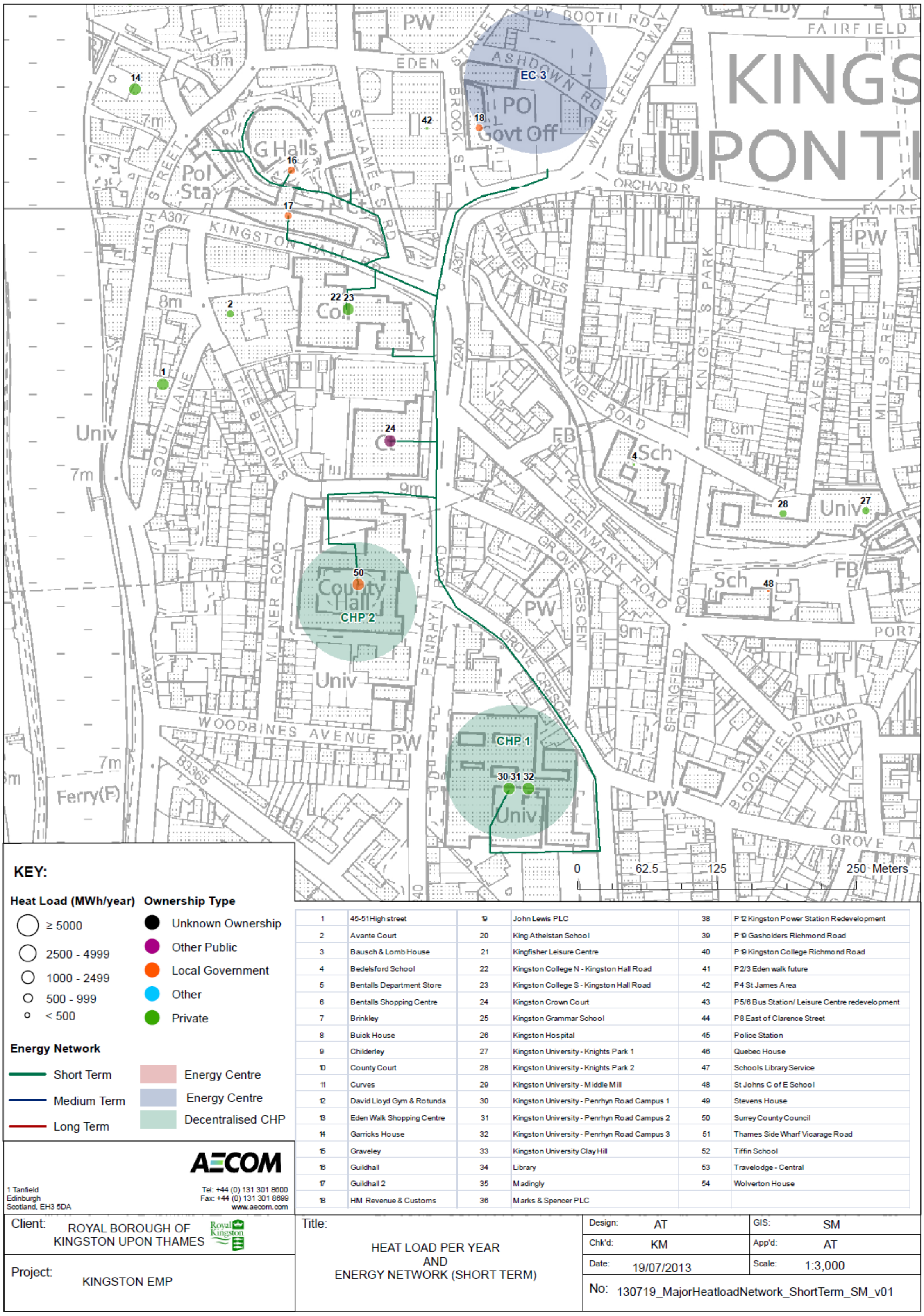
- Re-development of the railway station area. Whilst this area is identified in the K+20AAP as an area for re-development, no further information is available. However it is believed that any re-development options may include for improved links across the railway and therefore provide an opportunity for network installation.
- The section of road outside the station where Wood Street meets Clarence Street has been identified for future re-configuration to improve cycle and walking links to the station. RBK is currently developing a number of options for this area as part of a submission of cycle network improvements to support the London Mayors Cycle Vision. It is understood that this may include the lowering of the existing road carriageways such that cycle and pedestrian access remains at grade, and vehicular traffic lowered. If this scheme comes to fruition, it will require significant infrastructure reconfiguration in the area and may provide an opportunity for identifying DHN pipe installation corridors, and if timely, installation of the DHN pipes.

To the east of the town centre lie Clusters 3 and 4, with the latter area presenting the opportunity of connecting a heat supply to the Cambridge Road Housing Estate. A number of possible routes exist including the main A307 and A308, or a more minor route along Fairfield Street and Hawkes Road which includes the potential for routing of pipes in green landscaped areas which may reduce cost..

A further opportunity for a network route is the Hogsmill River. Sections of this are densely developed leaving little riverside space, but further away from the town centre near the Hogsmill Sewage Treatment Works (STW), the river opens out with green space which may be suitable for routing the DHN. This could be useful if the Hogsmill STW site is considered to host an energy centre (see below), by providing a less congested network route into the town centre. A possible layout is shown in Figure 14 below.

The following schematics in Figure 13 and Figure 14 show indicative network routes for a first phase, and long term scheme (further details are provided later in this report). It should be noted that for the purposes of this EMP, indicative network routs have been selected based on the high level constraints identified, and in the case of Phase 1, site visits examining potential connection points. As an example, the network route connecting the Guildhall and Guildhall 2 is relatively inefficient, but takes into account existing plant location, and the river Hogsmill. It is expected that a more detailed feasibility study will optimise these connections and layouts.

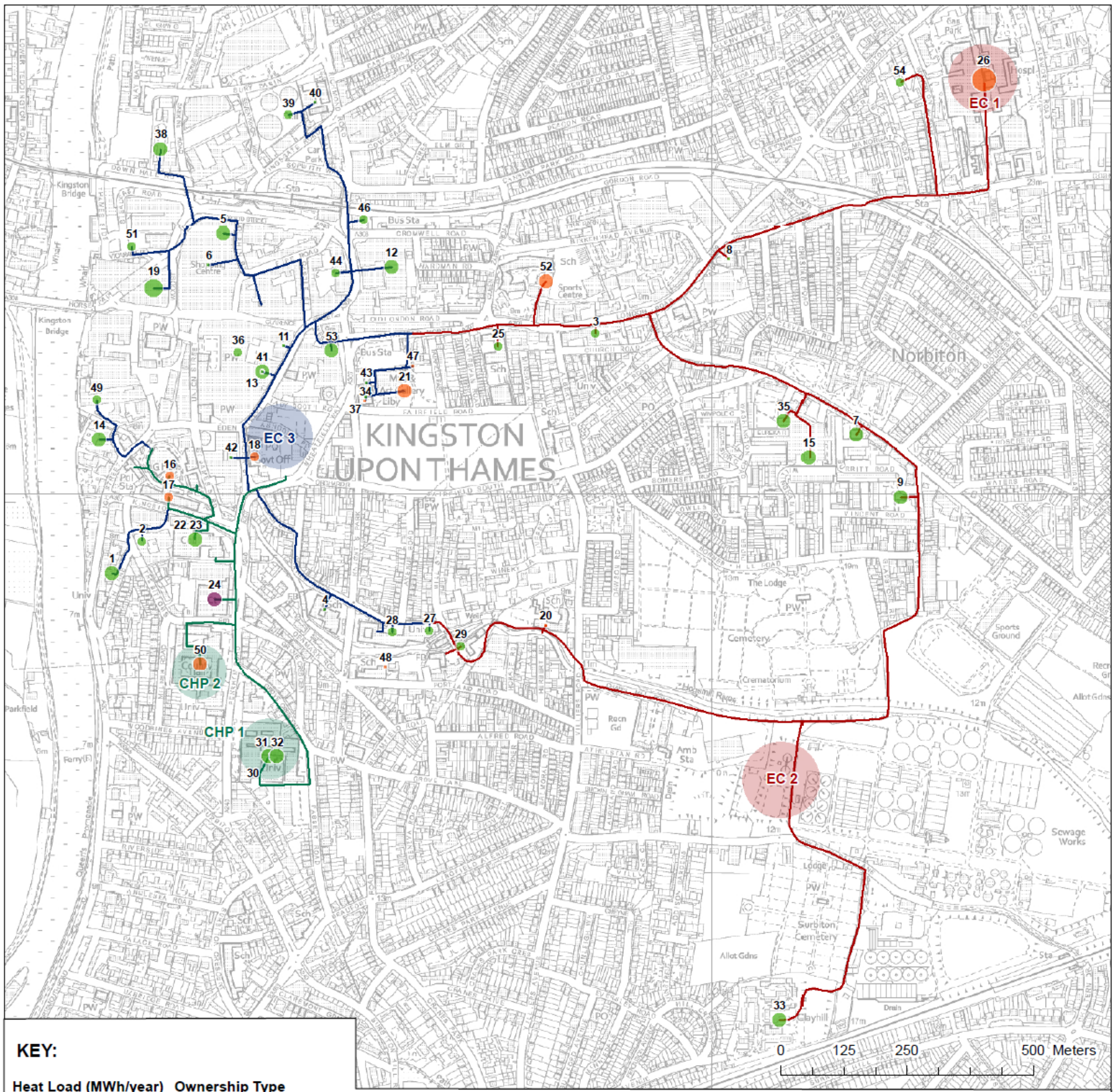
Capabilities on project:
Building Engineering



1	45-51High street	19	John Lewis PLC	38	P 12 Kingston Power Station Redevelopment
2	Avante Court	20	King Athelstan School	39	P 19 Gasholders Richmond Road
3	Bausch & Lomb House	21	Kingfisher Leisure Centre	40	P 19 Kingston College Richmond Road
4	Bedelsford School	22	Kingston College N - Kingston Hall Road	41	P 2/3 Eden walk future
5	Bentalls Department Store	23	Kingston College S - Kingston Hall Road	42	P 4 St James Area
6	Bentalls Shopping Centre	24	Kingston Crown Court	43	P 5/6 Bus Station/ Leisure Centre redevelopment
7	Brinkley	25	Kingston Grammar School	44	P 8 East of Clarence Street
8	Buick House	26	Kingston Hospital	45	Police Station
9	Childerley	27	Kingston University - Knights Park 1	46	Quebec House
10	County Court	28	Kingston University - Knights Park 2	47	Schools Library Service
11	Curves	29	Kingston University - Middle Mill	48	St Johns C of E School
12	David Lloyd Gym & Rotunda	30	Kingston University - Penrhyn Road Campus 1	49	Stevens House
13	Eden Walk Shopping Centre	31	Kingston University - Penrhyn Road Campus 2	50	Surrey County Council
14	Garricks House	32	Kingston University - Penrhyn Road Campus 3	51	Thames Side Wharf Vicarage Road
15	Graveley	33	Kingston University Clay Hill	52	Tiffin School
16	Guildhall	34	Library	53	Travelodge - Central
17	Guildhall 2	35	Madingly	54	Wolverton House
18	HM Revenue & Customs	36	Marks & Spencer PLC		

Figure 13: Map showing southern town centre locations.

Capabilities on project:
Building Engineering



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Client: ROYAL BOROUGH OF KINGSTON UPON THAMES

Project: KINGSTON EMP

Title: HEAT LOAD PER YEAR AND ENERGY NETWORK

Design: AT | GIS: SM
Chk'd: KM | App'd: AT
Date: 19/07/2013 | Scale: 1:8,000
No: 130719_MajorHeatloadNetwork_SM_v01

Figure 14: Map showing large scale Kingston Town Centre DHN

3.4.2 Tolworth network considerations

The potential customers and sites identified in Tolworth lie along the A240 dual carriageway which crosses the A3 on a bridged roundabout. This is therefore the obvious route for a DHN, and it is the only crossing of the A3 which would not require civil engineering works across the A3 carriageway itself (see Figure 8). .

The Tolworth Greenway, a scheme to improve public space, has recently commenced construction. This project aims to improve walking and cycling access to Tolworth along the A240, providing new public spaces, a more attractive retail frontage, and reducing the impact of vehicles. The works required to achieve this could have provided an opportunity for safeguarding network routes but the timescales of the EMP and the Greenway works are not compatible. However a legacy of the Greenway project will be improved routes across the A3 for pedestrians and cycles and this may provide a future opportunity for routing the DHN away from the main carriageways. However the routing of a DHN across the A3 using a bridge is likely to incur additional cost.

Outside of the immediate Tolworth Tower area, the roads are predominantly residential, serving 1930s housing. In some areas, small strips of grass verge are present, but the majority of routes would require any DHN to be located in the road.

Apart from the small mental health hospital, there are no other identified heating loads nearby. Connecting a network from Tolworth to other areas would necessitate either long transmission mains to other parts of the Borough, or expansion to supply existing residential areas and low density commercial buildings.

Overall, the potential for development of DHNs in the Tolworth area appears extremely limited due to the location and nature of the identified heat loads, and limited scope for expansion. A greater potential may lie in the Tolworth area becoming part of a wider network, if and when this becomes viable.

3.5 Technology options and potential energy centre locations

3.5.1 Existing technology options

The RBK Heat Mapping study identifies two potential energy sources which may be used as part of a DE scheme:

1. Kingston Hospital. This lies to the north east of the town centre cluster (Cluster 1), around 2km from the retail centre (see Figure 9). The hospital has recently upgraded its energy systems to include a new 1.4MWe gas-fired CHP system and hot water and chilled water distribution systems[8]. The hospital is the largest energy user in the Borough according to the RBK Heat Mapping report, hence the report's suggestion that it may also be a major energy provider. However given the recent development of the CHP and heat network on the site, it is likely that the engines are optimally sized, thus limiting or even preventing excess heat production. The potential for connection may therefore be extremely limited unless additional plant was located at the hospital site.
2. Hogsmill Sewage Treatment Works (STW). The STW in the Hogsmill Valley is operated by Thames Water. It incorporates a 0.94MWe gas-fired engine CHP operating from biogas sourced from the STW. In general, the energy (electricity and heat) produced by CHP at such a plant is used entirely on site, to power the STW and maintain temperature in the digester units. Sometimes additional heat may also be required. Therefore it is not considered that the STW will have a great potential for high grade heat provision. However there may be potential for accessing secondary heat using a heat pump (see section 4.3.2) .

These potential heat supply sources are discussed in more detail in Section 4.

3.5.2 Standalone technology options – short term

Whilst the DE scheme concept from the outset should consider the long term vision, short term (typically up to 15 years) technologies will be required which can supply heat to early phases of a DE scheme. The scheme may start as a relatively small network which can then be expanded over a period of years. An energy centre located close to the network it serves is typically the best option, as long transmission mains for more distant energy centres have a detrimental impact on the economics (except for very large schemes).

The supply technologies will need to meet the following requirements:

- They are currently commercially available and reasonably mature to provide a low risk initial investment.
- They are capable of providing CO_2 savings in the current UK energy mix (typified by a relatively high grid electricity CO_2 factor)
- They can operate economically when connected to the DHN such that the entire DE scheme is deemed economically attractive for investment, allowing customer benefits.
- They can operate at the scale of a DE scheme envisaged for an early phase network and meet the energy demands posed by the scheme. Modularity may also be important in the build out of a first phase.
- They can meet planning constraints imposed by a town centre location, including for example air quality, noise, visual impact, etc.
- They can be hosted on land which is available in a first phase network.

A range of systems are available which may meet these requirements, but the most mature technology, and potentially the lowest risk and most reliable technology is natural gas-fired CHP. This is compact, flexible, available in a range of suitable sizes, and suited to modular operation on phased networks. Other variations around gas-fired CHP may also be suitable including bio-gas sources, gasification, and pyrolysis. However, each of these is less mature, potentially more unreliable in terms of fuel supply and processing, and potentially less economic in the absence of incentives.

[8] http://carbonandenergyfund.net/content.php?page=kingston_hospital (downloaded 22/03/13) and consultation with the Hospital.

Biomass-supplied energy sources are often viewed as a suitable technology for providing heat for DE schemes and delivering large CO_2 reductions, and potentially economic operation with the Renewable Heat Incentive (RHI). However the availability of a reliable supply of biomass fuel at an economic price needs to be considered, alongside the impacts on local air quality and transportation impacts.

The availability and price is of biomass somewhat determined by whether an operator can secure a long-term supply contract. There is a risk that with future increasing demands for the fuel the fuel price will significantly increase as total biomass resource is limited. Long-term supply contracts may be available but it is unlikely to fully offset price risks.Furthermore air quality and transportation issues are inherent problems in an urban environment and the issue of pollutants is recognided in the Mayor's Air Quality Strategy[9].

Technology options for the short term are examined in detail in Section 4.

3.5.3 Standalone technology options – long term

The selection of technologies for the longer term (typically 20 years or more in the future) is inherently uncertain and will depend on a number of variables.

Firstly the evolution of the DE scheme needs to be considered, and technology options will need to be selected that can meet the energy demands of the mature scheme. The network may increase in size, and therefore have a higher heat demand and baseload. A future technology option could be used to replace existing modular plant, or even a number of existing energy centres which have been constructed in line with phased extensions to the DHN. The step change increase in energy loads provided by mature schemes or aggregation of existing plant may open opportunities for using types of heat generation plant which are not available or viable for smaller schemes. Alternatively the increase in size may mean that more than one energy centre and more than one technology type is deployed to provide heat into the system. The increase in network extent may also open up new opportunities for locating an energy centre, and could potentially justify a longer transmission mains from the energy centre to the DHN.

Secondly, external factors need to be considered which may influence technology and fuel selection. These include market conditions for fuel, maturity and development of technology, and the CO_2 intensity of the electricity grid. This intensity effectively determines the CO_2 savings from CHP and heat pump based DE schemes. There is uncertainty around all of these variables and projections are required which present reasonable cases, with the possibility to examine sensitivities around these.

The CO_2 intensity of the electricity grid in particular is important to consider and there are complexities in how this is dealt with. At the simplistic level:

- In the short term (mid to late 2020s) it is expected that electricity generation will continue to be heavily dominated by fossil fuels and have a relatively high CO_2 intensity. Therefore technologies which generate electricity alongside heat (CHP) can provide large CO_2 savings, even when powered by fossil fuels such as natural gas.
- In the longer term, it is expected that the grid will have decarbonised significantly with extensive uptake of renewable technologies, nuclear power, and potentially carbon capture and storage (CCS). If the CO_2 intensity is sufficiently low, then an electricity-sourced technology (such as a large heat pump) could be most suitable.

The transition period during which the grid will decarbonise has a large number of uncertainties. In addition, an assessment should also consider not only the average grid CO_2 intensity, but the marginal CO_2 intensity - this is the

[9] Cleaning the Air: The Mayor's Air Quality Strategy. 2010. It should be noted that whilst there are concerns over biomass use in London, the Air Quality Strategy suggests measures by which this can be mitigated. The strategy also suggests that emissions from gas fired CHP systems also need to be carefully considered.

intensity of electricity generation based on the marginal technology[10]. The marginal plant will typically vary between night and day, the seasons and the strength of the wind.

Current DECC projections suggest that non-CCS gas CCGT generation (combined cycle gas turbine) may remain in operation until at least 2050 to provide peak electricity generation[11]. Therefore gas-engine CHP schemes operating at peak times are likely to be offsetting electricity with a gas CCGT emissions factor even in the long-term, and thus reduce CO_2 emissions.

Given these uncertainties, there are a number of options for future technologies:

- The use of larger systems suited to aggregated heat demands. This step change may open up a range of new technologies not suited to smaller early phases.
- The use of electricity driven technologies, alongside CHP-based systems.
- The use of technologies which make use of alternative feedstocks such as biomass and waste.
- The use of a mix of different technology types assuming that a number of heat suppliers are connected to the network which can operate in response to the marginal generating plant on the electricity system
- The use of thermal storage to optimise the contribution from a range of heat sources

Technology options for the long term are examined in detail in Section 4.

3.5.4 Land availability for an energy centre

For the EMP, it is necessary to consider the availability of land in Kingston for an energy centre from the outset. The area of land required will depend on the size of the scheme and the type of technology selected. The location will be determined by land availability and the need for a site which can be economically connected to the DHN, and it will need to be in an area deemed acceptable for the development of an energy centre.

The Borough is a heavily urbanised area, with open undeveloped space at a premium and heavily protected against development. The borough is also relatively affluent, and there are no areas within the town centre which could be classed as low-value or vacant and which provide an obvious site. It is therefore likely that any site suitable for an energy centre will need to be a re-developed area and it is necessary to consider the short term and longer term uses of available sites.

In the early phases of development, the DE schemes will be relatively small (with a total length of circa 1 – 2 km), potentially with temporary or phased heat generating plant. The likely size of the schemes will mean that long transmission pipe runs from an energy centre are probably uneconomic, requiring the energy centre to be located close to, or within, the DHN. For the Kingston town centre network, this means potentially a town centre location. The selection of land will therefore need to consider the availability of areas for development, competing uses (and the implied cost of the land driven by these competing uses), the planning impacts of a town centre location, and the longer term aspiration for the sites. It is possible that an interim energy centre on a town centre site with a life of say 20 years is acceptable if a longer term location is available to allow further development of the original site for other uses.

The Hogsmill Sewage Treatment Works (STW) site and surrounding area may provide an opportunity for locating an energy centre. This area appears to have spare land (both within the Thames Water site, and the wider RBK owned area), and it is not suited to other forms of residential of commercial development. However the distance between the Hogsmill STW site to the town centre needs to be considered, as it is approximately 1.2km.

In the longer term, additional energy centre locations, or a larger single location, will need to be found to allow for expansion of the DH scheme. The timescales may mean that future opportunities arise as land becomes available for redevelopment and policies can be put in place which allocate and prioritise land for energy centre development.

[10] The short-term marginal technology is the technology which needs to be utilised to produce additional electricity at times of higher demand. The long-term marginal technologies are the ones which may or may not need to be constructed and drawn up, depending on the level of demand and the baseload, fluctuating and stored energy supplies.
[11] Gas Generation Strategy. DECC. 2012.

Opportunities should also be identified for other sources of heat supply, for example locating future energy-from-waste (EfW) schemes where they can connect to an existing heat network.

3.6 Phasing of DH networks

Many aspects of the phasing of DE schemes have been discussed in the previous sections. In relation to the DHN specifically, the following phases can be defined:

- Early phases (the first 10 years). The networks will be developed at a reasonably small scale of a few buildings representing the main or anchor energy consumers. This means that the initial customer base can be established to get the scheme running and de-risked, potentially with a large public sector take up. For the Kingston town centre scheme, the discussion of potential customers suggests a Phase 1 scheme may comprise the RBK Guildhall, Kingston College, County Hall, and Kingston University sites (Penrhyn Road and Knights Park). Other sites such as the Cambridge Road Estate and major town centre retail / commercial loads may also connect if viable.
- Expansion phases (10 – 20 years). Once the initial network has been established, and the performance and costs firmly understood, then the scheme could expand with a combination of two methods:
    - i. Further expansion of the network to distant major loads. For the town centre network, this may include commercial loads to the north and east of the town centre, including potentially the hospital.
    - ii. Infilling existing network locations with new customers. If new customers can be identified within the extent of the initial network (which may have been deemed unviable or risky in the early phases), then they could be connected and reinforce the existing demand. New customers may also be in the form of new development or refurbishments, supported by local planning policy.
- Maturity phase (20 years and beyond). As the network matures, it is possible that the extent and level of infilling will increase until it becomes the main heat supplier in an area. A step change will occur when, and if, the network can viably connect to small commercial premises, and individual dwellings, particularly in the private sector. During this phase, it is possible that individual schemes may also connect, leading to Borough-wide and even London-wide networks.

3.7 Potential for cooling networks

Cooling demand can help to diversify the heat demand profiles of an energy network, by providing a use for heat from CHP engines in the summer period in absorption chillers. This is known as Combined Cooling, Heat, and Power (CCHP) or Trigeneration. Cooling can be provided using two basic configurations:

- Locating absorption chillers at the site of buildings with a cooling demand. The absorption chiller takes heat from the DHN and uses this to drive the chiller. The benefit of this is that only a DHN is required and no additional cooling network. The disadvantage is that the absorption chillers are not centralised, and smaller chillers are generally more expensive and less efficient than larger chillers.
- Using centralised chillers and a cooling network. The cooling capacity can be centralised using a large absorption chiller located at the energy centre. Coolth in the form of cold water can then be circulated to buildings in a separate network. Cooling networks are less expensive than DH networks due to the use of simple plastic pipes – the low surrounding temperature of the ground means that insulation is not necessary due to the small ΔT between the chilled water and the ground. The advantage of this method is the use of larger, more cost effective, and more efficient centralised chillers. The disadvantage is that a separate network is required, which despite being relatively simple, still requires civils works and associated costs.

Assessing cooling demand at a masterplan scale is not practically possible. In general all buildings have a heating demand, and this is most often met by gas. Whilst gas is used for other purposes (for example cooking), this is generally negligible, and therefore gas consumption for commercial and residential buildings can be used as a proxy for heat demand. Cooling on the other hand is not required in all buildings, and the efficient design of buildings can help to reduce or eliminate its use. Cooling is generally provided via electric chillers, and often not sub metered.

Therefore it can be impossible to determine a buildings cooling demand without in-depth analysis. .Therefore developing robust assumptions for cooling demand is not possible at a high level.

Whilst cooling via absorption chillers can be perceived as a benefit (making use of CHP capacity in the summer months), the benefits in practice can be minimal in terms of cost and CO_2 savings. Under current grid electricity conditions, an efficient electrically driven chiller can provide coolth with lower CO_2 emissions than by using heat from a natural gas CHP system via an absorption chiller. As the electricity grid continues to decarbonise in the future, and if electric chillers continue to improve in efficiency, the electric chiller option will increasingly become lower carbon than CCHP. Therefore absorption chillers may only provide a long term environmental benefit where a much lower or zero carbon form of heat can be obtained, ideally from a waste heat source which would otherwise have no use in the summer period. Figure 15 shows a comparison of the performance of trigeneration systems with different electrical efficiencies compared with an electrically driven chiller. The data shows that even with highly efficiency trigeneration systems, the chillers are expected to be lower carbon if the electricity grid emissions factor reduces to 0.4 kg CO_2 / kWh or less – this is expected to be achieved within the next decade or so.

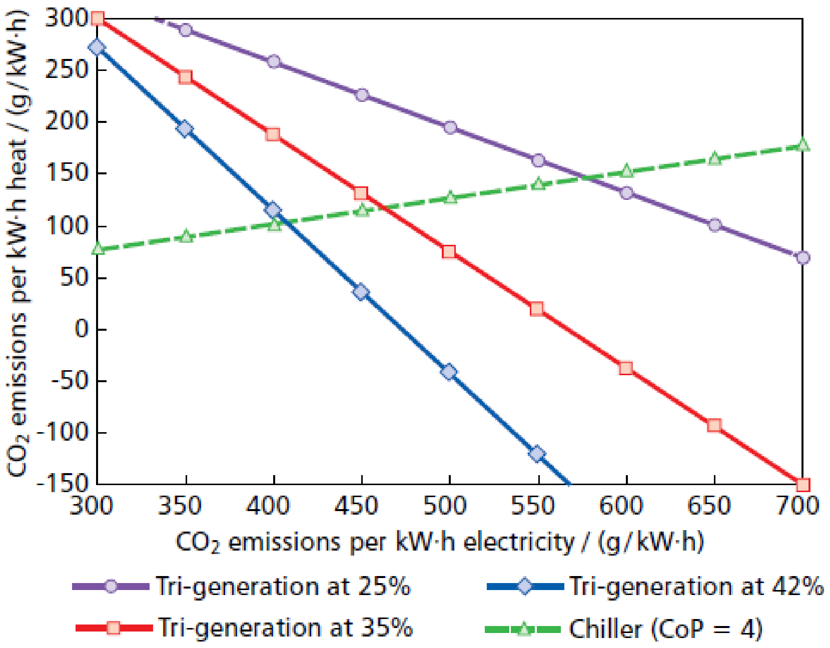

Figure 15: Comparison of tri-generation with electrically driven chillers (Note: tri-generation efficiencies refer to the CHP electrical efficiency; overall CHP efficiency is taken as 80% in all cases). Source – CIBSE AM12[12].

A situation where cooling networks and absorption chillers may provide a benefit is where there is a source of low carbon heat which otherwise can not be used during the summer months. This is effectively waste heat, and could be taken from industrial processes, or from geothermal systems. As neither of these have been identified in RBK, they are not considered.

In light of the uncertainties over cooling demands, and the negligible benefit, or even adverse impact, trigeneration can have environmentally and economically, district cooling networks are not considered further.

3.8 Assessment of the viability of a DE scheme in Tolworth

A DE scheme in the Tolworth area centres around the Tolworth Tower complex as discussed. AECOMs experience suggests that the most suitable option for this area is a CHP scheme for the tower complex with no further network –

[12] Combined Heat and Power for Buildings. CIBSE AM12. 2012.

the distribution and size of loads nearby suggests that a network will not be viable. The potential for connecting to other sites appears to be extremely limited due to the small number of site, their relatively dispersed nature, and uncertainty over some of the re-developed areas.

The importance of Tolworth Tower meant that consultation was required with the operators to understand the Tower in more detail, and obtain energy information so that a high level assessment could be made. Obtaining information from the Tower proved difficult but eventually the following information was obtained:

- The Tower contains a number of heating systems, with the majority of the office space in the tower itself on a common boiler system (although two floors of tenants have their own separate systems), and the retail tenants on ground floor having their own separate systems. It was suggested that the boiler will be replaced in the near future.
- The Tower's owner, Stevenor Investments Limited, is in administration, and the Tower may be sold to a new owner by the bank dealing with the administration.
- The Tower may be converted or re-developed into a different use including potentially student accommodation or residential.

No further information, including energy loads, was provided.

Given the importance of the Tower to any scheme in the Tolworth area, and the likelihood that a scheme may involve only the Tower at least for the foreseeable future, the uncertainty over the Tower's future and the lack of information available means that no meaningful analysis can be conducted. It is also suggested that a scheme revolving around a single building or site is not considered a DE scheme which requires inclusion in the EMP.

In light of this, AECOM do not believe that further analysis can be, or needs to be conducted on the Tolworth area at the current time. However the following recommendations are made:

- RBK should monitor the status of the Tower, and identify any re-development or change of use opportunities.
- RBK should engage with the new owners and encourage through planning the development of a CHP scheme if viable.
- RBK should keep a watching brief on the Tolworth area to identify any future major (re)development and assess the potential for these to develop a DH network, and potentially link to the Tower.

Once the viability of a scheme at the Tower can be established, the wider opportunities can be investigated further.

The remaining parts of this report are therefore concerned with the Town Centre only.

3.9 Summary

This section provides an overview of the high level opportunities and constraints which need considering when developing DE scheme options, and how they may apply with the Borough. The issues are addressed in further detail in this EMP, and may be revised as more details are ascertained, but this initial review helps to outline the direction of this study for both the Town Centre and Tolworth sites.

The town centre has a number of large energy users in a defined area as discussed, with a number of more remote loads located outside this immediate area which may support the expansion phase. Outside of these loads, medium density housing (typically terraced and semi-detached) is the predominant land use and the connection of these dwellings may offer long term connection potential if viable. If connection to medium density housing was deemed viable, then the expansion potential is significant and would provide a step change in connected heat load.

In the Tolworth area, the review of customers demonstrates that the potential for expansion is extremely limited unless lower density and smaller use customers are connected. The future expansion of a scheme (which initially may only be the Tolworth Tower complex) would therefore depend on the development of significant new loads in the area, or a step change in economic performance allowing expansion into supplying local housing. Based on the current analysis, Tolworth Tower is central to any scheme in the area, and is probably the most viable scheme in its own right without connecting elsewhere. Given the current status of the Tower and lack of information, it is proposed that all further work concentrates on the Town Centre opportunities.

Capabilities on project:
Building Engineering

4 Energy production

4.1 Introduction

This section provides an assessment of potential energy supply technologies which can be used to provide heat and electricity as part of a distributed energy scheme. The assessment is split into two parts: the first provides an overview of a wide range of technology options which may be applied to DE schemes and identifies which are the most suitable for use in the Borough, and the second provides a detailed assessment of the technologies deemed to be most appropriate.

Figure 16 below summarises the potential energy sources (traditional and renewable), the energy conversion methods, and the resulting energy supplies (power and heating/cooling).

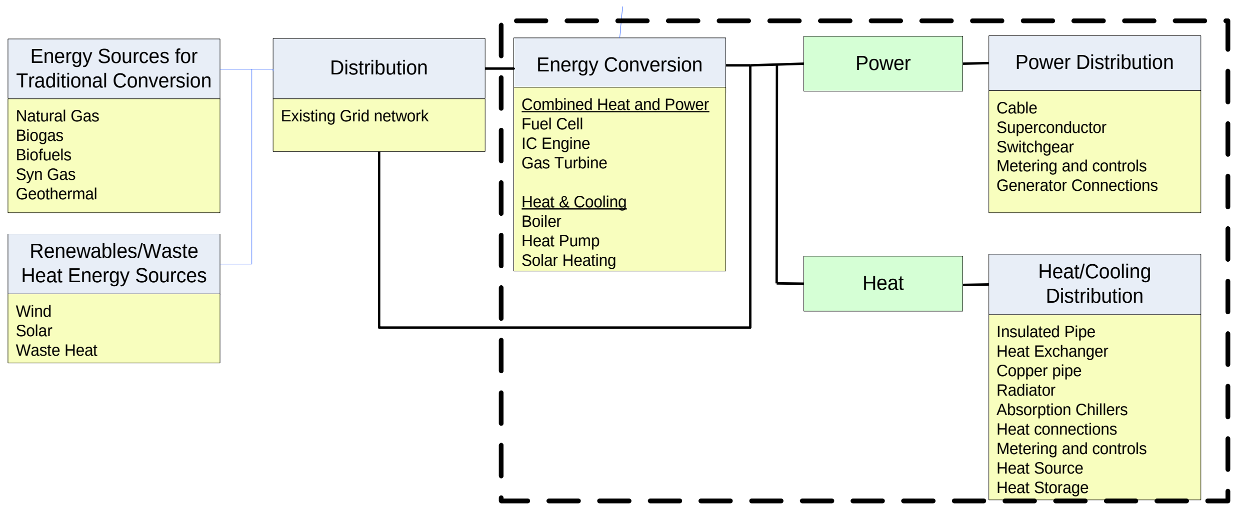

Figure 16: Potential energy sources and conversion methods.

4.2 Existing energy supply options

The RBK Heat Mapping study identified two existing potential sources of energy in the areas of interest. These are:

- Kingston Hospital – which has a Combined Heat and Power (CHP) plant
- The Hogsmill STW operated by Thames Water – which creates biogas through anaerobic digestion and uses this in an on-site CHP scheme

Our findings are presented below and summarised in Table 1.

4.2.1 Kingston Hospital

Kingston Hospital lies to the north east of the town centre and is a medium scale acute facility. A gas fired 1.4 MWe CHP unit is used to provide heat and electricity to the hospital. This is part of an energy services contract with Dalkia who own and operate the CHP unit, and sell heat and electricity to the hospital. This contract commenced around 6 years ago and is due to last 15 years. At the end of the contract, the ownership of the engine will be handed to the NHS Trust, who may then wish to continue maintaining and operating the unit, or replace.

Heat distribution on the site is via a steam main which connects to around 40% of the hospital buildings. There is no sub metering on the network but it is estimated by the hospital that around 60% of the site's heat load is met by the steam main. The remaining buildings are heated by individual gas boilers dispersed around the site. There are two main incoming gas meters for the whole site and this is the only way of monitoring heating consumption.

The use of a steam network is common in many hospitals. The network allows for the provision of steam for autoclaves, and reduced diameter pipe sizes for ease of installation. Steam systems were also common on hospital sites due to the potential to access high grade heat from incinerators, although many of these have now been removed, or replaced with boilers. The current steam network at Kingston is old, and historically poorly maintained, and so replacement is planned for 2014 with a new main (AECOM's understanding is that a decision has not been taken yet on whether this is steam or hot water based) sized for additional loads.

Replacement of the network could offer a number of opportunities for the EMP:

- The network could be converted to Low Temperature Hot Water (LTHW) with new pipework which opens up flexibility for alternative heat sources and would be compatible for connecting to a wider network. With a high temperature network, localised heat generation will be required on site to boost temperatures if the rest of the town network is lower temperature. Discussions with Kingston Hospital have suggested a LTHW network could be a possibility.
- The scale of the network could be expanded to connect to more of the hospital buildings. This would allow the provision of lower cost and lower CO_2 heat to more of the site. The costs of connecting to all buildings could be high and so a cost benefit analysis would need to be conducted to assess the cost of connecting versus the heat load met. This could be part of a gradual strategy where a replacement network is oversized, and additional buildings are connected during future refurbishment or re-development.
- The design of a new network could take into account future connection opportunities. The network could be sized with the capability of importing or exporting heat, with appropriate terminations and access provided for connection to a wider network.

Based on the consultation with the hospital, the key opportunities appear to be:

- Replacement, of the existing steam network, with a LTHW system with greater coverage of the hospital site, and capability for connecting to a wider network. The additional cost of a connection ready network would be minimal if designed in with appropriate connection points and the provision for controls.
- Purchasing of heat from a wider network for the hospital site (heat generation plant would probably need to be retained on the hospital site for back up and resilience).
- Increase in heat generation plant through expansion of the existing boiler house, and potential increase in CHP size, probably at the end of the energy services contract period, to allow export of heat to the wider network.
- Inclusion of a larger energy centre on re-development / modernisation of the hospital site (see also section 4.5.6).

Further information on the hospital site is provided in section 4.5.6.

4.2.2 Hogsmill Sewage Treatment Works (STW)

The Hogsmill STW is owned by Thames Water and has been identified as a potential source of heat in the RBK Heat Mapping study, due to the presence of a biogas fuelled 0.94 MWe CHP plant. A CHP plant is typical for most STWs as the biogas from the sewage anaerobic digestion (AD) process makes a valuable resource for energy generation on the site.

The AD process generates biogas by digesting organic waste in an oxygen-free environment. The digestion process requires the feedstock to be warm to catalyse and maintain digestion. The resulting biogas could be used in a number of ways:

- Flared off (to no benefit)
- Captured for use in a CHP unit providing heat and electricity
- Captured for use in another energy application, such as storage in compressed tanks for export (although there are at present limited applications apart from Transportation)
- Compressed, upgraded, and injected into the gas network (although this is an expensive process with few existing schemes).

In addition to the biogas output, the process results in a sludge of digestate which needs to be disposed of. This can either be transported from the site and spread as a fertiliser, or dried and used in pyrolysis or biomass combustion plant.

Sewage treatment plants have a high electricity process demand to power a range of systems. The electricity generated by the CHP systems is therefore generally used entirely on the site. The AD process also requires heat. Whilst some of this is self-generating, making use of thermal energy from the digestion process, additional heat is also required, particularly in the cold periods. In general therefore the heat output of the CHP system is also used entirely on the site, with additional boiler plant also often required, powered by natural gas.

The general description of energy within an STW above suggests the scope for energy export is limited. Consultation with Graeme Walker from Thames Water found this to be true for the Hogsmill site in the short term; there are currently no opportunities for extracting excess heat from the system. Indeed the STW imports a large amount of natural gas for the additional process heating.

Thames Water currently export sludge from their STWs for use as a fertiliser. However this is becoming increasingly challenging and expensive to do due to the lack of suitable locations for spreading where the existing soil conditions allow additional nutrients. In light of this, Thames Water have trialled a sludge drying plant at their Slough STW which involves de-watering and drying the sludge with warm air driers at 60°C to produce a cake . This process is currently inefficient and expensive, and they are about to trial a new form of sludge drying plant. If this process becomes efficient, it may become common at a number of plants resulting in a biomass type fuel which can be burnt, gasified, or used in pyrolysis. It is possible that a fraction of the resulting fuel will be used to power the drying plant, and the additional fuel could be used for maintaining heat in the digesters, in place of gas boilers. It is therefore uncertain what the net potential fuel export would be.

In the longer term, Thames Waster is keen to investigate energy generation and provision opportunities where these may provide improved asset value and contribute towards their target for “end of waste status”.[13] Therefore opportunities such as biogas export may be of interest if sufficient heat can be generated on site (possibly from sludge cake) and a cost effective gas export option exists. One concept could be the export of biogas from Hogsmill STW using a dedicated biogas pipe to a local energy centre located either at the STW site or elsewhere in Kingston.

4.2.3 Other existing supplies

Other potential sources of heat have also been identified:

- Kingston Crematorium. This is located to the north of the Hogsmill Valley in Kingston cemetery. The annual gas consumption is 540 MWh per year, and therefore any heat recovery is likely to be negligible over a large DE scheme. However, the source could be used in a local application, or as a decentralised generator on the DE scheme. Heat capture is used at some crematoria in a minor way in the UK (for heating offices and facilities belonging to the crematorium) but it is used more extensively in Scandinavia. Research is being conducted into heat capture by the University of Bath but public acceptability remains divided [14].
- Low temperature waste heat sources which can be upgraded using a heat pump. See section 4.3.

[13] The concept of “end of waste”, originating from scrap metal, is when the “waste material” is all re-used or recycled, and so has a further life/usefulness and so ceases to be “waste”.
[14] http://www.fsj.co.uk/news?articleaction=view&articleid=482

4.2.4 Summary of existing sources

Table 1 provides a summary of the existing heat sources which may be available for a DE scheme.

Table 1: Review of existing heat sources.

Source	Suitability for Kingston	Comments
Kingston Hospital CHP	Current source not suitable.	Existing scheme is unlikely to have an excess heat, but could connect in the future with new plant.
Hogsmill STW	Not suitable	No major source of energy identified for use in a DE scheme.
Crematorium	Suitable	Suitable for connection if a DH scheme is near the Crematorium. However the amount of heat available is small and this is likely to be a minor heat producer.
Low temperature heat source	Suitable	Potential to capture low temperature heat and upgrade using heat pumps. See later in section 4.3.

4.3 Review of secondary heat sources

Several potential new energy sources are also available in the Borough. The Greater London Authority (GLA) commissioned a study into the capacity and utilisation of secondary or low temperature heat sources in London; secondary heat is considered to be heat arising as a by-product of industrial and commercial activities, from infrastructure operation, and from the environment (air, ground, water)[15], This report identifies a potential resource of 447 GWh heat per year available from secondary source across the Borough, equivalent to 37% of the Borough's heat demand.

Table 2 provides a summary of the sources identified across London.

[15] London's Zero Carbon Energy Resource: Secondary Heat, Report Phase 1, January 2013, GLA and London's Zero Carbon Energy Resource: Secondary Heat, Report Phase 2, April 2013

Table 2: Secondary heat sources covered by the GLA's study

Category	Heat Source	Description / definition
Environmental sources	Ground source	• At depths below around 6m, ground temperatures are stable throughout the year. The ground can act as both a store and supply of heat. Heat can be extracted from open or closed loop systems, the former using aquifers, the latter boreholes. Both systems are included in this study.
	Air source	• Outside air, at any temperature above absolute zero, contains some heat, the quantity of which varies both seasonally and diurnally.
	Water and river source	• Water and river sources contain some heat. For rivers, the quantity of heat varies with both flow rates and temperature both of which can vary seasonally and diurnally.
Process sources	Power station rejection	• Power stations that burn fuel to generate electricity generally operate at electrical efficiencies of around 30-50% depending on fuel type and technology. Considerable energy is lost in the form of waste heat that is generally rejected to the atmosphere. Availability of this heat during the year will depend on the operating regime of the plant. • Gas fired open and combined cycle plant, energy from waste, landfill gas, biogas and sludge incineration are considered. • It is assumed that high grade heat from the CHP jacket cooler is utilised by the operator. Low grade 'waste' heat is recovered from the intercooler circuit and represents approximately 3% of the total input energy.
	Building cooling system heat rejection	• Buildings use a range of different cooling systems which mostly operate during summer months although many modern buildings with high cooling loads and efficient building fabric require cooling for significant periods of the year. Building cooling systems typically use air or water cooled chillers to reject heat at low temperatures.
	Industrial sources	• A number of industrial processes lead to the rejection of waste heat. Processes included in this study are crematoria, chemical industries, clinical waste incinerators and food producers.
	Commercial buildings non-HVAC	• Some buildings reject heat from equipment other than building cooling systems (e.g. from food refrigeration, IT equipment). Two key commercial operations analysed for the study are supermarkets and data centres.
	Water treatment works	• Low grade heat is released from water treatment works due to biological activity associated with sewage treatment.
Infrastructure sources	London Underground	• Heat generated underground through train braking, lighting and passengers is rejected through ventilated shafts at strategic positions along the network.
	UKPN / National Grid electrical infra-structure	• Electricity substations on both the transmission and distribution networks contain transformers to convert power from one voltage to another. Transformer coils are usually cooled and insulated by being immersed in insulating oil.
	Sewer heat mining	• Sewage in underground sewers contains heat which can be 'tapped' or 'mined' in a similar way to the extraction of heat from the ground or rivers.

We have reviewed this report to identify the potential low temperature heat sources for Kingston. The main sources identified of relevance at a strategic level are:

- The River Thames
- The Hogsmill Sewage Works Outlet Water.

These are discussed in further detail. The other sources identified also have relevance to Kingston, but due to their more distributed nature, they are not discussed at the strategic level.

It is important to note (see section 4.4.6) that this secondary heat is of low temperature and is not useful unless it can be upgraded to a higher temperature using an electrically driven heat pump. At present, the CO_2 emissions associated with operating the heat pump are likely to result in heat with a higher CO_2 content than that from Gas engine CHP systems. Therefore at present the secondary heat should not necessarily be viewed as a low carbon or low cost form of heat.

4.3.1 The River Thames

Extraction of heat from the River Thames has been identified from the GLA secondary heat study. This will require heat pumps to upgrade the heat to useful temperatures (see section 4.4.6). Figure 17 shows the distribution of River Water heat extraction potential.

Capabilities on project:
Building Engineering

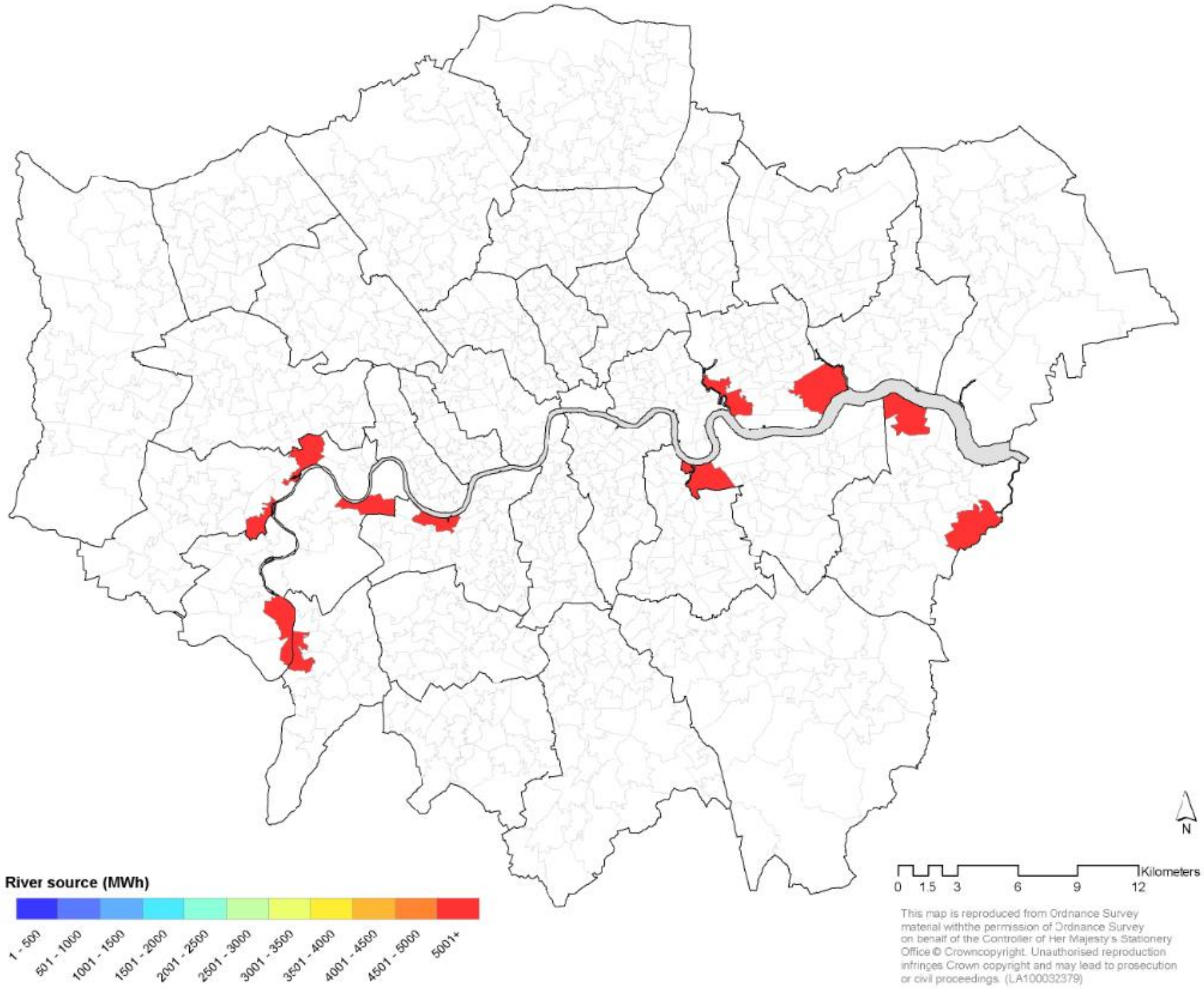

Figure 17: Distribution of secondary heat from river water extraction. Kingston is identified as one potential location. Source – GLA secondary heat study).

The GLA report identifies around 2,000 GWh of potential delivered heat from river water extraction across the sites identified, based on a 10% of flow extraction rate, and taking into account the varying temperature of the source through the year, and limits on rejection temperature, Therefore whilst the amount identified is illustrated as 5001+ MWh in Figure 17, the volume of available heat at each location is likely to be significantly higher and in the order of 10s or 100s GWh (it is understood that the scales selected for the GLA mapping were to allow comparison across all sources).

4.3.2 The Hogsmill Sewage Works Outlet Water.

It has been previously identified that there is no excess high grade waste heat from the CHP system at Hogsmill STW. However the GLA report has identified the low grade heat at the STW outlet as a potential source suitable for upgrading with a heat pump. The locations of these sources, including the Hogsmill STW in Kingston, are shown in Figure 18.

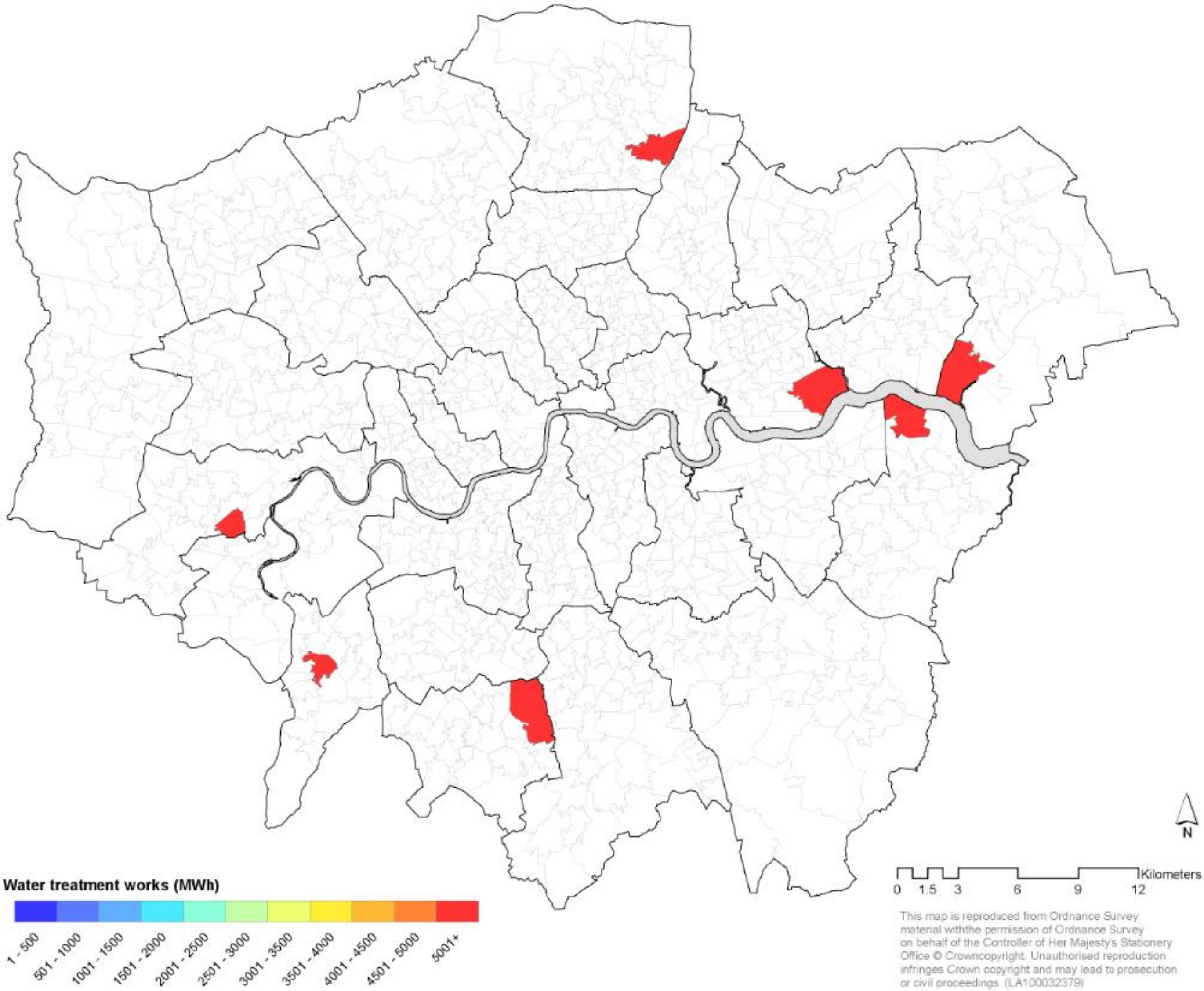

Figure 18: Distribution of secondary heat from STW outlet heat extraction. The Hogsmill STW in Kingston is identified as one potential location. Source – GLA secondary heat study).

The GLA report identifies around 10,000 GWh of potential heat from STW outlets across the sites identified. Therefore as with river water heat extraction, whilst the amount identified is illustrated as 5001+ MWh in Figure 18, the volume of available heat at each location is likely to be significantly higher and in the order of 10s or 100s GWh (it is understood that the scales selected for the GLA mapping were to allow comparison across all sources).

4.4 Review of possible energy supply options

In this section, we have reviewed energy supply options for generating heat for DHNs, and in some cases electricity, to identify their suitability in terms of providing a cost effective and reliable heat supply that will also deliver environmental benefits in an urban environment. These options are:

i. Community boilers
   - Gas boilers

  - Biomass/biogas boilers

ii. Large power station heat take-off

iii. Industrial/commercial waste heat with heat pumps if necessary

iv. Combined Heat and Power (CHP)
  - Gas reciprocating engine
  - Biomass CHP
  - Biogas-fuelled CHP
  - Fuel cell CHP

v. Energy from Waste (EfW) CHP
  - Incineration
  - Anaerobic digestion

vi. Large-scale heat pumps
  - Air sourced
  - Ground sourced
  - Water sourced

We have not considered large-scale solar-thermal as the land in RBK is considered of too high a value.

4.4.1 Community boilers

The first option considered is community boiler plant acting a prime heat generator for supplying heat distributed via a DHN.

4.4.1.1 Gas boilers

The use of gas-fired boilers supplying community heating can be ruled out almost immediately as a replacement for existing locally sited gas boilers. The only advantages would be:

- Ease of future fuel or heat source substitution
- Possible diversification of loads, improving boiler efficiencies.

However, these advantages need to be weighed against:

- The distribution heat losses associated with the network
- The lack of clear environmental benefits as a result of the distribution heat losses and no generation efficiency gains
- The need to find a location for an energy centre
- The capital and additional running costs of the district heating network and energy centre
- The need to procure or set up a management company – typically an Energy Services Company (ESCo)

Therefore this option has not been considered further.

4.4.1.2 Community biomass/biogas boilers

Biomass refers to the use of a wide variety of organic material such as wood, straw, dedicated energy crops (e.g. willow coppice or specific types of grasses), sewage sludge and animal litter for the generation of heat, electricity or motive power.

Biomass is regarded as a low carbon fuel because the CO_2 released when it is converted for energy purposes by combustion/burning or fermentation and distillation to produce liquid transport fuels is largely offset by that absorbed by the organic material during its growth.

With the appropriate management this emitted CO_2 can be recaptured provided new growth of the same amount of biomass is achieved. However the carbon balance may not be achieved overall as a result of energy used by harvesting vehicles or in transporting biomass to its point of use.

Biomass heating plant is available in a wide range of sizes from a few kWs to many MW of heat.. At the smaller sizes, fuel is usually supplied as wood pellets. At the larger scale, wood chip is one of the most common fuels at present.

The advantages and disadvantages of supplying a DHN from communal biomass boilers are identified below.

The advantages are:

- Environmental benefits as a result of the low kg CO_2 per kWh for biomass compared to gas
- The eligibility of the technology for the Renewable Heat Incentive (RHI)
- Ease of future heat source substitution.

However, any such scheme would require:

- An energy centre large enough to incorporate not only the boilers but also a fuel store and a thermal store (to avoid operating the boilers at low loads), plus gas-fired top-up/back-up boilers
- Measures to ensure air quality standards are met
- A suitable access route to the fuel store for delivery lorries
- A management company, typically an ESCo
- A secure source of biomass fuel over a significant period, say 20 – 25 years.

In general, biomass boilers are only economic compared with gas boilers when the RHI is obtained. This means that there are no cost savings without the RHI which can be used to fund the required energy centre and distributed network infrastructure capital and running costs. There will also be distribution heat losses associated with the network.

Although the higher biomass fuel costs, compared to gas, could be offset by RHI payments, this option has not been considered further due to the uncertainty over future incentives. In addition, there are concerns over fuel supply and cost, transportation, and air quality as discussed earlier.

4.4.2 Large power station heat take-off

A significant amount of low grade heat energy is produced in the generation of electricity, which is normally rejected to atmosphere or rivers. When a suitable heat demand is located nearby, heat can be extracted at a higher temperature to supply a DHN. This involves a reduction in electrical output of the power station so the heat is not 'waste heat'. There are both economic advantages to such an approach and environmental benefits, providing the cost to install the network and connections is less than the cost of producing the heat (related to the value of the electricity reduction), over a prescribed period.

With regard to the two areas in Kingston under consideration – the Town Centre and the Tolworth Regeneration Area – there are no large power stations nearby which could supply heat in this way and so this heat source has not be considered any further.

4.4.3 Industrial/commercial waste heat

Another potential source of heat for a DHN is waste industrial or commercial heat. The principle is the same as that for the power station; an organisation is generating heat, in this case as a result of a process, which is surplus to requirements and therefore rejected to atmosphere or water.

Although the area being considered does not contain any significant industrial plants, a potential source of waste heat within the Borough is Kingston Hospital. The potential to provide heat from the hospital has already been considered, see Section 4.2.1.

Industrial/commercial waste heat has not been considered further other than from Kingston Hospital.

4.4.4 Combined heat and power

In general, the economics of using an energy centre and DHN to supply heat to a number of buildings are much improved, as are the environmental benefits, when the heat is provided by a Combined Heat and Power plant (CHP) which generates electricity as well. Typically the CHP scheme is designed to be "heat led", so that all of the "waste heat" produced as a bi-product of electricity generation is used and none is simply released. The electricity is either used on site, displacing grid supplied electricity, or it is exported to the grid. Ideally all of the electricity is used on site and none is exported to maximise the income from electricity generation. However, this requires a suitable host site with a large electrical demand or the construction of a private wire network to sell electricity direct to customers. In most cases these situations are not available and most of the CHP electricity generated will be sold in bulk to a licensed supplier for onward sale to customers

Any CHP scheme should have a top-up and back-up energy supply, typically gas-fired boilers.

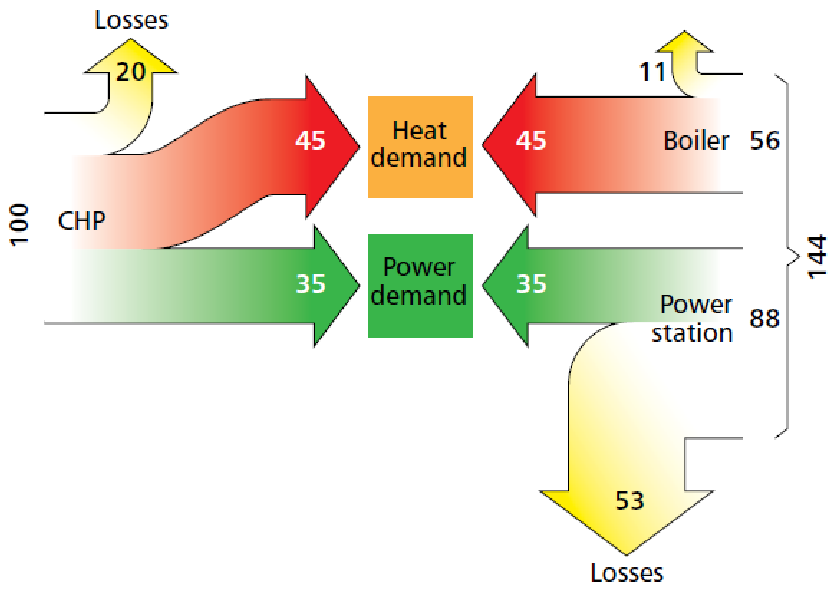

Figure 19: The efficiency benefits of CHP over conventional power generation and boilers (Source – CIBSE AM12[16])

In the next sections, several energy sources for a CHP engine are considered.

[16] Combined Heat and Power for Buildings. CIBSE AM12. 2012.

4.4.4.1 Gas-fired Combined Heat and Power (CHP) – gas reciprocating engine

This technology has been utilised widely for many years and is considered mature and economically viable. The most noticeable advancement over the years is higher shaft efficiency and lower emissions. The normal system configuration is that an electrical generator is connected to the engine mechanically and a heat exchanger is used to extract the heat from the engine jacket, oil cooler and exhaust gas. Apart from natural gas (i.e. most prevalent fuels), gas engines have been developed to run on fuels which have lower heating values and higher contents of impurities such as anaerobic digestion gas (biomethane), landfill gas and syngas.

A CHP plant based on a gas engine can produce heat from three main sources - the engine jacket cooling system, the oil cooler, and the exhaust gases. Typically two-thirds of the heat is available in the engine jacket/oil cooler while the remaining one-third in the exhaust. A gas-engine CHP is normally used in low temperature hot water applications due to the maximum temperature in the engine jacket circuit (typically 95°C).

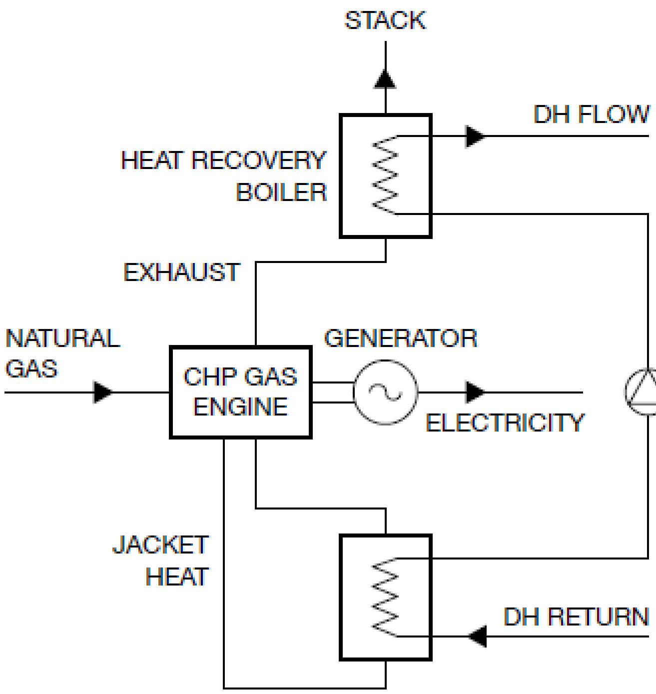

Figure 20: Typical DH connection to a Gas reciprocating engine CHP system (Source – District Heating Manual for London [17]).

Gas reciprocating engine CHP is considered a suitable energy source for DE schemes in Kingston.

4.4.4.2 Biomass -fuelled CHP

Biomass CHP can be based around gasification or combustion.

Gasification is a process to break down the biomass fuel source (which can include organic waste) into gaseous fuels by heating but without having combustion. The process creates a chemical reaction which combines waste with oxygen and steam under high pressure at a temperature generally in excess of 800°C. The continuous gasification process produces a syngas which contains carbon monoxide, hydrogen and methane. The gas has a

[17] District Heating Manual for London (DRAFT). GLA. 2013.

net calorific value of 4-10 MJ/Nm^3 and can thus be used to generate electricity. Figure 21 shows the schematic diagram of a gasification plant.

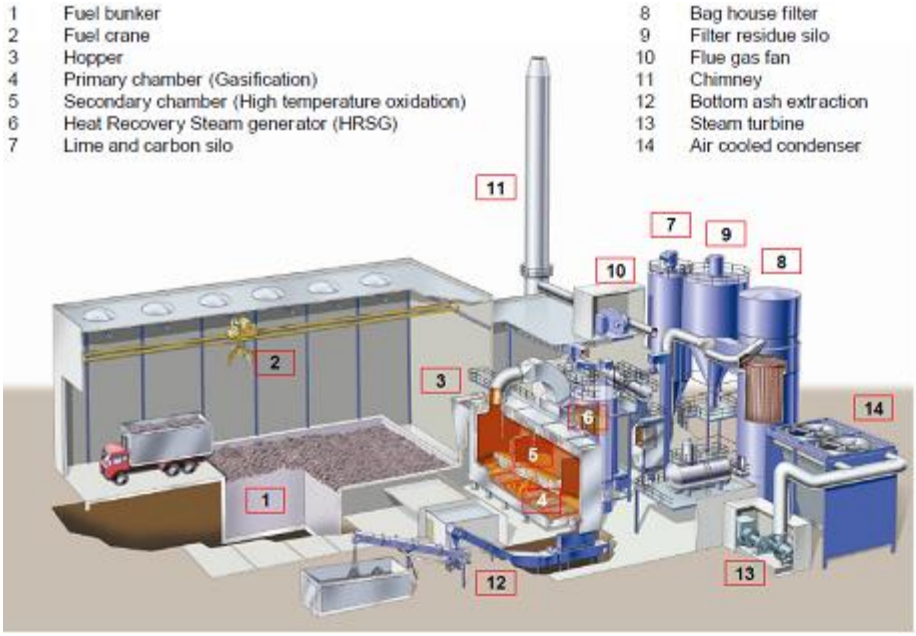

Figure 21: Schematic diagram of a gasification plant [18]

Gasification systems turn biomass material into a fuel known as synthesis gas or syngas through a high temperature process where the fuel is reacted with oxygen and/or steam, but without combustion. This gas is then burned in a modified gas engine to produce electricity and heat. The quality of the syngas is important and a range of cleaning techniques are used to ensure the product is uniform and tar-free. If a suitable quality can not be achieved, the the engine may malfunction.

The most recent gasification system appear to have made progress in ensuring the syngas is of high quality. These units are typically fully integrated systems with the gasifier and CHP system running from the same control system Gasification brings higher electrical efficiencies due to gas engine technology having advantages over steam based systems.

There is limited experience of wood gasifiers at a small scale but there are now a few applications in the UK of larger schemes of 1 to 5 MWe capacity. In Europe there are several wood gasifiers of less than 1 MW capacity that have been running successfully for some years, and this technology is now starting to become available in the UK.

Biomass gasification has been trialled at a number of sites in the UK for smaller scale CHP (100s kW – 10s MW) with varying degrees of success. There have been some instances of poor performance and it is considered that this technology is pre-commercial and immature.

At a larger-scale, typically over 10MWe, biomass combustion CHP plant is well established and is usually fuelled by straw, forest residues (e.g. wood-chips), or waste wood (which is usually classed as a waste product and therefore required Waste Incineration Directive compliance). The system normally includes the major components as fuel storage and feed-in system, combustion chamber, high-pressure steam boiler, steam turbine, generator and flue-gas heat recovery boiler (hot water or steam) as indicated in Figure 22.

[18] Typical gasification plant, http://www.wtert.eu/default.asp?Menue=12&ShowDok=15.

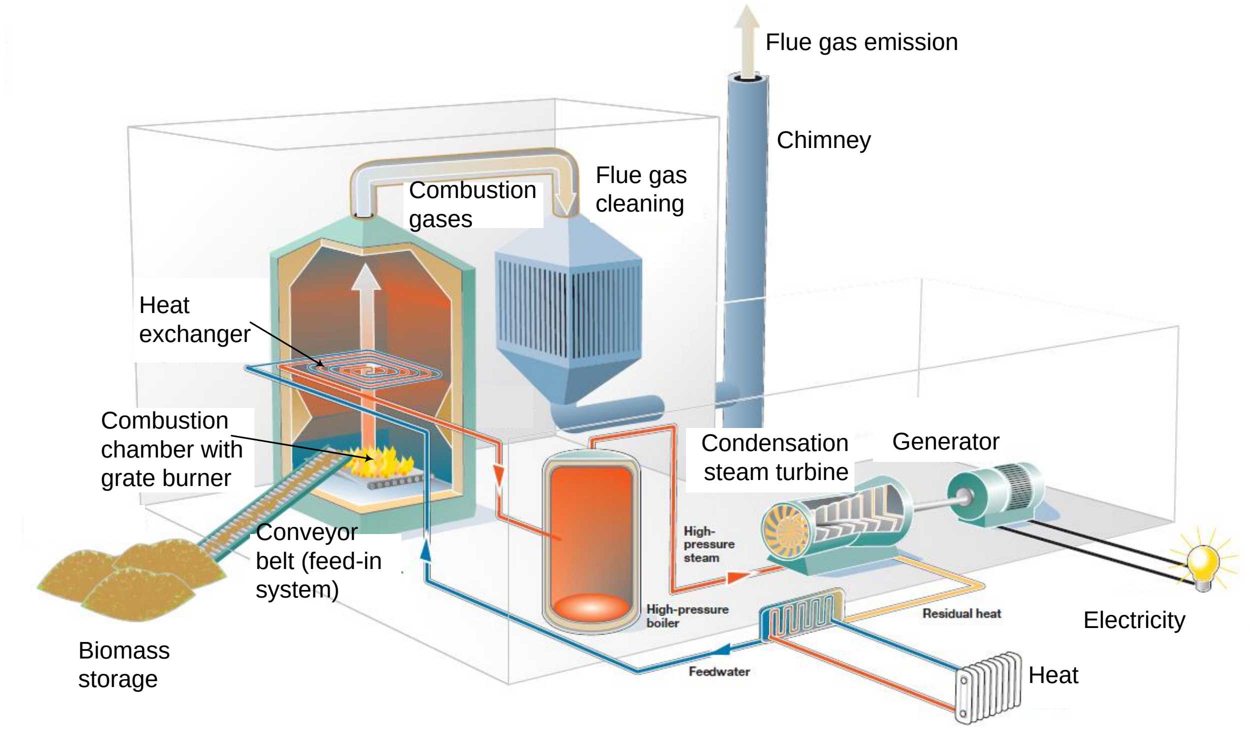

Figure 22: Schematic diagram of a typical biomass CHP plant [19]

Such biomass plants tend to be large in physical space terms, because it requires space for fuel handling, storage and potentially processing, in addition to the need for relatively large boilers. Because these issues apply to any system, this means that smaller scale plant is relatively expensive.

Due to the use of steam turbine technology, small scale biomass CHP (100s kW – 10s MW) is relatively low in efficiency. Electrical efficiency is often 20% or less meaning that when operated in heat led mode, small scale systems are required on smaller DE schemes due to the large heat outputs, resulting in the use of smaller, less efficiency and more costly systems.

As smaller-scale biomass CHP remains an unproven technology and there is no suitable site for a larger-scale plant in the Borough we have not included this technology in further analysis.

4.4.4.3 Biogas-fuelled CHP

Biomethane is produced from the decomposition of organic matter. It can be produced specifically from Anaerobic Digestion systems designed for treating organic products (see section 4.4.5) or as a by-product from other processes (which are also in effect a form of anaerobic digestion). As with biomass boilers, biogas-fired boilers are unlikely to be as financially and environmentally attractive as biogas CHP, so only the latter has been considered.

The only potential local source of biogas which has been identified is from the Hogsmill STW. Further information on this is provided in section 4.2.2, but in summary:

- The STW currently captures the biogas produced for use in a CHP system which provides the onsite requirements for electricity and heat

[19] Typical biomass CHP plant, http://www.unendlich-viel-energie.de/uploads/media/Biomass_CHP.pdf.

- There is considered to be no excess biogas or heat whilst the CHP system is operated.
- There may be a future potential for capturing biogas or heat from the CHP system, if alternative sources of heat are available for the STW process.

The potential use of biogas has been considered further to supply a DE scheme within the Borough in relation to strategic decisions around energy centre locations.

4.4.4.4 Fuel cell CHP

A fuel cell is an electrochemical device that converts the chemical energy contained in fuels into electrical energy and heat. It is typically composed of a fuel electrode (anode) and an oxidant electrode (cathode) separated by an ion-conducting membrane. Oxygen passes over one electrode, and hydrogen over the other, generating electricity, water and heat. Fuel cell CHP is in its infancy and this is reflected in the capital costs.

As there is no combustion, the pollutants are relatively low compared with a gas-engine or gas turbine. Fuel cells can operate continuously as long as the necessary reactant and oxidant flows are maintained. Most fuel cells use natural gas (or derivatives) or hydrogen as reductant, and ambient air as the oxidant

There are five main types of fuel cell classified by the electrolyte used in the cells. Three of these five types, the Phosphoric Acid Fuel Cell PAFC (150-200^{o}C), the Molten Carbonate Fuel Cell MCFC (600-700^{o}C), and the Solid Oxide Fuel Cell SOFC (700-1000^{o}C) are suitable for district heating application due to their operating temperature range.

Fuel cells are commercially available, although generally considered to be an immature technology and significantly more expensive than conventional gas engine alternatives. They offer the advantages of low emissions and high electrical efficiencies, but this needs to be balanced against cost and reliability.

In general, the additional cost of fuel cells at present does not justify the additional costs, and gas engine CHP systems are more viable. As the cost of fuel cells reduces (if they reduce), then they may become more viable in the future. However due to the expected reduction in the electricity grid CO_2 intensity, this maturity may not happen in time for fuel cells to remain effective at saving CO_2 if powered by natural gas.

4.4.5 Energy from Waste (EfW)

Two forms of energy from waste have been considered – incineration of municipal waste as an alternative to landfill, and anaerobic digestion of food waste to create biogas to power an engine.

4.4.5.1 Incineration

Energy from Waste systems are typically based around the incineration of waste in boilers to generate steam for a steam turbine. A schematic of a typical plant is shown in Figure 23.

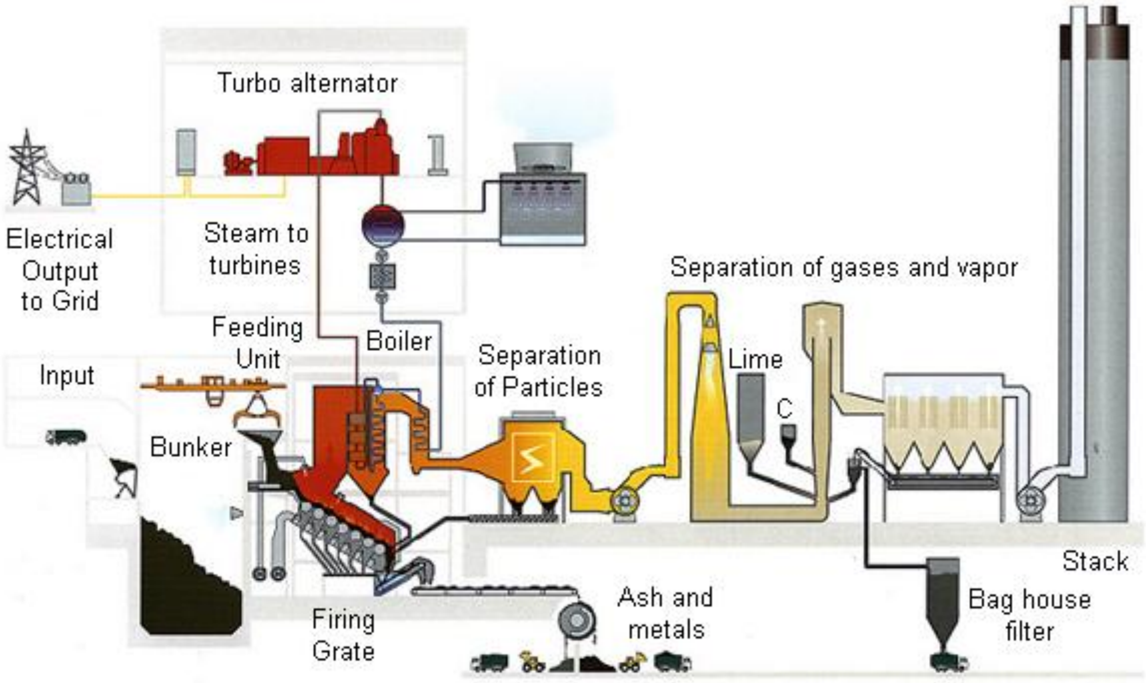

Figure 23:Schematic diagram of an energy from waste incineration plant [20]

RBK is part of the South London Waste Partnership (SLWP) which covers the Boroughs of Kingston, Sutton, Merton, and Croydon. This provides a coordinated and efficient waste service across the four boroughs. The partnership is responsible for the collection and treatment of household waste from across the four boroughs, and therefore the consideration of waste as part of an energy masterplan needs to consider any potential role for the SLWP.

The SLWP has taken a strategic decision to develop an Energy Recovery Facility (ERF) based around incineration for processing mixed waste which would otherwise be sent to landfill. The plant is to be located at Beddington Lane in Sutton, the site of existing waste handling, processing, and land-filling. This decision was made based on achieving a more economic solution than landfill with the associated landfill tax, and also the opportunity to provide a source of low carbon electricity, and potentially heat.

The plant will have an annual capacity of 275,000 tonnes waste and will export up to 22MW of electricity. Planning permission was granted for the plant in May 2013, and it will be delivered under contract by Viridor.

The location of the proposed ERF facility in Sutton is deemed to be of no benefit to heat networks in RBK, due to the 11 km distance from the Kingston Town Centre to the site at Beddington Lane, which would require an expensive heat transmission main. There are likely to be more viable DE options closer to the ERF site with lower transmission costs.

The development of the ERF in Sutton means that any further energy generation from waste is unlikely because:

- The waste resource available locally has been allocated to the ERF, and is projected to decline over time with increases in recycling. It is therefore considered that no further additional plant is viable.
- Land is at a premium in RBK, and whilst potential options may exist in areas such as Hogsmill Valley, it is likely that other areas in the four boroughs are more suited to an ERF facility if a future replacement plant needs to be built at an alternative location.

[20] Typical incineration plant, http://wtert.eu/default.asp?ShowDok=13.

For these reasons, heat from waste incineration and future thermal waste treatment technologies are not considered further in this study.

4.4.5.2 Anaerobic digestion

Anaerobic digestion (AD) produces biogas through the decomposition of organic waste in an oxygen-free environment. Feedstock for AD plants can be from a range of organic sources including animal waste, food waste, and purpose grown feedstocks (such as maize). A wet AD system typically processes feedstock using shredding and pulping systems before digesting in an air-tight reactor (usually batch processed). The biogas produced is taken off for energy generation (usually in a gas CHP engine, but also potentially for export), with some of the CHP heat used within the process. The resultant digestate is removed for use as a fertiliser. An alternative dry-batch system is also used for green waste where the feedstock is digested in air tight bunkers using a watering system to aid the process. Figure 24 shows a schematic of a typical wet batch process system.

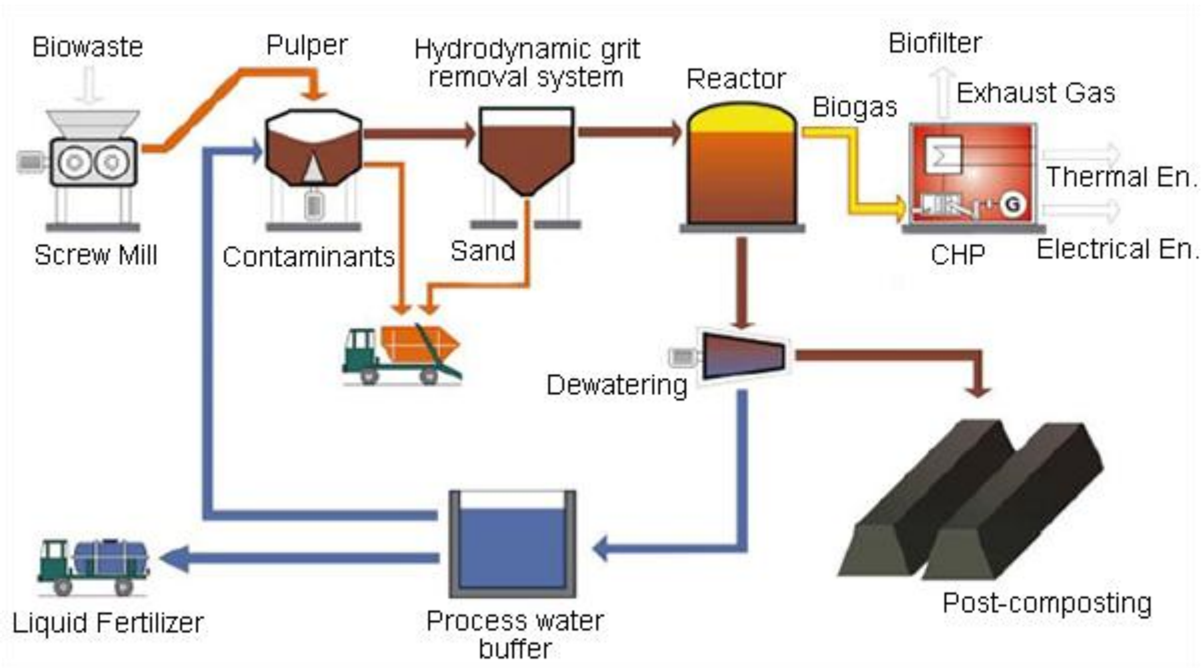

Figure 24: Schematic of a typical wet process AD system [21]

One potential source of biogas is from the STW in Hogsmill Valley and this is discussed in Section 4.2.2. Another potential source of organic matter is food waste. At present RBK collect segregated kitchen waste from households and process it at an in-vessel composting plant in Mitcham, resulting in the production of compost.

Assuming each home produces around 0.29 tonnes of food waste per year, and there are circa 65,000 homes in the Borough, the total annual food waste generation is around 19,000 tonnes per year[22] [23]. This is an upper limit and assumes that food waste generation in Kingston is the same as the UK average, that all food waste is collected, and that all food waste is suitable for AD. The actual figure is likely to be lower to account for collection uptake and suitability. Additional sources of food waste may be available from commercial premises or food processing.

[21] Typical Anaerobic Digestion plant http://www.wtert.eu/default.asp?Menue=13&ShowDok=17

[22] A figure of 0.29 tonnes per year per household is based on WRAP estimates of 7.2 million tonnes of food waste per year from UK homes. There are assumed to be 25 million homes in the UK. (New estimates for household food and drink waste in the UK, WRAP, 2011).

[23] The actual number of homes in 2011 was 65,198. Source – Neighbourhood Statistics Dataset Dwellings (QS418EW).

A typical AD scheme operating on food waste will require around 40,000 tonnes per year of food waste feedstock for a 1 MWe output unit – this is around the minimum size considered to be commercially viable. It can therefore be seen that even with significant increases in food waste availability, the contribution that AD can make from RBK resource alone is likely to be limited, and will be relatively small if it is part of a DE scheme.

Whilst other feedstocks could be imported for use in Kingston, the significant volumes of feedstock required, and the corresponding transportation, means that AD systems are best located near to the source of feedstock, often a rural location. In addition the significant transportation of digestate from the scheme also needs to be considered, which also benefits from a rural location.

For this reason, AD is not considered as a key heat generation option in the Borough. However if future organic waste treatment using AD is proposed in RBK, their location should allow for connection to a current or future DE scheme to allow export of heat.

4.4.6 Large-scale heat pumps – air, water, ground sourced

Heat pumps take heat from the ambient surroundings (air, ground, or water) and convert deliver this heat at to a higher temperature through a closed process; either involving a compressor (using electricity) or absorption (using heat; e.g. steam, hot water or flue gas).

Of these heat sources, air is a diffuse source and so is less suitable for a centralised heating plant for DH. The area required is large, particularly if noise levels are to be well-controlled.

Closed loop ground source systems are similarly limited in capacity as a large ground area is required. In general, closed loop, borehole ground energy systems are best suited to individual building systems, rather than wide area heat networks as the energy source is diffuse. Each borehole provides around 5-8kW of heat output (3.7-6.4MWh/yr). A closed loop system extracts heat through the use of a secondary medium. A glycol mix is circulated around the borehole array, and this is connected to the evaporator side of the heat pump.

In the case of open loop GSHPs, water is extracted from the ground, passed through a heat exchanger and returned to a separate borehole. The heat extracted is available through a water to water heat exchanger. Boreholes are typically arranged at 100m centres. Open loop ground water systems could produce water at higher temperatures than typically used for closed loop systems. The flow rate from a single well is still limited though so a number of such installations would be needed across the RBK area. A typical open loop borehole pairing can only provide around 380kW of heat energy. The amount of energy available from open loop schemes is subject to regulatory constraints imposed by the Environment Agency (EA). To avoid long term cooling of the ground, preference is given to balanced schemes which both extract and reject heat to aquifers on an annual cycle.

The potential for deep geothermal is also known to be limited in the London area.

The proximity of RBK to the River Thames does however represent an important opportunity to develop a large-scale heat pump technology using the river water as the heat source. The RBK area has already been identified as having good potential for this approach in the GLA’s report in low temperature heat sources (see 4.3.1). With river source heat pumps, heat is extracted by passing a proportion of the river flow through a plate heat exchanger system (water to water). The water is then returned to the river, with no net abstraction and no changes in chemical composition but at a lower temperature. Robust water intake arrangements are required, along with measures to deal with biological fouling and to protect fish from being entrained within the intake pump suction.

The heat output is restricted to the allowable temperature difference and the minimum water return temperature, both of which are regulated by the EA. The heat available is directly proportional to the volume of water abstracted and to the temperature difference allowed. There is a significant degree of temperature variation, roughly corresponding to variations in average monthly air temperature.

As a result of the above we consider the river water sourced heat pump to be the most viable type of heat pump to be considered for RBK.

The performance of heat pumps is generally represented by a Coefficient of Performance (CoP), which is the ratio of the heat generated to the electrical input. A CoP is used, rather than an efficiency, because the CoP exceeds 100% (CoP = 1). So a CoP of 3 refers to 3 units of heat output for 1 unit of electricity input.

The CoP is highly dependent on the temperature difference between the source of the heat and the supply of heat. We have considered heat pumps with a low temperature source of heat. A reasonable supply temperature for a DH scheme would be 80°C. It is possible to operate DH nowadays at temperatures lower than that in the past, and the supply temperature does not need to be constant through the year. For example DH can could be run at 70˚C in summer, 80˚C in mid season, and 90˚C only at times of peak demand. In addition, the peak heat demands can be met by boilers or gas-fired CHP which operate in series with the heat pump to increase the flow temperature.

As noted earlier, the GLA report on low temperature heat sources identifies the River Thames and the Hogsmill Sewage Outlet Water as the two major sources within the Borough (see section 4.3). Typical heat outputs of heat pumps are circa 5 MW which could operated be installed on a modular basisas a modular unit. In line with the GLA report, it is considered that up to 20 MW of large scale heat pump capacity, in 5 MW units, could be located at both the Hogsmill STW site for heat extraction form from the STW outlet, and by the River Thames for heat extraction from the River. A typical 5 MW heat pump will have a footprint of circa 10m by 5m totalling 50m^2. Therefore a space allowance of circa 200m^2 is required for the heat pumps alone for a 20MW system with additional space for ancillary services.

In contrast to CHP systems where it is an advantage to operate during the day period there would be advantages in operating a heat pump system mainly at night and storing the heat for the following day. This does however require very large thermal stores which are likely to be impractical so we have not modelled this option.

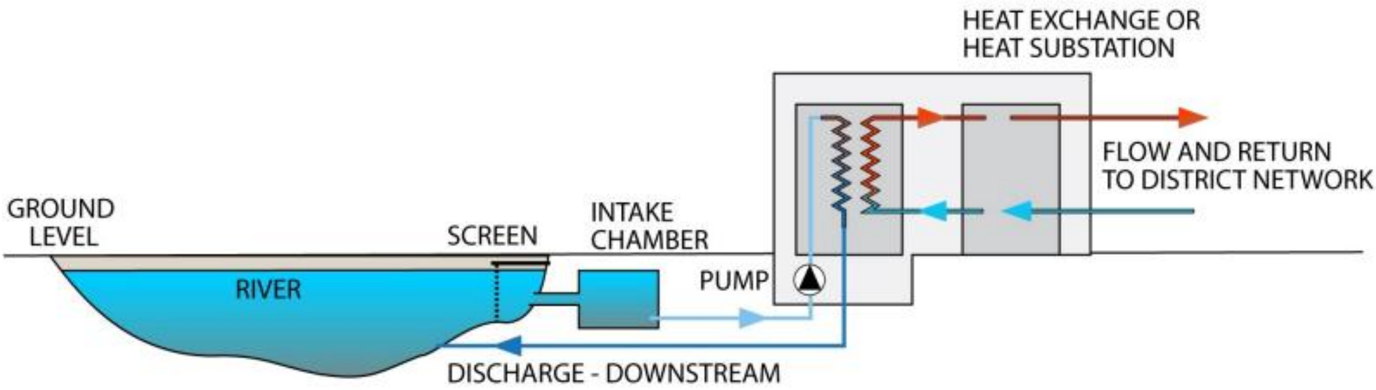

Figure 25: Schematic of a river water heat extraction heat pump (Source – GLA Secondary Heat report Phase 1).

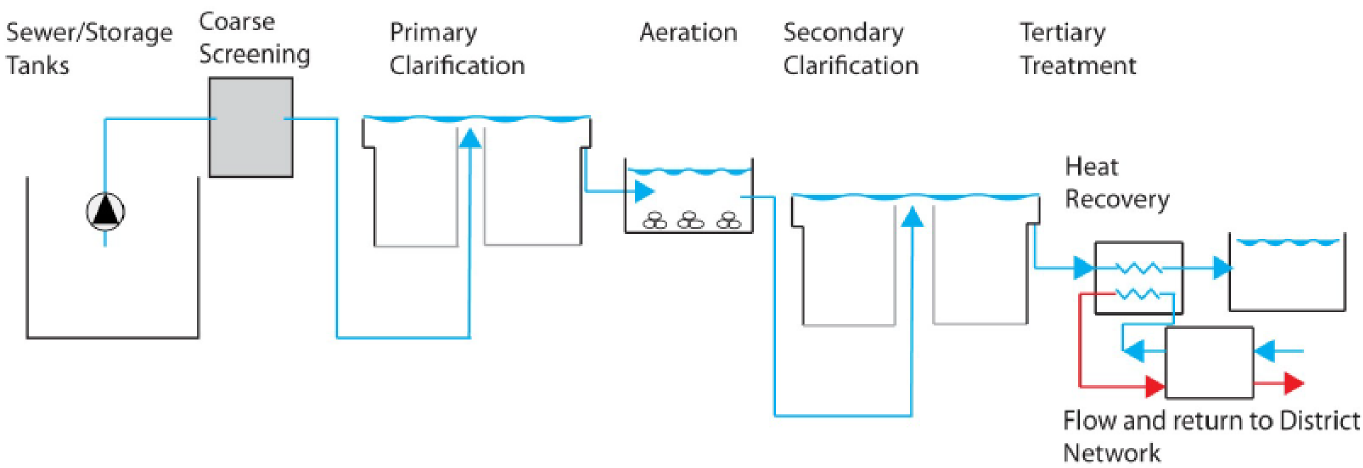

Figure 26: Schematic of an STW showing heat extraction at the water outlet for upgrading via a heat pump (Source - GLA Secondary Heat report Phase 1)

For large scale heat pumps used to supply district heating, as for all heat pumps, the CoP has a significant impact on unit cost and carbon intensity of the heat supplied. To inform the GLA study, a review of heat pump CoPs was carried out based on manufacturers' data, as described in the Phase 1 report. A central case was assessed for a 500-1,000 kW unit[24] and a scale factor was applied to adjust for the relationship between scale and performance.[25]

Figure 26 taken from the GLA Report 2, indicates the performance of this heat pump range for different source (evaporator) temperatures for four output temperatures on the heat network (condenser) side; 40°C, 55°C, 70°C and 85°C.

The performance of a heat pump also relates to the refrigerant used as the heat transfer medium. When selecting the refrigerant, there is a compromise between flexibility and performance – those with the highest CoP can typically operate at a high efficiency for a limited range of input water temperatures and conditions. In relation to the graph, two different refrigerants were assumed. The limits in refrigerants account for why it is not possible to raise water temperatures from 30°C to 40°C or from 10°C to 85°C as these conditions are outside the standard operating conditions of most heat pump refrigerants.

[24] Heat Pump data is based on information provided J&E Hall International for high efficiency inverter drive water source heat pumps.
[25] Based on heat pump performance data provided by Star Refrigeration for 3 to 10MW industrial heat pumps.

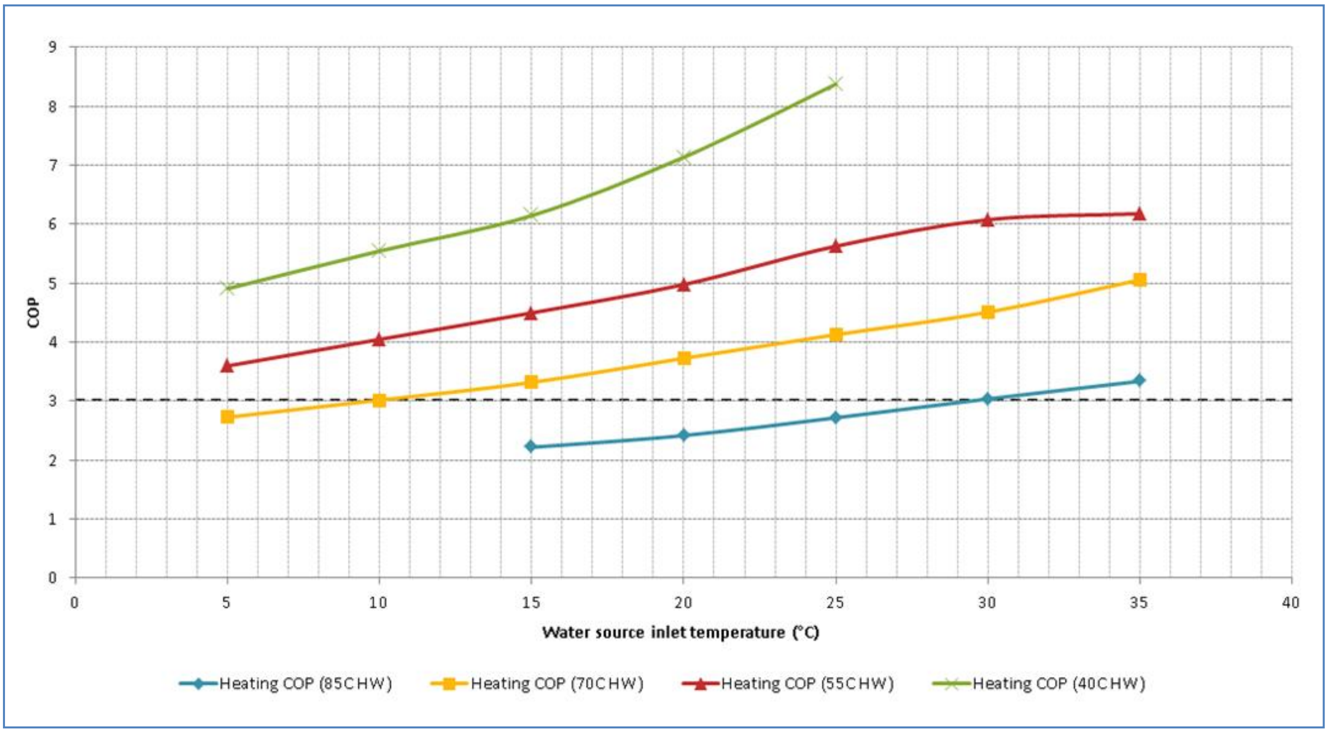

Figure 27: Graph showing the variation in heat pump CoPs by evaporator (source) temperature for four different heat output (condenser) temperatures (500-1000kW scale heat output) – from GLA Report Phase 2

The dashed line associated with a CoP of 3 indicates the minimum desired performance. Below a CoP of 3, a heat pump is typically unviable because of the electricity required to produce the heat, and the ratio of the carbon intensity of the grid-based electricity to the carbon intensity of an alternative way of delivering the heat, although over time as the grid is decarbonised, heat pumps with a lower CoP will save carbon.

Achieving a higher heat pump CoP needs to be balanced against the usefulness and compatibility of the resulting lower temperature distributed hot water, especially for existing buildings with their installed building services.

Taking both factors into account, the GLA modelling assumed a 70°C district heating flow temperature for all carbon and cost modelling of heat pumps. Reducing the return temperature of water back to the district heating network improves the efficiency of the heat source, as well as reducing pumping costs and allowing smaller diameter pipework to be used. This is a key requirement for low temperature heat networks.

4.4.7 Summary

The analysis of possible energy sources is summarised in below. Those in green have been examined in further detail.

Table 3: High level review of potential energy sources

Technology	Suitability for DE in RBK	Comments
Community gas boilers	Not suitable	Whilst technically viable, this is not expected to lead to financial savings which can justify the costs of the distribution network, and there are unlikely to be any environmental benefits.
Community biomass/biogas boilers	Not suitable	Technically suitable for connection to a DH network and will result in environmental benefits. Requires significant plant space for the biomass boilers, fuel storage, thermal store and gas-fired top-up/back-up boilers. Also requires consideration of air quality. Not expected to lead to financial savings which can justify the costs of the distribution network. There are high risks surrounding future availability and cost of fuel, but the costs could be partially offset by the Renewable Heat Incentive.
Large power station heat take-off	Not suitable	Currently no suitable power stations locally which could supply waste heat to a DHN in Kingston. A new local power station is possible but unlikely.
Industrial/commercial waste heat	Not suitable	There is no source of waste heat at Kingston Hospital. No other industrial waste heat sources have been identified.
Gas-fired CHP	Suitable for connection to a district heating network	Gas CHP combines a mature technology with large CO_2 reductions.
Biomass-fired CHP	Not suitable	Biomass CHP can deliver large CO_2 reductions and air quality issues can be addressed where plants are sufficiently large. The technology at the proposed scale is currently considered to be immature / pre-commercial. There are significant concerns over the availability and future cost of fuel.
Biogas-fired CHP	Potentially suitable, depending on availability of biogas within Kingston	A small scale scheme based around water treatment could be viable. This is likely to make only a small contribution to the wider DHN and so is considered from an energy centre location perspective only.
Fuel cell CHP	Not suitable	The technology is currently considered uneconomic and immature. In the future, the CO_2 reduction potential may be limited.
Energy from waste - incineration	Not suitable	Whilst technically feasible, this is not considered economically feasible. An Energy from Waste plant has been developed in Sutton, which is taking waste from the RBK area. It would not be economic to connect a DHN to the Sutton-based EfW plant because of the distance. It is unlikely that an EfW site will be developed in RBK in the future.
Energy from waste - Anaerobic Digestion,	Not suitable	No current schemes using food waste from the Borough exist. Potential for a future scheme to generate biogas from food waste, but a commercially viable scheme (1 MWe) would need to collect waste from 3 – 4 times the number of households in RBK.
Heat pumps - Water source	Suitable	Heat pumps are not predicted to save much (if any) CO_2 under the current grid mix. They may be more suitable for later phases of the development with decarbonisation of the grid. Under the current RHI heat pumps can perform cost effectively although there is no certainty over the future of the RHI. .
Heat pumps - Ground and air source	Not suitable	The limitations with capturing secondary heat from the ground or air at the scale required for DHNs means these systems are not suitable.

4.5 Review of Energy Centre locations – Town Centre

As outlined in the scoping section, the level of future development in and around the Town Centre is likely to be relatively limited with sites being bought forward generally on an ad-hoc basis. However the following specific options have been identified for the location of heating plant or an energy centre.

4.5.1 Distributed plant – phase 1

In the early phases of the scheme, and for specific buildings, it may be preferable to make use of existing boiler plant, and have a distributed boiler system for standby and peak supply, which involves some of all of the buildings. Advantages of this option include reduced land take for central plant, potential for sizing the DH network for baseload heat provision, resilience for customers, and maximising the use of existing assets. Disadvantages include the need to operate, maintain, and replace dispersed plant (with a possible loss of economy of scale), possible complex ownership and operation structures for the boilers, and long term future proofing.

If extensive use was made of distributed boiler plant, the remaining centralised generation plant (comprising CHP plant, thermal storage (if centralised), and pumping equipment) could be located at one of the customer's sites if there is sufficient space available.

For a phase 1 scheme, location options could include:

- The County Hall. There may be potential to locate a temporary packaged CHP plant in or around the County Hall, making use of existing car park areas. The most obvious location is the car park located along the West side of the building. Consideration would need to be given to acoustic pollution and aesthetics given the proximity to residential areas.
- The Kingston University Penrhyn road campus. Plant could be located in existing car park areas, or as part of re-development of the Townhouse at the north of the site. This location is well suited due to the large load presented by the Penrhyn Road campus on a Phase 1 scheme. Location on the University site will need to consider land ownership and the role the University take in the scheme. They may wish to retain the land for greater control, or sell or lease the land to the DE scheme.
- The re-developed Kingfisher Leisure centre site (see section 4.5.4).

No other large areas were identified at customer's sites, either externally to the buildings, or within existing plant rooms.

For a distributed plant option for phase 1, the amount of central plant, and therefore land requirements, will depend on the configuration of the scheme. It is suggested that an indicative 500m^2 land requirement is assumed for a Phase 1 distributed option subject to more detailed feasibility work. This would allow for one or two containerised CHP engines, thermal storage, electrical and gas sub stations and plant rooms, and associated services such as pumping equipment, oil storage, and staff facilities. This is typical of smaller schemes such as the Bunhill Energy Centre at Islington.

4.5.2 Distributed plant – future phases

As the scheme develops, a mix of larger centralised, and de-centralised plant may be used. This may be due to availability of suitable distributed plant (for example recently installed large boiler plant), existing centralised heat generation plant (such as CHP at the Hospital, or heat pumps at the Power Station site development), or optimisation of the network (providing local peak plant to reduce the network capacity).

At all stages of network assessment in the future, the opportunity for making use of decentralised plant should be considered alongside centralised options. In general, the benefits of a large DE scheme are that larger more efficient centralised plant can be used, and so the benefits of incorporating decentralised options will need to be weighed against the alternative central options.

4.5.3 South East of the town centre – Eden Quarter

This location comprises the following areas:

- Clarence Street South (Area P2 in Figure 28)
- East of Eden Street and the Ashdown Road sites (Area P3 in Figure 28)
- St James area (Area P4 in Figure 28)

RBK have a vision for the Eden Quarter to improve retail and commercial facilities, access for pedestrians from the town centre, and improve the general appearance and amenity. Area P2 is made up of the Eden Walk shopping centre, parts of which are 40 years old and which the owners wish to redevelop. Areas P3 and P4 are made up of a variety of lower grade uses including surface car parking owned by RBK. The overall proposals for the area are covered by the “Kingston Futures” project, although little information is available at the time of writing due to the recent creation of Kingston Futures.

The potential strategic re-development of the Eden Quarter could allow for an energy centre to be developed somewhere within the areas outlined.

The Eden Walk shopping centre is of prime commercial value. AECOM have consulted British Land, the current owners, and learnt that whilst British Land have long term plans for re-development, there are no specific proposals at present. However British Land would be willing to engage and consider further the following aspects:

- Re-development of the shopping centre to allow connection to a future DH scheme. This may include the use of common heating services across the centre including retail units, rather than the current conventional fragmented services.
- Re-development of the shopping centre with the potential to include some centralised heat generation plant. This could be as part of a de-centralised scheme (with the location of CHP plant in the area), or a larger centralised energy centre.

Due to the land ownership, and commercial nature of the shopping centre combined with the central location, it is likely that any significant land requirements in this area will have a large cost premium. The timescales for the re-development are also uncertain and nothing could be incorporated until re-development occurs.

Areas P3 and P4 are under a variety of ownerships, including large areas of surface car parking owned by RBK. The proposals outlined for this area in the K+20 AAP include a mix of amenity space, improved parking, retail and residential, although no more detailed information is available at present covering the location and quantum, as these will be defined through the Kingston Futures programme.

The proposals for P3 and P4 combined with their current status and ownership allow for the potential development of an energy centre. The strategic redevelopment vision allows for the inclusion of an energy centre in the schedule of development, and the land ownership combined with current low-value use as a car park, could enable an energy centre to be developed in the near term, prior to further development works. This would require the inclusion of an energy centre in the area to be considered as a priority by Kingston Futures. The location of this site is also close to the proposed Phase 1 network route, adjacent to the Phase 2 routes, and location on the southern side of the site adjacent to the busy A307 could be preferable for both the land uses, and connection to a DE scheme.

Capabilities on project:
Building Engineering

Figure 28: Kingston Town Centre AAP – Vision key diagram (Taken from K+20 AAP)

4.5.4 East of the Town Centre - Eastern Approach

This location comprises the following areas:

- Cattle Market car park and Fairfield bus station. (Area P5 in Figure 28)
- Kingfisher Leisure Centre and Kingston Library and Museum (Area P6 in Figure 28)
- Former Fairfield nursery site (Area P7 in Figure 28)

Sites P6 and P7 are both RBK owned providing leverage for future use. However the sites are relatively constrained and the main potential for locating an energy centre or decentralised plant may be with the re-development of the leisure centre, possibly with the inclusion of a CHP plant located within the centre.

Site P5 is owned by Transport for London (bus depot) and RBK (the car park). The K+20 AAP proposes re-configuration of this area to improve land utilisation, and there may be the potential for incorporation of an energy centre, in particular on the car park area due to RBK ownership. The area of the existing car parking is estimated at 0.3 Ha and so depending on the amount of land which could be used, there is sufficient space for an energy centre.

4.5.5 North of the town centre

Redevelopment sites in the north of the town centre include the Gas Holder site (P19). This currently comprises gas holders which are partially decommissioned. On the eastern edge of the site is the Art faculty for Kingston College for which an extension is proposed.

The Gas Holder site is identified for future development in the K+20 AAP for a number of potential uses. AECOM have consulted the planning consultants, QUOD Planning Services Ltd, who represent owners of the site Scotia Gas Networks. Initial discussions have commenced with RBK and it is thought the site may be developed for residential uses (circa 200 – 300 flats potentially) or student residences (circa 600 rooms). Current proposed timescales are for a planning application in 12 – 18 months.

There may be potential to incorporate some heating plant or an energy centre on the site, but the overall area is limited and the commercial pressure including decontamination works from the gas holders would mean that land will be expensive. The location is potentially on phase 2 of the network route, but not adjacent to a main transmission pipe or the ring main. In addition, the near term development of the site means that it is unlikely that an energy centre could be developed for export of heat to a wider network due to absence of a network in the vicinity in the near term.

4.5.6 Kingston Hospital

(A description of the Hospital site is provided in section 4.2.1)

The hospital site is relatively dense with no large areas for potential energy centre development. Most undeveloped areas are used for car parking which is currently stressed, and it is not envisaged that any of this land could be allocated to a large energy centre.

However the existing boiler house has some room for expansion and could accommodate additional plant. It is not clear whether this space would allow for additional plant for heat export, or whether simply to provide additional centralised heat generation for the hospital site itself.

The hospital also has plans for some re-development and modernisation, subject to funding. It is not clear at the current stage what the scope of this will be, but there may be potential during this period for incorporation of additional plant in the proposals, and potential reconfiguration of the heat network.

4.5.7 Hogsmill Sewage Treatment works

(A description of the STW site is provided in section 4.2.2)

The Hogsmill site owned by Thames Water is relatively large and its use as a STW precludes re-development for other uses. Alongside the current operational plant, the site also consists of empty land and redundant plant.

The strategic planning and development of water treatment infrastructure is subject to 5 year asset plans which are approved by Ofwat. These effectively limit investment by the water companies and ensure that prices are regulated for customers. The Hogsmill site is one of a number of STW sites which may need to be expanded to cater for increased loads, and any expansion plans will be submitted to Ofwat and the next 5 year asset period is 2015 – 2019.

AECOM have consulted with the Thames Water property team to discuss options for using the land. Until the plans for the next asset period are confirmed, it is not possible for Thames Water to make a commitment as to land availability at the site. However in principle, Thames Water are keen to maximise the use of the site and view an energy centre as a potentially suitable use. Whether land is leased or sold will depend on the exact location, and the nature of the energy centre – clearly if the energy centre is in some way connected to the STW (for example through biogas extraction or outlet water heat extraction), then the relationship would be different to a situation where the energy supply is independent of the STW.

It is recommended that Thames Water are consulted with on a regular basis through the development of strategic planning proposals for the Hogsmill area (see next section).

4.5.8 Hogsmill Valley and Kingsmeadow area

The Hogsmill STW takes up a large proportion of the Hogsmill area, but there are neighbouring land uses under the ownership of RBK. Figure 29 shows a map of the land ownership with the majority of the area to the south owned by Thames Water, and the area to the North, and South West by RBK. The other ownerships are considered insignificant and have existing uses.

This area (including Thames Water) has previously been covered by the Kingsmeadow AAP and is currently being included in a revised Hogsmill Valley AAP [26]. Proposals include making use of redundant STW land, developing areas of under-used amenity and leisure space, and improving access. Whilst large parts of the RBK owned land to the West will remain unchanged due to use as the Kingston and Surbiton Cemeteries, opportunities to the North and East could be provided for a large centralised energy centre, if not on the Thames Water site. This should be considered in any future work on the Hogsmill Valley AAP.

A waste transfer station is located at the North Western corner of the Hogsmill valley area under the ownership of RBK, and managed by Viridor as part of the SLWP contract. The site is used for the aggregation and sorting of waste prior to transfer to other waste processing sites.

Due to its location and ownership, the site had initially been identified as a potential energy centre location. However consultation with RBK has concluded that any relocation of the waste transfer station would need to happen after the current 25 year SLWP contract, and also that when previously contracted to SITA, alternative locations were examined and no suitable ones found. Therefore this site is not considered any further.

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26 http://www.kingston.gov.uk/browse/environment/planning/planningpolicy/local_development_framework/hogsmill_valley_dpd.htm

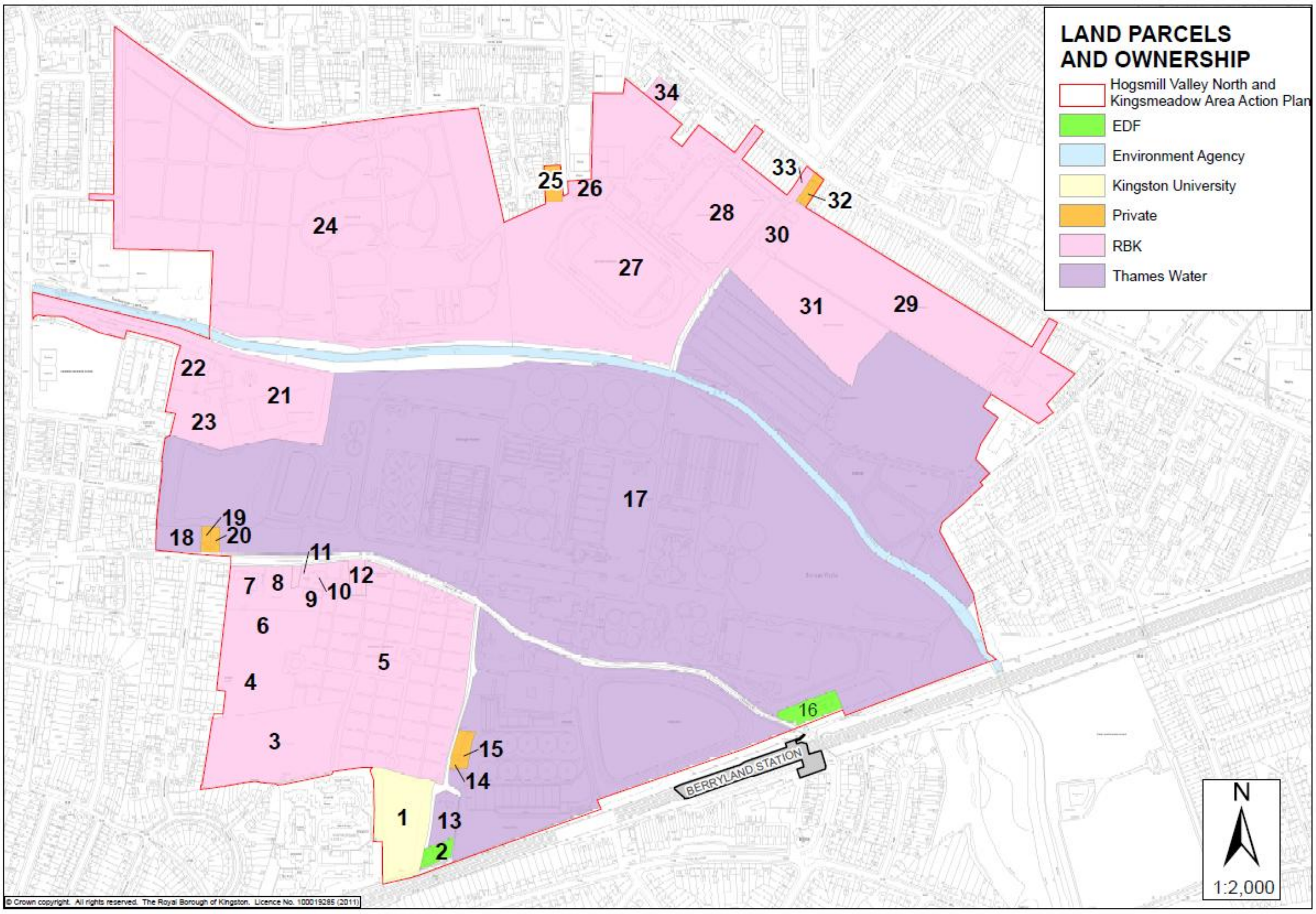


Figure 29: Land ownership in the Hogsmill Valley area (provided by RBK).

4.5.9 River Side locations

The use of a river water extraction heat pump will necessitate the location of an energy centre along the side of the Thames unless water is extracted and pumped to an alternative location.

The K+AAP identifies three main sites along the Thames:

- P17: The old power station site. This has been redeveloped into flats, and includes small river water extraction heat pumps for the site's own heating demands.
- P12: Bishops Palace House. This is an "unattractive" building from the 1970s which has been identified for re-development into a mixed use development.
- P13: Northern Riverfront. This site includes some vacant land in private ownership and has been identified for re-development with mixed uses.

The riverside is prime development land and has such will have a high value. However if heat pumps are to be used as a source of heat by extracting water from the river, then they will ideally need to be located alongside the river to prevent the installation of additional pipework from the river to transport the water and the associated pumping requirements. In light of this, it is suggested that an energy centre located along the river should be sized for the minimum amount of plant necessary, i.e. the heat pumps and associated pumping and filtering equipment only, and not any additional back-up boiler plant.

It is recommended that RBK identify any future development opportunities and land availability along the river bank for the inclusion of a heat pump energy centre, which may be a stand-alone building, or part of a mixed use development, even incorporated into other buildings. It is uncertain exactly where suitable opportunities may arise along the river bank, and so identification of a site will need to consider and potentially influence the layout of the DHN in this area to ensure a connection can be made.

The location will also need to consider access to the river to allow installation of water extraction and re-injection equipment. An ideal location would be on the re-developed power station site, if land is available, and may be able to make use of the redundant arrangements and location for water extraction and re-injection that was used by the power station [27].

4.5.10 Distributed sources of low grade heat

The GLA secondary heat report identifies a number of other smaller scale sources of heat which may be upgraded using heat pumps. These by their very nature are distributed at the source of low grade heat, and therefore any heat pumps will need to be located at these distributed sites.

It is recommended that during the development of any DE scheme in Kingston, potential local sources of low grade heat are identified, such as waste heat from building cooling systems, and heat extraction heat pumps installed where viable when making a DH connection to each site.

4.5.11 Considerations when locating an energy centre

An energy centre can be developed in a range of forms designed to suit the surrounding area and neighbouring building uses. The building can be stand-alone, or incorporated into other buildings (including residential), and can take a simple form (such as an industrial shed) or be architecturally more advanced. An energy centre will typically be two storeys tall to allow for plant installation although additional height could allow the footprint to be reduced through careful plant layout.

The actual buildings is therefore relatively flexible allowing location in a range of sites. However the following requirements must also be considered:

- Air quality. The use of fuel burning technologies such as gas CHP will need air quality to be considered, especially when located in an air quality management area such as the Town Centre area. The mitigation measure required will depend on the nature of the AQMA and the technology used in the DE scheme. In general, gas CHP, sometimes with flue cleaning technologies, can be accommodated in AQMAs successfully. Many urban AQMAs are due to low level particulate pollution arising from diesel vehicles, whilst the flue gases from gas CHP are low in particulates and exhausted at a high level away from receptors.
- Flue heights. A flue will be required to exhaust flue gases from the CHP units and boiler plant (if present) such that the exhaust gases do not impact on neighbouring buildings and sites. Dispersion analysis will be required on a site-by-site basis to determine the requirements of the flue, but a typical benchmark for the flue is that it must have a height of at least 3 m more than neighbouring buildings. Careful architectural design and placement can ensure flues are unobtrusive and fit in with the surroundings. Where thermal storage is incorporated, the flue could be incorporated alongside a vertical cylindrical thermal store.
- Access. Sufficient road access is necessary for the delivery of plant and the replacement of plant. Due to the size of CHP plant, boilers, and thermal stores, the access should allow the use of large articulated vehicles. Where space in the energy centre is limited, it may be necessary for the energy centre building to include de-mountable walls (eg cladding) to allow the servicing and replacement of equipment along the sides of the building. Again this will need to consider access, but also the ability to use (albeit on an infrequent basis) neighbouring areas (for example car parks) when required.

[27] The energy statement submitted as part of the Kingston Heights development at the power station site suggests that the existing cooling water ducts for the power station remain, and could be re-used once the caps are removed.

4.5.12 Summary of town centre site options

Table 4 provides a summary of the town centre energy centre site options including:

- Suitability of site for connection to a DE scheme
- Availability of site / ease of delivery
- Constraints
- Options for phasing
- Conclusions

Capabilities on project:
Building Engineering

Table 4: Summary of energy centre locations.

Site	Suitability for connection	Availability	Constraints	Phasing options	Conclusions
Distributed plant phase 1 – County Hall	This is a central location on the Phase 1 network and could allow the incorporation of CHP plant and ancillary equipment	Owned by Surrey County Council and so could be acquired, potentially as part of a partnership. Current use as car parking allows early development.	Adjacent to both the County Hall and residential areas. Noise and visual impact will need to be considered.	Suitable for initial phases of the network.	Discussions should commence at the next stage of feasibility with the County Council to ascertain viability.
Distributed plant phase 1 – Kingston University Penrhyn Road	This is a central location on the Phase 1 network and could allow the incorporation of CHP plant and ancillary equipment	Land owned by Kingston University, and may require negotiations to acquire or make use of. Car park areas may be available in the short term, but the north Townhouse area would need to wait for redevelopment.	Energy centre / plant would fit in with the current research nature of the site, but consideration required of noise and visual impact.	Suitable for initial phases of the network.	RBK should open discussions with Kingston University to ascertain future plans for the campus. This may include discussions around ownership and governance of the phase 1 scheme.
Distributed plant – future phases	Depends on location.	Depends on location.	Depends on location, but will need to consider existing / remaining site uses.	Potentially suitable for future phases of a DE scheme if providing benefits over larger centralised generation.	To be considered during each stage of DE scheme feasibility work.
Eden Quarter – P2	Located close to phases 1 and 2 of the network facilitating ease of connection.	Privately owned land, and an energy centre could only be developed on re-development of the Edenwalk shopping centre. Potentially a high development cost, although planning policy could be used to require the construction of an energy centre.	Located in retail centre and so careful consideration will be required of a number of environmental factors.	Re-development requirement means that this is likely to be an option for future phases of the network and not phase 1.	Potential for further examination and discussion with British Land, but sites P3 and P4 are more suitable.
Eden Quarter – P3 and P4	Located on the south side of the town centre close to phase 1 and adjacent to phase 2 and the ring main.	Certain areas of land owned by RBK, and current use as surface car park could afford immediate delivery with consideration of long term vision.	Located in a future retail and commercial area, and so careful design consideration required to ensure an energy centre is compatible with future uses.	Suitable as a central energy centre location for phase 1 and future phases. Potential for re-development at a later date if other sites are used later.	This site needs to be included as a priority within the masterplanning of the area and Kingston Futures. Viability of using car parking needs to be assessed.
Eastern Approach – P5 (Bus station and car park)	Located close to the Phase 1, Phase 2, and ring main networks. Potential for delivery of a large centralised energy centre if car parking can be reduced.	Ownership of car parking uncertain but not under RBK ownership therefore the commercial value of the land will need to be considered.	This is a heavily used public and and gateway to the town centre, and so careful incorporation required to minimise effect on local environment.	Suitability will depend on timescales for re-development.	This site needs to be included as an option during further scoping studies for re-development of the area.
Eastern Approach – P6 (Kingfisher Leisure centre) and P7	Located close to the Phase 1, Phase 2, and ring main networks.	Council ownership and re-development of leisure centre could allow incorporation of decentralised CHP plant, but space is limited for a large central energy centre.	Consideration is required if a large CHP engine and associated plant is to be co-located with the leisure centre, although no specific constraints are identified.	Suitability for phased connection will be determined by the timescales for the leisure centre redevelopment.	Maintain engagement with the leisure centre development team to ensure this is retained as an option during future Phase 1 feasibility study work.
Gas Holder Site	Located on a spur of the north of	Owned by Scotia Gas Networks	Potential contamination issues	Suitable for phases 2 and	Further engagement should aim

Site	Suitability for connection	Availability	Constraints	Phasing options	Conclusions
	Phase 2 and main networks. Not suitable for connection to the current identified Phase 1 network.	who want to realise commercial value of land. Current ambition for residential development.	which will increase development costs, but could favour an energy centre over residential uses. Design needs to consider neighbouring college site.	beyond only due to remoteness from phase 1, but development of site is incompatible with network proposals.	to ensure that a heat network is developed on the site, suitable for a future connection to phase 2 of the DE scheme.
Kingston Hospital	Located in future phases of the network and so not suited to phase 1 and 2. The size of the hospital (as a consumer and potential generator) justifies a branch connection.	Owned by the NHS and so public sector leverage and policy may encourage engagement. Currently no land available on the site, but future re-development may allow incorporation of an energy centre.	Consideration is required of neighbouring hospital and residential uses, but nature of a hospital site should allow for incorporation of further plant.	Suitable for long term network connection and not Phases 1 or 2.	Further engagement with hospital to ensure that re-development of site and services improves connectivity and loads for a future network, and identifies opportunities for hosting additional heat generation plant.
Hogsmill Sewage Treatment Works	Located on the ring main and so suited for future phases. A connection for phase 1 would be expensive and unlikely to be viable. Potential synergies between STW and energy generation and use.	Owned by Thames Water. In principle, spare land may be available, and Thames Water are keen to maximise asset value. Other uses for the land are limited and so an energy centre could be a suitable option.	Few constraints considered due to existing use of the site as a STW.	Most likely suitable for future phases of the DE scheme unless viability can be justified for Phase 1 and no other more central locations are found. Phasing needs to consider the Ofwat asset periods.	Further engagement with Thames water to ascertain land availability and costs, and maintain strategic relationships in terms of energy production and sales.
Hogsmill Valley Area (RBK land) including waste transfer station.	Located on the ring main and so suited for future phases. A connection for phase 1 would be expensive and unlikely to be viable.	RBK land ownership accesses land at a low cost. Certain areas, in particular adjacent to the STW, are likely to be unattractive for alternative uses making an energy centre an attractive option. Waste transfer station in RBK ownership but required for foreseen future for waste management.	Depends on exact location, but may need to consider location adjacent to residential areas. Sensitive design may also be required if adjacent to the Cemetery areas.	Most likely suitable for future phases of the DE scheme unless viability can be justified for Phase 1 and no other more central locations are found.	Inclusion of energy centre within the Hogsmill Valley AAP development.
Thames side - for river water extraction with heat pumps.	Located close to Phase 2 of the network. May require some re-configuration of the network depending on location of the site.	Identified land in private ownership and identified for re-development. A small energy centre could be included as part of the new developments.	High value land for high value development. Any proposals will need to minimise land take.	Suitable for connections from phase 2 onwards. Likely to provide larger CO_2 benefits in later phases of a DE scheme (around 2020s onwards).	RBK need to identify any parcels of land which appear along the Thames and assess potential for incorporation of a heat pump energy centre. Engagement required with the power station site to see whether additional plant can be accommodated on the development.
Distributed sources of low grade heat	Location dependent. Many of the sources from buildings are likely to be close to the network as the buildings may have a DH connection.	Depends on location. This may require heat capture heat pumps to be located at a number of sites which may or may not be in private ownership.	Site and source dependent.	Suitable for all phases where viable.	Sites to be identified during detailed feasibility work.

In summary, the following key conclusions are made in relation to energy centre locations:

i) The phase 1 network should investigate both a decentralised peak and standby boiler plant option and centralised boiler plant option:

   a. Decentralised with CHP plant located at either the County Hall, University Penrhyn Road site, or Kingfisher Leisure Centre;

   b. Centralised option with an energy centre on existing RBK car park areas in the Eden Quarter (P3 and P4) or potentially the bus station site (P5).

ii) Irrespective of whether a de-centralised or centralised option is selected for phase 1, early work is needed on allocating land for an energy centre for Phase 1 and Phase 2. The most suitable locations are P3, P4, and P5, although discussions should also commence with British Land to identify opportunities for incorporation into a re-developed Edenwalk shopping centre (P2).

iii) Strategic long term energy centre locations need to be identified and allocated in relevant strategy documents:

   a. The Hogsmill Valley area (either Thames water land or RBK land) needs to consider the location of an energy centre within the forthcoming Hogsmill Valley AAP.

   b. Ongoing communication with Kingston Hospital is required to identify opportunities for locating plant at the hospital site.

iv) A riverside location should be identified for a heat pump energy centre by the Thames, either on a site identified for re-development, or an existing site.

v) A number of smaller heat pump installations could be made around the network where suitable secondary sources of heat are identified.

In addition to the above specific opportunities, identification of land for an energy centre should remain a consideration when identifying areas for re-development, and drawing up strategic land allocations and AAPs.

4.6 Summary

This section provides an assessment of the energy supply opportunities for DE schemes in RBK.

The RBK Heat Mapping study identified the Hospital and STW as potential sources of heat. However following consultation, neither of these sites are deemed to have potential for exporting heat from current plant or equipment. The hospital has a CHP and steam main system with all heat used on site. There may be opportunity for hosting some additional plant, but the site is relatively constrained. The STW also includes a CHP system on site powered by bio-methane, but the heat and electricity output is used on site, and there is no foreseen potential for additional bio-methane production.

From a technical perspective, the most suitable technologies for producing heat are gas fired CHP systems and large scale heat pumps.

Gas CHP engines are a mature and reliable technology with advantages of modularity and a large range of sizes. Under the current grid electricity generation mix, gas fired CHP engines can provide large CO_2 savings, and if the electricity can be sold for a sufficient value, economic operation which can help fund the DH network development.

Large scale heat pumps do not currently reduce CO_2 emissions due to the relatively high CO_2 intensity of the electricity grid. However as the grid decarbonises they could provide large CO_2 savings in the future and act as the long term heat supply technology. The efficiency of heat pumps is improved with low temperature outputs, and a source temperature which is as high as possible. To potential sources of secondary heat identified are the River Thames and the outlet from Hogsmill STW, and both of these could be used on a future DE scheme.

Finding land for an energy centre/s will be critical for the development of DE in RBK. In the short term, a phase 1 network could make use of distributed boiler plant, and a central CHP engine either at the Kingston University Penrhyn Road campus, the Surrey County Council buildings, or if completed in time, the redeveloped Kingfisher Leisure centre. An alternative location is on existing surface car parking in the Eden Quarter, which would allow the development of a larger centralised energy centre, which could also be used to power a phase 2 scheme.

The main long-term option for an energy centre is in the Hogsmill Valley area, either on RBK land or on the Thames Water STW site. This provides opportunities for using secondary heat from the STW outlet in a large heat pump for future phases. The location of an energy centre in the Hogsmill Valley, in an area which can potentially connect to the STW outlet, should be seen as a priority for the forthcoming Hogsmill Valley AAP .

If heat pumps are to be a long term strategy taking secondary heat from the River Thames, a location is also required along the river bank. Therefore suitable locations, including potentially as a future addition to the power station site, need to be identified and promoted through planning.

5 Energy demands

5.1 Introduction

This section describes the energy demands within the Borough to identify potential customers who could connect to DE schemes. A more detailed discussion of the major potential customers is provided which is used to assess their suitability for connecting to a network, and how they may influence the network design or phasing. This section also includes a summary of site visits to some of the major consumers in a phase 1 scheme.

5.2 Data collection - existing sites

The main consumers of energy have been identified using the RBK Heat Mapping Study as the prime source of information. For smaller loads, the RBK Heat Mapping study data is used directly to provide information on heat demands. For larger loads, in particular in the area of the town centre phase 1 scheme, where understanding the size and nature of the heat load is important, new data requests were sent to the relevant "Large" heat consumers (as listed in Table 5.1 of the RBK Heat Mapping study) and some additional sites of particular importance. These data requests were then followed up by further questions and discussion where required. A list of the large sites is provided in Table 5.

Table 5: Sites for which individual consultation was conducted

Site name	Comments
RBK Heat Mapping study "Large" Heat consumers	
Kingston Hospital	This is the largest energy consumer considered for connection to the DHN, it is further out at about 1.5km for the Town Centre, so would only be considered for a later phase. It could be a suitable site for an Energy Centre as discussed earlier. The site has a steam distribution system which is about to be replaced, and is powered by a gas engine CHP. Further information was requested to determine future plans for the site and its heating system.
Edenwalk Shopping Centre	The location of Edenwalk shopping centre makes it well placed for connection to a town centre DHN. At present only the central atrium areas and office accommodation is on a central heating system. All retail units are on independent systems, predominantly electricity based. . Under this configuration connection to DHN would be less favourable. There is potential for future redevelopment of this site, but there are no further details available at present. However re-development of the shopping centre could provide an opportunity to install a site-wide heating scheme.
David Lloyd Gym	David Lloyd gym is part of a larger complex called The Rotunda, containing cinema, bowling alley and restaurants. The location of the gym would make it suitable for connection if extending a northern branch from a town centre, as a second phase, or a later extension.
Kingston University Penrhyn Road , Knights Park Middle Mill & Clayhill	There are a number of University sites with potential for connection to a DHN. The most likely site for connection to the Phase 1 is the main Penrhyn Road site, both in terms of location and heat load.
Kingston College	Kingston College is well placed for inclusion in Phase 1 of and is likely to for a key customer so further information was requested.

Surrey County Council	Surrey County Council is located next to Kingston College and has been identified as a “Large” Heat Customer, so is considered to be of importance for Phase 1.
John Lewis Plc	John Lewis has the largest gas consumption of all of the individual retail units identified in the RBK Heat Mapping Study. This makes the site of potential importance for connection to DHN around the Town Centre area.
Marks & Spencer	Similarly to John Lewis, Marks & Spencer is considered to be one of the larger retail units in the town centre so could be an important customer to consider for Phase 2, further information was requested.
Kingston Power Station (Kingston Heights & Kingston Riverside)	This area was granted overall consent in 2008 for 359 apartments and a 150 room hotel. The close location to the Thames has enabled the site to include a water-source heat pump, and could be the location for a future DE scheme heat pump energy centre.
Additional sites of interest	
Crown Court	The Crown Court was not identified in the RBK Heat Mapping study, presumably due to not appearing on the common databases used. Its size and location between the County Hall and College makes is a potentially important and obvious inclusion for Phase 1. Further information was requested.
Guildhall and Guildhall 2	These are not identified in the RBK Heat Mapping study as a Large consumer due to being split into the 3 Guildhall buildings. Due to the obvious ownership interest and overall size, further information was requested for these buildings. .
Bentalls Shopping Centre and Department Store	Bentalls Shopping Centre contains the Bentalls department store as well as a number of other smaller retail units. For any network that connects to John Lewis or extends north to Kingston Power Station Redevelopment, a connection to Bentalls should also be considered. As with Edenwalk shopping centre, the nature of the load is important as most shopping centres make use of individual heating systems for each retail unit.
Cambridge Road Estate – RBK Housing	This site consists of 650 social homes owned by RBK. 240 homes are located in the Brinkley, Madingley, Graveley, and Childerley 15 storey tower blocks, with the remaining in low rise flats. This estate has recently been retrofitted with new wet heating systems (it used electric heating originally), and individual gas fired condensing boilers in each unit. The opportunity has thus been missed to retrofit with a community heating system in the near term, but this may be an option in future phases of a DE scheme when the boilers need replacement. The central ownership of RBK could help facilitate this, although leasehold arrangements, if any, will need to be considered.

Further information on the data received and any follow up discussions is provided in Appendix 1: Site visits. As can be observed, the data request process had a varying degree of success with some sites unable to provide some or all of the data requested. This shows the importance of RBK developing a robust communication strategy as part of their DE development programme to ensure there is buy-in from all potential customers.

5.3 Assessment of RBK data

The RBK Heat Mapping study data has been used as the basis for this study, with additional information obtained on the large loads as described above. . It is important to note that the RBK Heat Mapping dataset contains information for a large number of buildings from a range of sources, and a comprehensive check of this data and verification is beyond the scope of this EMP. Therefore a simple approach was taken to sense-check the information

- Where data is provided and based on data collection from the building occupiers or managers, this is assumed to be correct. It is assumed that no further changes have been made to the buildings which affect heat demand since the original data collection for the RBK Heat Mapping study.
- Where benchmarks have been used for non-domestic buildings, a simple check has been made by dividing the stated annual fuel consumption by the GIA where available. The expected energy consumption varies for different building types so the buildings for connection to the DHN are categorized in terms of building type and checked against the CIBSE Guide TM46 benchmarks.
- For domestic buildings, the gas consumption per dwelling in the RBK heat mapping study ranges from 6.5MWh to 15MWh per year. The assumptions used for the new and proposed developments give a gas consumption of approximately 4.5MWh per dwelling based on a relatively small flat size and current building regulations. Both of these appear reasonable and in line with models of new dwellings and average consumption from existing dwellings. Therefore the data from the RBK Heat Mapping study is assumed to be reliable for flats.

In general, most of the information provided from the RBK Heat Mapping study showed a good match with the benchmarks. Key inconsistencies in the RBK Heat Mapping study included:

- It was assumed that the retail units in the Bentalls shopping centre, and Eden Walk shopping centre were on a common gas fired boiler system. Consultation with the shopping centres showed that only the central atria areas (and the Millennium House office area for Edenwalk) are on the centralised system, and all individual retail units are on separate systems electrically powered. This makes a DH connection to all these units unviable without major retrofit.
- The RBK Heat Mapping study identified Regents Court, a large development of private flats located to the North of the Railway station, as being heated by a common gas fired system. Research shows that these units all have individual electric radiant panel heating systems, and are therefore not suited for connection to a DE scheme without major retrofit.

Further information on inconsistencies are identified in Appendix 2: Energy demand analysis

5.4 Site visits

Site visits were carried out for the major consumers considered for the first phase of a DHN, with details given in Appendix 1: Site visits. The sites were selected based on their size, the opportunity they present for connection to a DE scheme, and on the basis that some energy users may be more complex, requiring a more in-depth understanding.

The following sites were visited:

- RBK Guildhall buildings (Guildhall, 2, and 3).
- Kingston College
- County Hall
- Kingston University Penrhyn Road site

- Kingston University Knights Park site
- Bentalls shopping centre
- Edenwalk shopping centre
- David Lloyd gym

The aim of the visits was to obtain information on:

- The location of existing plant and distribution around sites
- Access potential for a DHN connection including routing of pipework
- The type of existing heating system to assess compatibility

No site visits were made to the Tolworth area. The only site of interest (from the scoping work) is the Tolworth Tower complex and no suitable contacts were found at the time.

5.5 Assumptions used in developing energy load information

For the DE scheme concept design and assessment, a monthly profile is used to optimise the number and size of CHP engines and boilers, as well as thermal storage. The peak energy demand is also used to model the network and determine the size of the pipes required, and ensure sufficient peak heat generation capacity is provided.

For the major energy consumers this information was requested directly. Where this information could not be provided and only annual energy demand was available, for example from the RBK heat mapping study, the following assumptions were used to estimate the peak demand and monthly profile:

- 10% of the total annual demand for non-domestic buildings is for DHW. This forms a constant base load and is evenly spread across the year. The remaining 90% of the annual demand is for space heating, which varies according to the season, and is accounted for by 20 year average degree days[28], assuming there is no space heating required for the months of June to August inclusive.
- For dwellings, assume a baseline demand of 2,500 kWh per dwelling per year for hot water. The remaining demand is accounted for by 20 year average degree days.
- For new build dwellings, assume the hot water consumption accounts for 67% (two thirds) of the heating demand, which forms the baseline of the annual profile. The remaining third, for heating, is accounted for by 20 year average degree days. (Note that the actual split will depend on the dwelling type, but this simple approximation is typical of new build flats with very low space heating demands).
- The peak load for each building is based on the annual heating demand with a 10% load factor where alternative information is not available. This provides a suitable order of magnitude value, and from AECOM's experience on other schemes, is typical of many non-domestic buildings. This is used to size the DHN and the heat exchangers.

Other general assumptions include:

- All energy data is provided in terms of consumption, so to determine demand an efficiency of 80% is assumed for all boilers.
- Gas price = 2.6p/kWh is used where not other information is provided

[28] Information on degree days is taken from www.vesma.com using a 20-year average for the Thames region.

- Electricity price = 10p/kWh is used where no other information is provided

5.6 Energy load information - heating

Table 6 lists all of the energy consumers considered for connection to a DHN, and key information on energy consumption.

Table 6: Energy Consumption and peak load for each building

Name	Annual heating demand (MWh)	Peak heat demand (kW)	Data source	Typology
Phase 1				
Surrey County Council	2450	3000	Request	Local Government
Kingston Crown Court	2000	2000	Estimate/Benchmark	Government
Kingston University – Penrhyn Road Campus 1	1970	1440	Request	Education – Private
Kingston University – Penrhyn Road Campus 2	1850	1000	Request	Education – Private
Kingston University – Penrhyn Road Campus 3	1850	4050	Request	Education – Private
Garricks House	1300	1490	Heat mapping Study	Multi-address building
Kingston College N – Kingston Hall Road	1150	2180	Request	Education – Private
Kingston College S – Kingston Hall Road	1150	490	Request	Education – Private
Guildhall 2	910	960	Request	Local Government
Stevens House	900	1030	Heat mapping Study	Multi-address building
Avante Court	860	990	Heat mapping Study	Multi-address building
Police Station	710	810	Heat mapping Study	Public
Guildhall	600	760	Request	Local Government
HM Revenue & Customs	590	670	Heat mapping Study	Local Government
County Court	120	130	Heat mapping Study	Public
Phase 2				
John Lewis PLC	3370	1500	Request	Private commercial
Bentalls Department Store	2430	2600	Request	Private commercial
P2/3 Eden walk future	2110	2410	Estimate/Benchmark	Multi-address building
P12 Kingston Power Station Redevelopment	1910	1740	Energy Statement	Multi-address building
Travelodge – Central	1530	1750	Heat mapping Study	Private commercial
David Lloyd Gym & Rotunda	1360	1500	Estimate/Benchmark	Sport & Leisure
45-51 High street	1300	1480	Energy Statement	Multi-address building
Kingfisher Leisure Centre	1270	1450	Heat mapping Study	Sport & Leisure
Marks & Spencer PLC	960	1100	Heat mapping Study	Private commercial
P19 Gasholders Richmond Road	910	830	Estimates based on dwelling number	Multi-address building
Kingston University – Knights Park 1	860	1100	Request	Education – Private
Kingston University – Knights Park 2	860	1200	Request	Education – Private

Name	Annual heating demand (MWh)	Peak heat demand (kW)	Data source	Typology
Quebec House	670	770	Heat mapping Study	Multi-address building
Thames Side Wharf Vicarage Road	610	560	Energy Statement	Multi-address building
Kingston University – Middle Mill	590	680	Request	Education – Private
P8 East of Clarence Street	510	640	Estimates based on dwelling number	Multi-address building
Museum and Heritage Service	440	510	Heat mapping Study	Sport & Leisure
Curves	410	470	Heat mapping Study	Sport & Leisure
P4 St James Area	360	800	Estimates based on dwelling number	Multi-address building
P19 Kingston College Richmond Road	280	320	Request	Multi-address building
Bedelsford School	270	310	RBK	Education – Private
Bentalls Shopping Centre	170	1000	Heat mapping Study	Private commercial
Library	140	160	Heat mapping Study	Local Government
P5/6 Bus Station/ Leisure Centre redevelopment	140	120	Estimates based on dwelling number	Multi-address building
Schools Library Service	40	50	Heat mapping Study	Local Government
Eden Walk Shopping Centre	20	20	Request	Private commercial
Phase 3				
Kingston Hospital	37600	42900	Heat mapping Study	Healthcare
Kingston University Clay Hill	2390	2730	Heat mapping Study	Education - Private
Cambridge Road - Brinkley	1580	980	Heat mapping Study	Multi-address building
Cambridge Road - Madingly	1580	980	Heat mapping Study	Multi-address building
Cambridge Road - Graveley	1580	980	Heat mapping Study	Multi-address building
Cambridge Road - Childerley	1580	980	Heat mapping Study	Multi-address building
Tiffin School	1060	1210	RBK	Education - Local Government
Wolverton House	900	1020	Heat mapping Study	Multi-address building
Kingston Grammar School	670	770	Heat mapping Study	Education - Private
Bausch & Lomb House	580	660	Heat mapping Study	Private commercial
Buick House	490	560	Heat mapping Study	Multi-address building
King Athelstan School	230	270	RBK	Education - Local Government
St Johns C of E School	110	130	RBK	Education - Private

Table 7 gives the total monthly profile of each of the different building typologies, shown graphically in Figure 30 . This total includes energy consumers listed in the table above split by phase of DHN. This shows that due to the predominantly commercial and public sector nature of the customers, the monlty profile is dominated by winter space heating demands. It should be noted that if more accurate monthly data was obtained from individual customers rather than the use of assumptions, then the exact nature of the profile could be established.

Table 7: Monthly heating profile by Phase

Phase	Monthly Heat Demand (MWh)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	2900	2700	2300	1600	1200	300	200	200	800	1000	2200	2800
2	6400	6100	5100	3700	2800	900	800	600	1700	2600	4700	6200
3	14700	13500	11700	8400	5700	1300	1200	1000	3300	6000	10700	14700

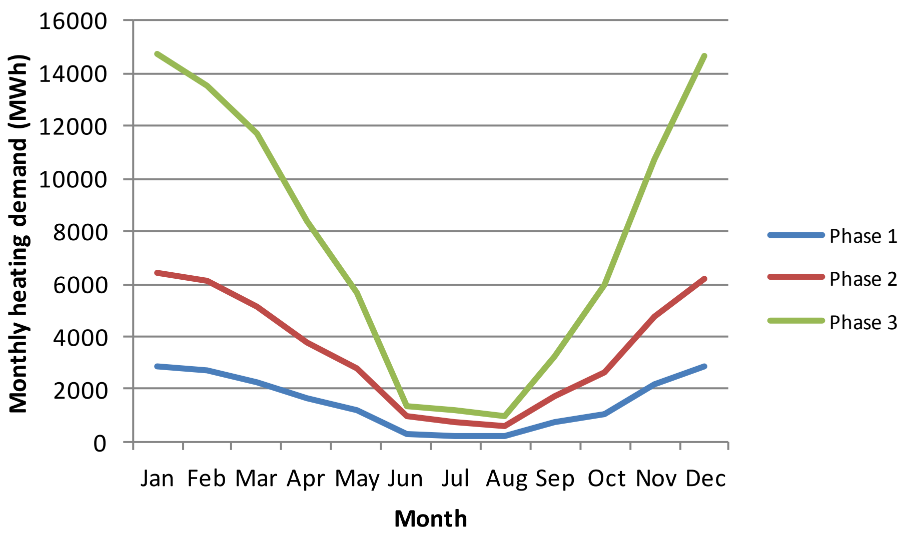


Figure 30: Graph of heat demand profile by phase

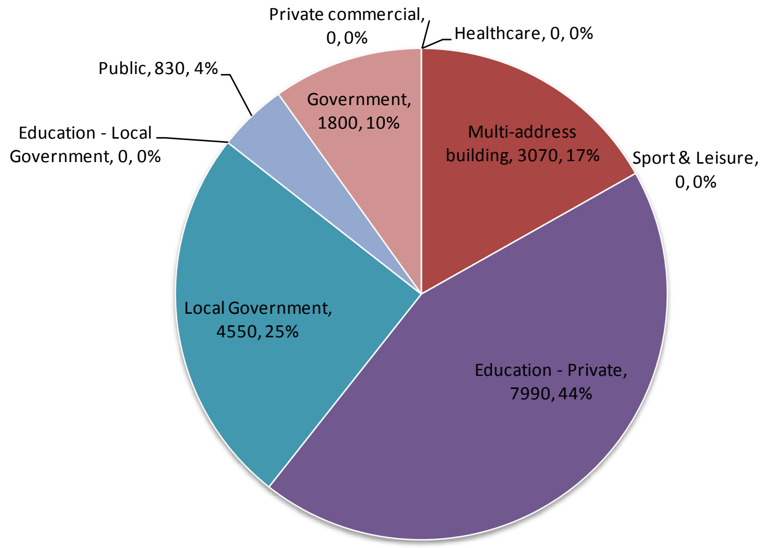
The charts in Figure 31 provide a breakdown of the annual heating demand by phase and tenure.

In phase 1, the heat loads are dominated by the Education sector, with almost half of the heat demand from the Kingston University Penrhyn Road campus and the college. The Kingston University site is around three quarters of this and so could be considered the anchor load for a phase 1 scheme in terms of annual heat sales. If the Education sector was considered as a public sector customer, then over 80% of the Phase 1 heat load is with the public sector.

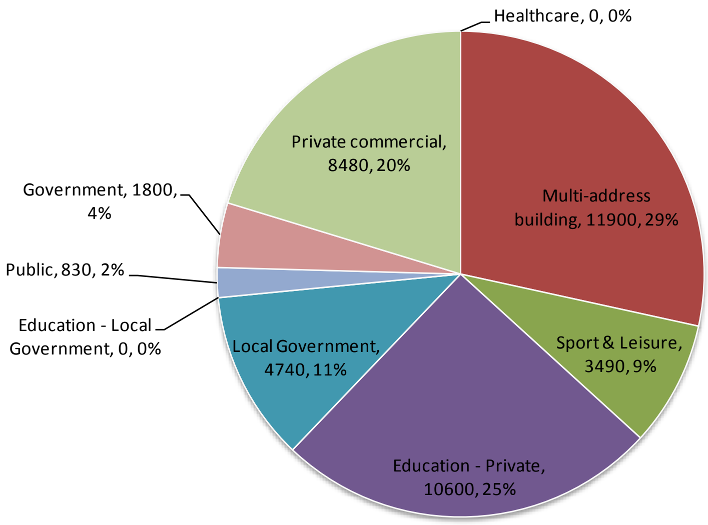
In phase 2, there is a greater diversity in demand by sector, with the private commercial sector (predominantly retail) making up almost one fifth of the annual demand. Multi-address customers with new development in the town centre also accounts for almost one third of the annual demand.

The phase 3 network shows a large transition in customer base with the connection of Kingston Hospital. The hospital provides a significant baseload of over 40% of the annual heat demand. This shows the importance of working with the NHS Trust during the development of the scheme, and to identify the role the hospital may take, either as a heat purchaser or supplier.

Phase 1: Total demand 18,200 MWh / yr



Phase 2: Total demand 41,600 MWh / yr



Phase 3: Total demand 92,200 MWh/ yr

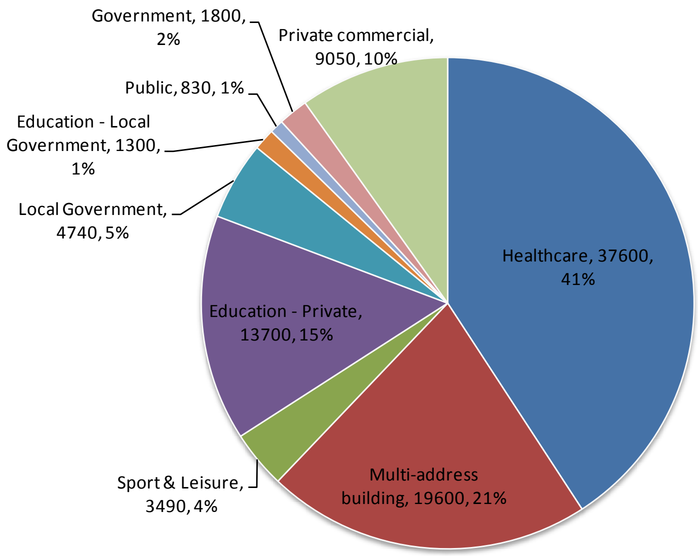


Figure 31: Pie charts of Annual heating demand by building type for each phase

Further information is provided on the energy demand analysis, including detailed descriptions of individual sites, in Appendix 2: Energy demand analysis.

6 Energy distribution analysis

6.1 Introduction

This section describes the options for DHNs in the Town Centre and Tolworth areas. Based on the energy demand analysis, network options are developed which link together the identified potential customers. Routing of the network options is considered based on major opportunities and constraints. The network options also consider phasing, with a more detailed analysis of the Phase 1 options.

6.2 District heating network design considerations

Before considering potential network layouts for RBK, a number of factors need to be considered which may influence the DHN layout and design .These include:

- The flow and return temperature difference.
- The operating temperatures
- The choice of layout type
- The phasing of the network and future expansion
- The location of the energy centre
- Distribution of energy supply sources

These are discussed in more detail in this section, and help inform the analysis of network options for RBK.

6.2.1 Flow and return temperature difference

The capacity of the network to transmit thermal energy is determined by the difference in flow and return temperatures. Modern networks designed for LTHW distribution typically operate with a flow of around 90°C and a return temperature of around 50°C – 60°C giving a temperature difference ΔT of circa 30°C - 40°C. The ΔT determines the amount of thermal energy which can be extracted, with a larger ΔT allowing more thermal energy to be extracted for the same volume of water.

DHN pipes are sized to carry the required thermal load. The combination of ΔT and the desired flow rate results in a pipe diameter. The optimisation of diameter also needs to consider pumping energy requirements such that pipes are sized to be economic and with low heat losses (suggesting a small diameter), but with acceptably low pressure losses and pumping requirements (which requires a larger diameter). For this study, it is assumed that optimal pipe diameters will be given if a maximum flow velocity of 2.5 m/s and maximum pressure drop of 250 Pa/m are assumed.

For the purpose of this study, a ΔT of 30°C is assumed to inform the sizing of the network. This is conservative and allows for some future increase in load carrying capacity if a larger ΔT can be achieved. It also allows for a low temperature operating regime (see below).

6.2.2 Operating temperatures

Whilst the temperature difference on a network determines the load carrying capacity, the actual operating temperatures impact on the building heating systems and the energy supply technologies.

The typical flow and return regime of 90/60°C is potentially suited for connection to existing buildings which have heating systems design to operate at circa 80/70°C if the return temperature of the heating system can be reduced. If the operating temperatures are too low, then the average temperature is reduced and the building's heating system may be undersized to provide adequate heating at the lower average temperatures. In reality, there is some flexibility here:

- Building heating systems are often oversized, and there may be some leeway for operating at lower temperatures without any impact on thermal comfort.
- Heating systems are designed for extreme temperatures and therefore even if the temperatures from the DHN are lower than the heating system's design temperature, adequate heating will be available for the majority of the year with only a small drop in extreme conditions (further information on this is provided in the GLA secondary heating study, footnote 15).
- For older buildings, the heating systems may be refurbished in the future, allowing the incorporation of lower design temperature systems (effectively larger and more efficient heat emitters). In addition, thermal efficiency improvements to existing buildings may have reduced the heating demand thus allowing for a reduction in operating temperatures.

The considerations above mean that whilst the operating temperatures for buildings which are to connect to a DHN are important, there is a degree of flexibility, and these alone should not determine the operating regime for the network.

In addition to the building systems, the operating temperature needs to be suited to the energy supply technology. At present, the majority of energy supply technologies are combustion based giving high grade heat to develop a flow temperature of around 90°C. In the future if lower carbon technologies are to be used to provide heat, including the use of electrically driven heat pumps, the ability of the building heating systems to operate when supplied with lower temperatures (for example 70/40°C) will be important. Technologies such as heat pumps are either unable to achieve the higher temperatures, or become very inefficient, and operate most efficiently at lower temperatures. Therefore if DHNs are to be developed as a future proof heat supply infrastructure, the design needs to consider low temperature operation.

There are limits on the operating temperature of a network. At 70/40°C, the average temperature of 55°C will require higher output systems in buildings. This may be achievable for new buildings, but more difficult to achieve with existing heating systems unless there is extensive retrofit. In addition, the network needs to be able to deliver a high enough temperature to ensure that DHW systems do not develop legionella. This means storage of hot water must be kept at 60°C and heated above this temperature periodically. Local top-up heat boilers can be used for this purpose in areas where this is an issue.

6.2.3 Layout type

There are two basic DH layout options as shown in Figure 32.

A branch network consists of a single set of flow and return pipes to each load or section of the network, with the energy centre at the beginning of the system. This layout can be optimised such that the overall length of pipework is minimised to help reduce costs. The disadvantage is that there is little resilience, and if part of the network fails, there is no alternative route to distribute heat.

In a branch based system, the diameter of the pipework generally decreases further away from the energy centre such that each section of pipe is sized for upstream loads only. The network layout is therefore heavily influenced by the location of the energy centre.

In a ring configuration, the network consists of two sets of pipes from the energy centre which are linked to form a ring. This means that if there is a failure at any point of the network, heat can be provided through the alternative route. As an extreme case, the entire ring could be sized to take the total load – this provides full resilience and flexibility for energy centre location. This would however be significantly oversized for the majority of the network and correspondingly expensive. A compromise is for the ring to be sized as two halves (as shown in Figure 32) with the network reducing in size each direction. This allows for some resilience, but not full load around the entire network. However if a failure occurred, the network would still be able to provide part load to all customers, which in combination with temporary changes to operation (for example increasing pump pressures) would be sufficient for most periods except in the coldest weather.

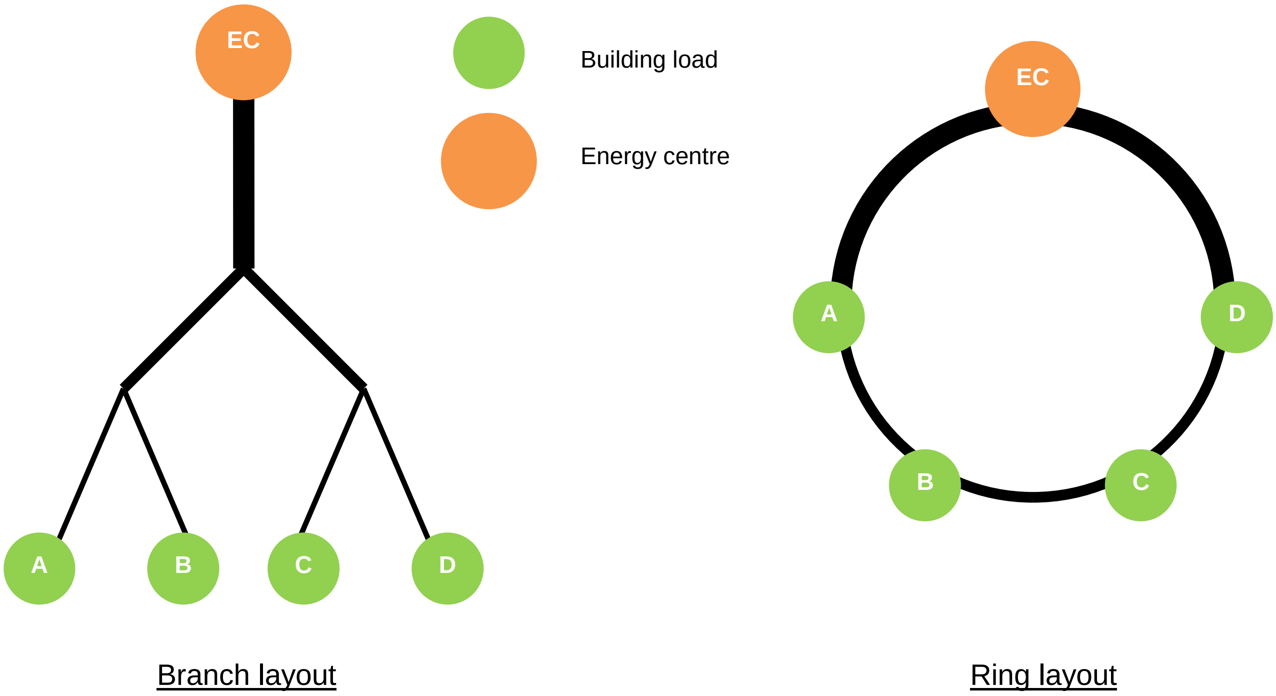


Figure 32: Types of DHN layout showing a branch layout (left) and ring layout (right).

In reality, large networks will probably comprise a mix of layouts with some areas being served by a ring and others by a branch. The form of the network is often determined by the phased build out of the network over a period of years which responds to changes in energy supply and heat loads.

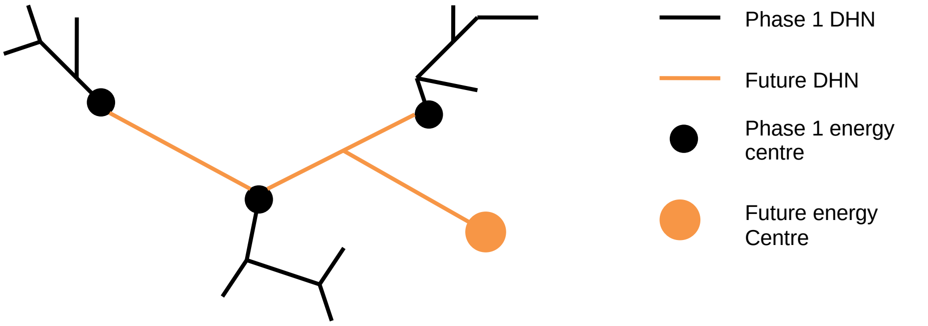
6.2.4 Phasing and future expansion

This EMP aims to establish the future vision for DE in Kingston. It is unlikely that a large scale DHN will be developed in one phase, and most likely that a DHN grow from a first phase scheme, potentially connecting a number of smaller schemes together. It is therefore essential that the design of each element of the network and each phased build out considers the long term DHN opportunity such that the network is future proofed as much as possible.

There are a number of ways in which networks can be phased as illustrated in Figure 33.

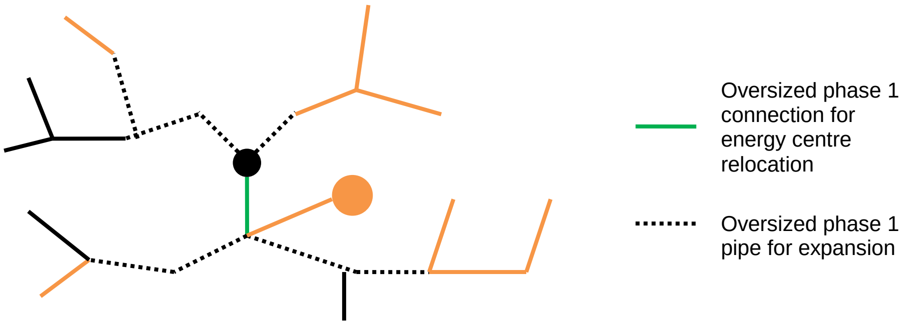
Case 1: Connection to nodes

A number of smaller networks develop, each with their own energy centre. These are then connected in the future by a large network and energy centre. By connecting to the existing individual energy centres, the phase 1 schemes do not need to be sized for future expansion.



Case 2: Expansion

A phase 1 network expands to connect to additional loads. This expansion may require a larger energy centre located in a different area. The phase 1 design may need to be oversized to allow for the energy centre re-location, and to enable future expansion



Case 3: Linking

A number of smaller networks link together linearly to form a larger network. Some pipes in the phase 1 network are oversized to allow linking. A new energy centre may be developed in future phases.

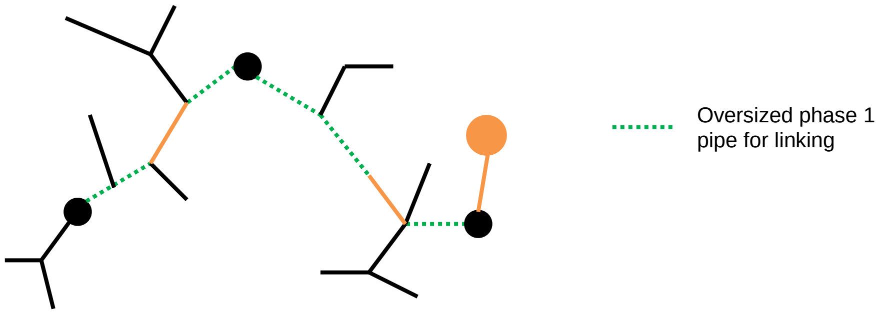


Figure 33: Basic network phasing and expansion options

The types of expansion in Figure 33 are simplified and often more than one of these will occur or be desired. In each of the cases, there are different consequences for the network design:

- In Case 1, the long term vision has no impact on the phase 1 network/s due to future connections being made at the energy centre locations. This means that the network sees the same heat loads and same heat supply and is sized appropriately.
- In Case 2, the network grows organically with new branches being added to the existing network. This means that the phase 1 network needs some routes to be oversized to be capable of taking the future loads. Whilst it may not be possible to predict the size or location of all future loads in the first phase, key routes can be oversized to allow for this expansion, for example main transmission pipes and areas where there may be pinch-points such as railway crossings or areas where future retrofit will be challenging.

- In Case 3, a number of smaller networks are joined together, such that they form part of a larger transmission system. This means that certain elements of the smaller networks need to be oversized to allow for heat provision to neighbouring networks as well as their own loads. It is possible that this linking will also include a new larger energy centre and so some consideration is required of where this may be located during phase 1. This case is typical of schemes where smaller starter networks are developed with temporary plant which later link and connect to a single energy centre once the aggregated loads are sufficient.

The design of networks in Kingston will need to consider which of these cases (or combination of) may be relevant to allow phase 1 DHNs to expand and develop into a wider town centre scheme. This means that the design of phase 1 DHNs will need to consider the long term vision for the Borough, and ensure that certain network components are sized to allow this future expansion and connection.

6.2.5 Energy centre location

The descriptions above on layout type, and phasing and expansion, show the importance of the energy centre location in terms of the network design and layout. In all cases, the DHN needs to be appropriately sized to enable the required flow rates of LTHW to be achieved to meet loads in all part of the network, such that the capacity of the network increases closer to the energy centre.

In the phase 1 schemes, the pipes can potentially be sized as a stand-alone scheme if it expands through a new connection to the Phase 1 energy centre location. However in all other cases, the phase 1 network will need to be oversized in some components to allow an alternative heat source location.

In the case of a ring network, there may be some flexibility in energy centre location although significant over-sizing of the network is to be avoided to limit capital investment.

6.2.6 Distribution of energy supply sources

In a conventional network with centralised heat generation, possibly in a single energy centre, the network can be sized to meet the peak load of each building. In the final section of each branch connection to the individual loads the pipes will be sized for the peak capacity, whilst pipes closer to the energy centre meeting the loads of a number of buildings can be potentially reduced in size due to diversity (not all buildings require peak capacity at the same time).

An alternative option is to make use of a number of heat sources, including having centralised CHP plant, but using the boilers in each building to provide top up. This can provide greater resilience (some/all buildings retain boiler plant), reduce capital investment, and limit the land required for an energy centre. If this set-up is to be retained in the future, then the DHN pipes can be sized so that they only distribute the CHP output and not the peak load, reducing the capital investment.

However, maximum flexibility will be provided if the network is sized for centralised heat generation plant allowing future changes and greater centralisation in heat supply. Whilst an undersized DHN with distributed heat supply may be lower cost, there is reduced future flexibility without significant re-investment into the network. The cost savings from under sizing the pipes may also be relatively small – the cost of the pipe is only one element of the DHN investment and other costs such as civil engineering works and installation may be less dependent on pipe size. Oversized pipe will increase capital costs but have the benefit of lower pumping costs if used to supply the CHP output only in the initial phases.

6.2.7 Design considerations for Kingston

Section 6.2 sets out a number of considerations for network design. Based on this discussion, the following design parameters are proposed for the development of DHNs in Kingston:

- The network should be designed for operation at a ΔT of 30°C. This allows for future flexibility if larger ΔTs can be used, whilst allowing for adequate heat provision to existing buildings in phase 1.

- The network should be designed with initial flow and return temperatures of 95/65°C to ensure that adequate heating can be supplied to existing buildings in future phases with minimal modifications. The design should allow for lower temperature operation (for example 70/40°C) in the future if retrofit of existing buildings combined with purposed designed heating systems in new buildings allows. This will enable more efficient operation (with lower thermal losses) and the ability to use alternative sources of heat.
- The network should use a combination of ring and branch layouts where appropriate.
- The design of early phases of the network should be compatible with the long term vision such that expansion can be achieved with little or no modification or replacement of existing pipework. This means that some sections of early phases will need to be oversized.
- The design of the early phases will need to consider early and later phase energy centre locations. This may impact on both the layout and sizing of branches of the network.

6.3 Concept design of DHNs in Kingston

This section outlines DHN options for Kingston to identify potential routes and layouts for further analysis. All routes and layouts discussed in this report are based on the high level energy load information used, and basic mapping analysis. These have been developed for the purpose of identifying strategic options, and further more detailed feasibility analysis will be required to assess the layouts in more detail.

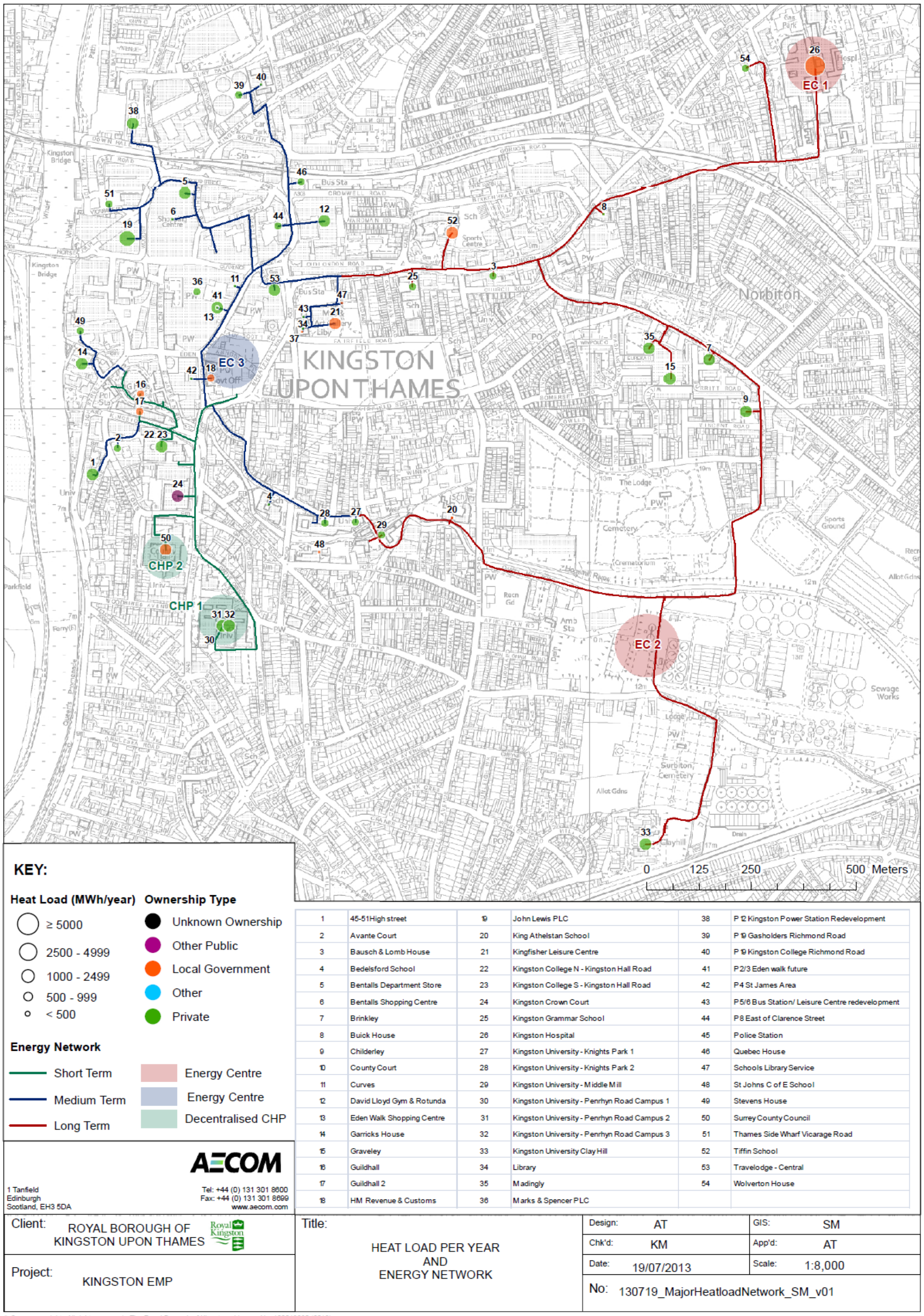
6.3.1 Long term vision

Based on the identification of energy sources in Section 4 and energy demands in Section 5, the combination of a ring and branch based network has been developed. This allows for connection to the major loads identified in the Town Centre and Hogsmill areas, and potential for sourcing heat from a number of locations to allow for future flexibility.

The proposed layout for the long term vision of the DHN is shown in Figure 34 below.

The concept is based around a main ring network linking together the town centre and Hogsmill Valley area, and a branch off the ring along Penrhyn Road. A number of smaller branches will also be required to connect small groups of buildings or individual loads.

Capabilities on project:
Building Engineering



1	45-51High street	19	John Lewis PLC	38	P 12 Kingston Power Station Redevelopment
2	Avante Court	20	King Athelstan School	39	P 19 Gasholders Richmond Road
3	Bausch & Lomb House	21	Kingfisher Leisure Centre	40	P 19 Kingston College Richmond Road
4	Bedelsford School	22	Kingston College N - Kingston Hall Road	41	P 2/3 Eden walk future
5	Bentalls Department Store	23	Kingston College S - Kingston Hall Road	42	P 4 St James Area
6	Bentalls Shopping Centre	24	Kingston Crown Court	43	P 5/6 Bus Station/ Leisure Centre redevelopment
7	Brinkley	25	Kingston Grammar School	44	P 8 East of Clarence Street
8	Buick House	26	Kingston Hospital	45	Police Station
9	Childerley	27	Kingston University - Knights Park 1	46	Quebec House
10	County Court	28	Kingston University - Knights Park 2	47	Schools Library Service
11	Curves	29	Kingston University - Middle Mill	48	St Johns C of E School
12	David Lloyd Gym & Rotunda	30	Kingston University - Penrhyn Road Campus 1	49	Stevens House
13	Eden Walk Shopping Centre	31	Kingston University - Penrhyn Road Campus 2	50	Surrey County Council
14	Garricks House	32	Kingston University - Penrhyn Road Campus 3	51	Thames Side Wharf Vicarage Road
15	Graveley	33	Kingston University Clay Hill	52	Tiffin School
16	Guildhall	34	Library	53	Travelodge - Central
17	Guildhall 2	35	Madingly	54	Wolverton House
18	HM Revenue & Customs	36	Marks & Spencer PLC		

Figure 34: Concept diagram of the long term DE vision

6.3.2 Near term vision

As identified in Section 3, a potential Phase 1 scheme exists along Penrhyn Road linking together some key public sector loads which are all located adjacent to each other. Penrhyn Road offers the most obvious route for the main branch of the DHN although other routes using smaller roads may also be viable. The buildings identified for connection are as follows:

- Kingston University Penrhyn Road campus
- County Hall (Surrey County Council)
- Kingston Crown Court
- Kingston College
- Kingston County Court
- Guildhall, Guildhall 2 (RBK)
- Kingston Police Station

The buildings are all in the public sector which can help support the development of an early stage network, allowing cooperation between parties, and reducing the need to provide an aggressive commercial heat price. The longevity of the sites also allows long term contracts to be developed with the building occupiers / owners confident of long term occupation. Connection to these buildings forms a baseline scheme, and sensitive's are examined on this.

The energy supply for a first phase network could be from a number of sources:

- Centralised CHP plant, with localised boiler provision. This will offer the lowest cost initial option.
- Centralised CHP and boiler plant located on the phase 1 network.
- Centralised CHP and boiler plant located elsewhere and connected to the phase 1 network. For example at the re-developed Eden Walk area.

The location and layout of Phase 1, as shown in Figure 34 allows initial development independent of any future ring network, and could therefore be viewed as a standalone scheme which can operate irrespective of future expansion. This reduces the investment risk by removing the need for investment in Phase 1 which is to facilitate future phases, for example, strategic pipe over-sizing.

6.4 Phase 1 network options

There are a number of possible options to be considered for the layout and extent of Phase 1. These are discussed below:

6.4.1 Phase 1 Baseline design

Connection to the seven sites listed above, with energy supply from a centralised CHP and boiler plant located at the south end of the re-developed Edenwalk area. Figure 35 shows a schematic of the preliminary Phase 1 network.

Capabilities on project:
Building Engineering

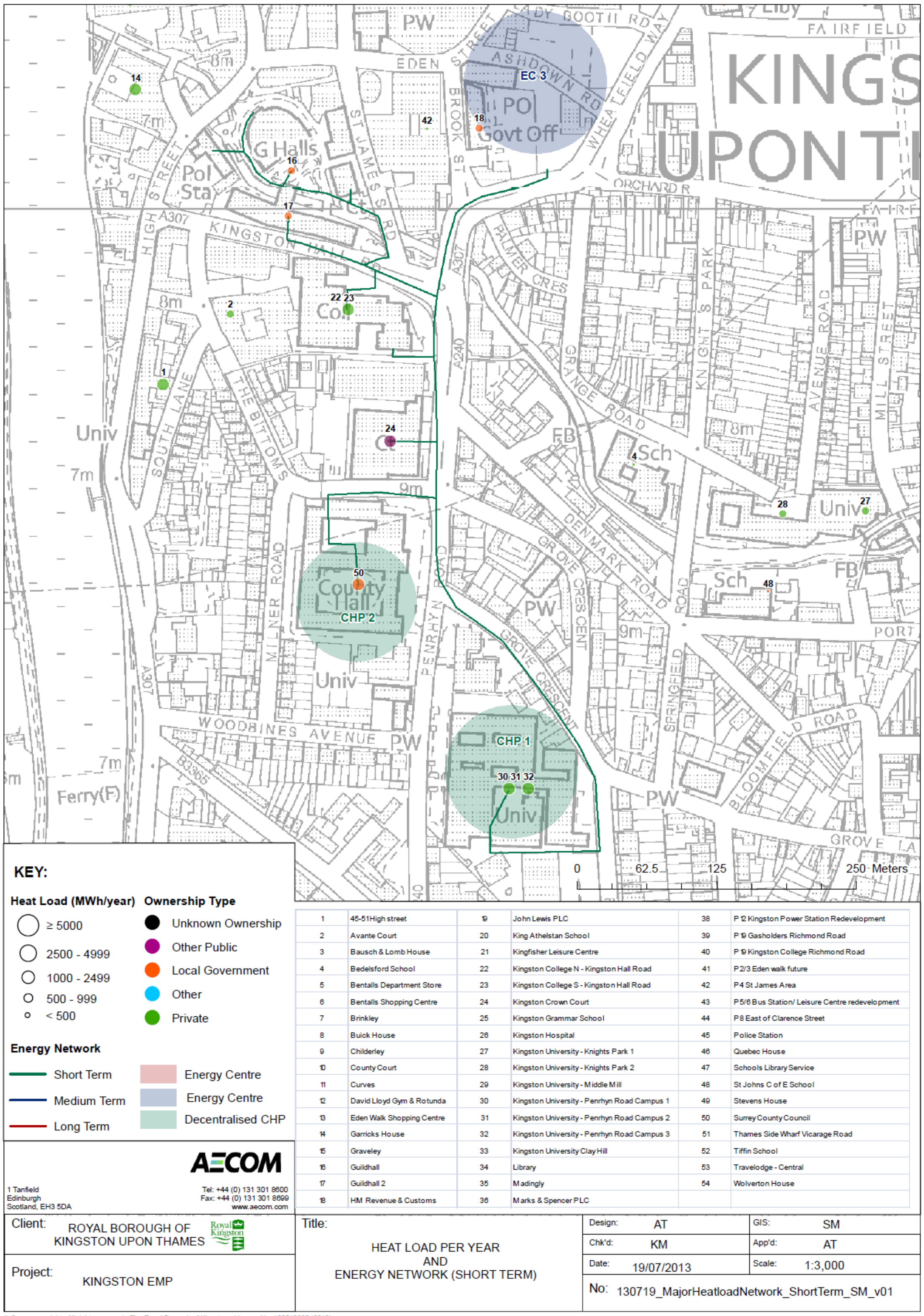


Figure 35: Schematic of the Phase 1 network

6.4.2 Phase 1 Network Variations

In addition to the baseline Phase 1 option, a number of variations are considered.

1. Centralised CHP and boiler plant located on the baseline Phase 1 network, located at Kingston College

This option is selected to determine the impact of locating the energy centre directly on the phase 1 network, and not at the more distant Edenwalk site. The selection of Kingston College is for illustration purposes only – at present it is uncertain whether an energy centre could be located on this site and no obvious areas were identified on the site visit. However location of an energy centre on or close to this location could offer compatibility with an extension to later phases as this is the likely area of connection with a Phase 2 network. This results in optimisation of the DH pipe sizing as described in Case 1 of 6.2.4.

Whilst Kingston College does not appear to offer a realistic opportunity for location of an energy centre at present, if this variation is attractive economically (see section 8), then it could promote the identification of sites immediately on the Phase 1 network, either at the College or other locations.

2. Centralised CHP and boiler plant located on the baseline Phase 1 network, with flexibility of location, therefore all pipes along the main branch are sized for total load

As the location of an energy centre is uncertain, this option offers flexibility of connection, both in the short term and for future phases. The distribution main along Penrhyn Road is sized to take the total load, with a diameter of 300mm, and therefore an energy centre could in theory be connected anywhere along the Phase 1 network.

3. Centralised CHP plant as for baseline, with localised boiler provision

This option examines locating the CHP plant at a central boiler house, but makes use of distributed standby and top-up boilers around the scheme (potentially the existing building's boilers). This allows the energy centre to be significantly smaller with no major boiler plant, and with a smaller land take. The costs of this option may also be reduced if the network is sized for baseload heat supply from the CHP rather than peak heat supply. In this EMP, it is assumed the network is sized for 50% of peak loads – this means that the future flexibility of the network is reduced and that all buildings may need to retain boiler plant.

4. Kingston University Penrhyn Road campus not connected

Connection to the Penrhyn Road campus accounts for approximately a third of the pipe length, which increases the capital cost, but also accounts for a third of the heat demand for Phase 1. This option allows the economic benefit of connecting to the Kingston University Penrhyn Road campus to be assessed.

5. Connection of additional loads

This option assesses the impact of connecting some additional loads to the network which are not on the baseline scheme.

- Avante House
- 45-51 High Street Redevelopment
- Stevens house
- Garricks House

These sites are more distant from the Phase 1 DH network than the rest of those identified for Phase 1, but they do add additional heat load, and so there may be a case for connecting to them, either as part of the initial Phase 1 installation or as an extension in the future once the initial network has been established.

6.4.3 Summary of Phase 1 networks

Table 8 shows a summary of the baseline and variation phase 1 networks. The capital cost of the baseline network is £2.2M resulting in a network with 16.8MW thermal load and a length of 1.6km. The capital cost per annual unit of heat delivered is £0.16 per kWh (this in reality would be spread over the life of the network but is used as a simple proxy for cost efficiency).

The most cost efficient network is Variation 1, with the location of the energy centre on the network resulting in a reduction in network length of 265m and a cost reduction of around £0.6M. The large reduction in cost is due to the fact that the reduction in length of the largest diameter pipe on the network.

The least cost efficient network is Variation 2 where the central distribution pipe is sized uniformly allowing flexibility in energy centre location and some capacity for future expansion. This increase in cost needs to be balanced against the benefits of future flexibility.

By using distributed boilers and only sizing the network for base load (Variation 3), the cost is reduced by £0.4M which has a relatively small impact on the cost efficiency.

Table 8: Summary of Phase 1 networks (please note that capital costs include the DH network pipework only. The total scheme costs are provided in section 8).

	Baseline	Network Variation 1	Network Variation 2	Network Variation 3	Network Variation 4	Network Variation 5
Pipe length (m)	1635	1370	1635	1635	1090	2045
Length of Oversized pipe (m)	-	-	540	-	-	-
Total network capacity (kW)	16,820	16,820	16,820	8,410	10,330	21,800
Line load (kWh/m)	8220	9800	8220	8220	7590	8510
Capital cost of network (£million)	2.21	1.65	2.62	1.82	1.32	2.79
Capital cost per metre (£/m)	1353	1206	1604	1115	1214	1363
Capital cost per kWh (£/kWh)	£0.16	£0.12	£0.20	£0.14	£0.16	£0.16

The distribution of DH pipe sizes is shown in Figure 36.

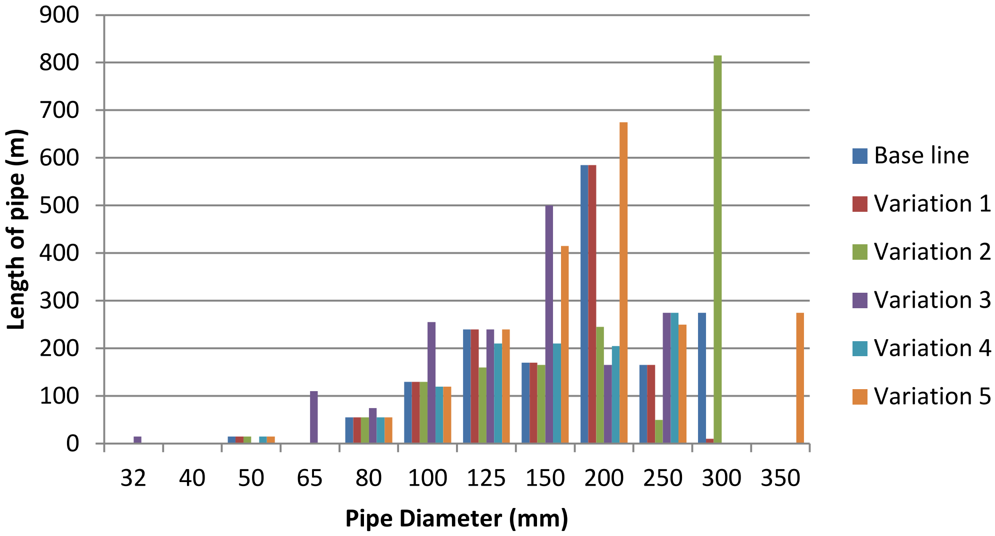


Figure 36: Summary of pipe sizes in the baseline and variation options of Phase 1.

6.5 Phase 2 network options

The second phase for this scheme entails extending to the north, connecting to major loads across the town centre and beyond, and extending south east towards the Kingston University Knights Park campus. This extension to the Phase 1 network would be set out as two additional branches connected directly to the energy centre, so that Phase 1 remains independent of this later phase.

Rather than one main line, Phase 2 is considered to be made up of a number of branches which are spread out to reach all of the larger energy customers in the town centre. The buildings are mostly private commercial properties which may require some incentives for connection. A well established Phase 1 scheme based around the public sector may also encourage connection for commercial customers by demonstrating costs and reliability.

The energy supply for a second phase network could be from a number of sources, similar to those listed for Phase 1, this includes:

- Centralised CHP plant, with localised boiler provision.
- Centralised CHP and boiler plant located on the Phase 2 network. For example at the re-developed Eden Walk area.

There are a number of proposed redevelopments for the Kingston Town Centre, which have been identified in the K+20 AAP. It is assumed that all major redeveloped areas would be connected to the DHN through planning requirements, therefore heating systems should be designed such that they are suitable for connection if/when Phase 2 is installed. The information used to model these redevelopments has been reviewed in Appendix 2: Energy demand analysis

There are a number of possible options to be considered for the layout and extent of Phase 2 as discussed below.

6.5.1 Phase 2 Baseline

The baseline Phase 2 scheme has a connection to all sites listed in below and the Phase 1 network, with energy supply from a centralised CHP and boiler plant located at the south end of the re-developed Edenwalk area. The heat loads for all proposed redevelopments are included except Edenwalk shopping centre and the Leisure Centre. The Edenwalk heat loads used are based on the current central atrium areas and Millennium House offices to reflect the uncertainty over when the shopping centre will be redeveloped to allow connection of the retail units. A schematic is illustrated in Figure 37 which is a zoomed in section from Figure 34. The list of sites connected to the Phase 2 network is given in Table 6.

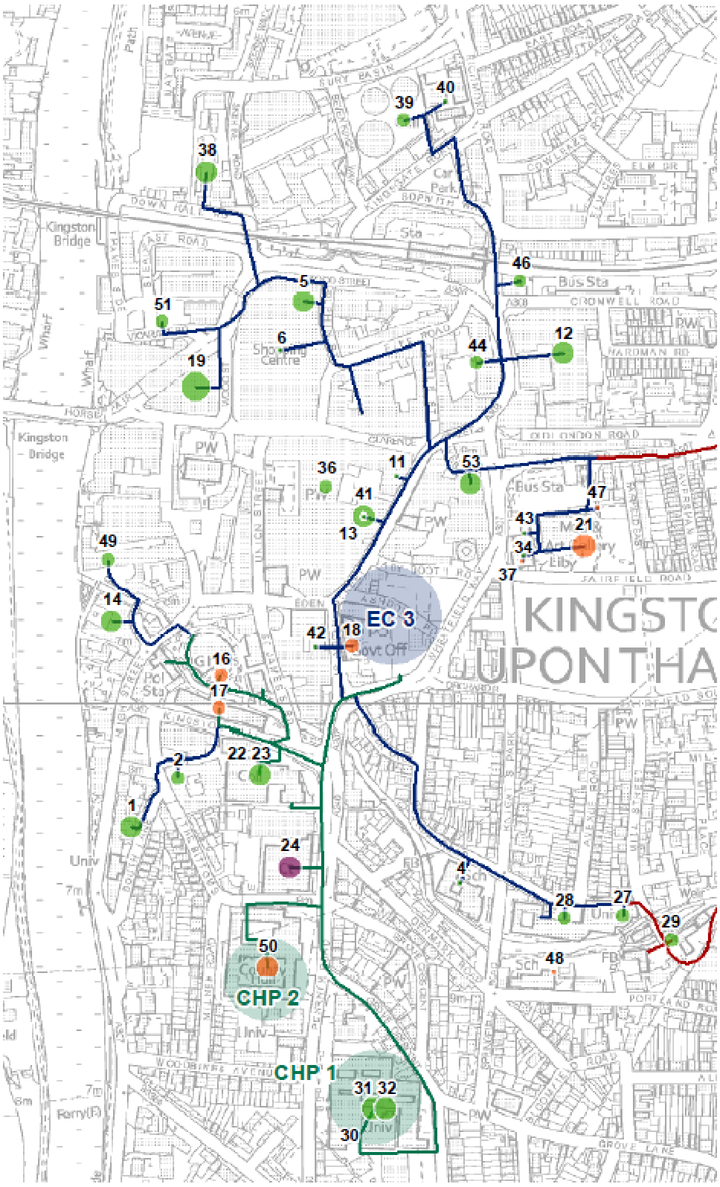


Figure 37: Schematic of Phase 2 DHN layout

6.5.2 Phase 2 network Variations

In addition to the baseline Phase 2 option, a number of variations are considered.

1. <u>Ring is sized at 300mm</u>

The potential location of an energy centre for future phases is uncertain, therefore to allow for future flexibility of the network the entire ring is set to a constant diameter pipe of 300mm, such that the energy centre can be connected to anywhere along the pipe, with no change to the capital cost. This diameter is lower than the combined peak load requirements, but assumes a degree of diversity.

2. <u>Redevelopment of Edenwalk and Kingfisher Leisure centre</u>

If there is a large scale redevelopment of the Edenwalk site and the Kingfisher Leisure Centre, the load for these sites will be higher than considered for the baseline case. Energy loads are based on the re-developed schedules.

3. No network development north of the railway

The potential customers over the railway (Kingston Power Station Redevelopment, Gasholders Redevelopment and Kingston College Richmond Road Campus) are more distant than the rest of those listed for Phase 2, which may not be cost effective, or may be more suitable as a future extension rather than the initial phase 2 installation. This variation assesses the impact of not connecting these customers.

4. Alternative town centre layout

There are several possible layouts for the town centre area, so a second possible layout is examined. Whilst the layouts proposed in this EMP are indicative, this variation allows sensitivity to layout options. A zoomed in sketch of the proposed variation for the northern section of Phase 2 is shown in Figure 38.

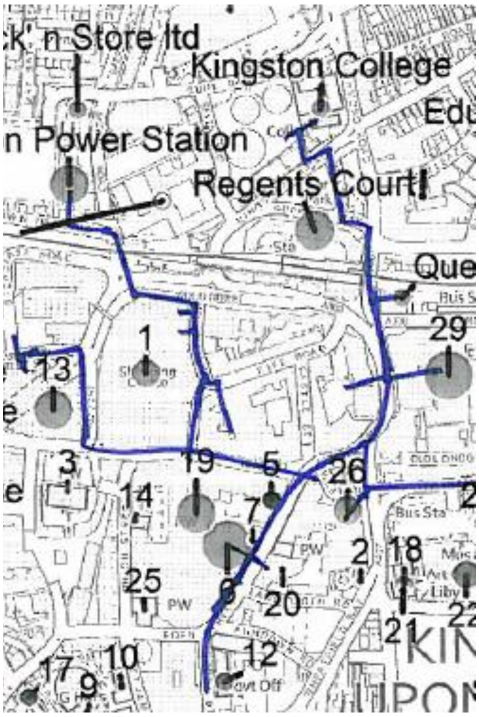


Figure 38: Variation in town centre layout assumed

6.5.3 Summary of Phase 2 networks

Table 9 shows a summary of the baseline and variation Phase 2 networks. The capital cost of the baseline network is £6.1M which is an additional £3.9M on top of the Phase 1 baseline. The connected load has more than doubled to 38MW, and the length tripled to 4.8km. The cost efficiency of the network has reduced from £0.16 per kWh for Phase 1 to £0.19 for Phase 2.

The Variation results show that if the Phase 2 network was oversized to allow peak load distribution from an energy centre located in Phase 3 (Variation 1), then the capital cost increases by £1.8M and results in the lowest cost efficiency. However if diversity is included in this resulting in oversizing to 300mm for the future ring main, the cost increase is only £0.7M and the cost efficiency is £0.22 per kWh.

The results also show that re-development of the Kingfisher Leisure Centre area and Edenwalk Shopping centre have a small benefit on the cost efficiency of the scheme.

Table 9: Summary of Phase 2 networks (please note that capital costs include the DH network pipework only. The total scheme costs are provided in section 8).

	Baseline	Network Variation 1	Network Variation 2	Network Variation 3	Network Variation 4	Network Variation 5
Pipe length (m)	4835	4835	4835	4840	4265	4970
Length of Oversized pipe (m)	-	1170	775		-	
Total network capacity (kW)	37,865	37,865	37,865	40,378	34,205	37,865
Line load (kWh/m)	6540	6540	6540	6920	6610	6355
Capital cost of pipe (£million)	6.08	7.94	6.81	6.18	5.30	6.09
Capital cost per metre (£/m)	1,259	1,641	1,410	1,277	1,243	£1,225
Capital cost per kWh (£/kWh)	0.19	0.25	0.22	0.18	0.19	£0.19

Figure 39 shows a summary of the pipe sizes required for the Baseline and variation Phase 2 DHNs.

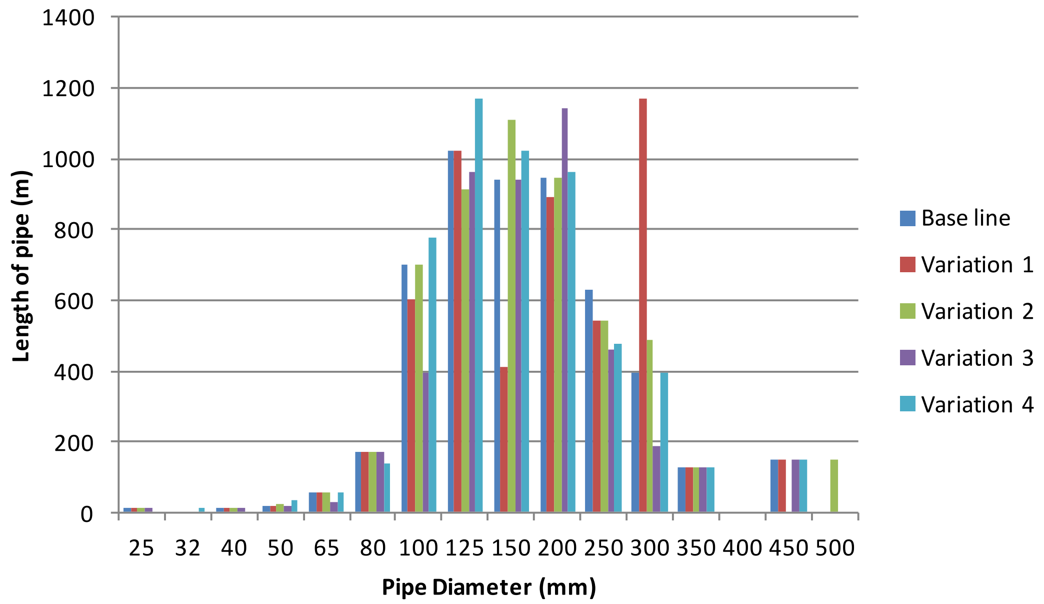


Figure 39: Summary of pipe sizes in the baseline and variation options of Phase 2.

6.6 Phase 3 network options

The two ends of the Phase 2 DHN could be further extended to form a large ring, extending west towards Kingston Hospital and the Sewage Works, as shown in 6.3.1.

The extension for Phase 3 involves connection to Kingston Hospital, which accounts for a significant proportion of the total heat load. The network is also expected to connect to a number of schools and more residential area, in particular the Cambridge Road Housing owned by RBK.

The Phase 3 network opens up the opportunity to locate an energy centre around the Hogsmill Valley, including the potential to use heat pumps to capture secondary heat from the STW outlet. It is likely that there would be additional energy centres located at other points around the ring, options include:

- Kingston Hospital (if further plant or space can be provided on site).
- Edenwalk Redevelopment (i.e. retain Phase 1&2 Energy Centre)
- Cambridge Road Development
- Gas holders redevelopment site
- Thames riverside location (for heap pump capture of secondary heat from the river).

6.6.1 Phase 3 baseline

The Phase 3 network represents the full extent of the town centre DE scheme. It includes connection to all sites listed in below, with energy supply from a centralised CHP and boiler plant located at Hogsmill Sewage works. For the main ring network, the pipes are sized at 300mm to allow for diversity of heat supply. This allows for future flexibility of the networks as an energy centre as constant sizing allows for an energy centre to be located anywhere on the ring. The preliminary layout is illustrated in Figure 37 which is a zoomed in section from Figure 34. A list of the sites connected is provided in Table 6.

6.6.2 Phase 3 network Variations

In addition to the baseline Phase 3 option, a number of variations are considered.

1. Connection to Kingston University Clayhill Campus

The connection to the Clayhill Campus, for student accommodation, requires an additional length of network of around 900m. The balance between the expenditure for this network length needs to be balanced against the benefit of connecting to the site as a heat customer. This variation allows assessment of the cost effectiveness of this connection.

2. No connection to Kingston Hospital

Kingston Hospital accounts for a significant proportion of the heat load for the network, but also has its own CHP plant, which could in the future be expanded to cover more of the hospitals heat demand. There is also limited potential for locating significantly more plant at the hospital due to the density of the site. In light of the relatively long network connection to the Hospital, and the viability of the hospital as a stand-alone scheme, this variation assesses the impact of not connecting.

The assumption for this model is that the whole branch towards the hospital is removed, so there is no connection to Wolverton house or Buick house, which connect to that route

3. Removal of south-east corner of ring main

The location of an energy centre at Hogsmill Sewage Works requires long lengths of network to reach the customers identified, and there are few customers on the south east section of the ring main to benefit. Therefore an alternative scheme is proposed which removes this section of the ring.

The southern end of the network is left as it would be for Phase 2, with no further extension. The northern part of the network starts from an energy centre at Kingsmeadow Sports Ground, connecting to the Cambridge Road Development and then completing the rest of the phase 3 layout as stated for the baseline.

The northern part of the network becomes an extension of Phase 2, ending at Cambridge Road Development. The energy centre is located at Kingston Hospital, which already has a CHP system.

This variation may be more applicable if additional energy centres are located on the scheme in addition to Hogsmill Valley (these may include in the Town Centre and at the riverside).

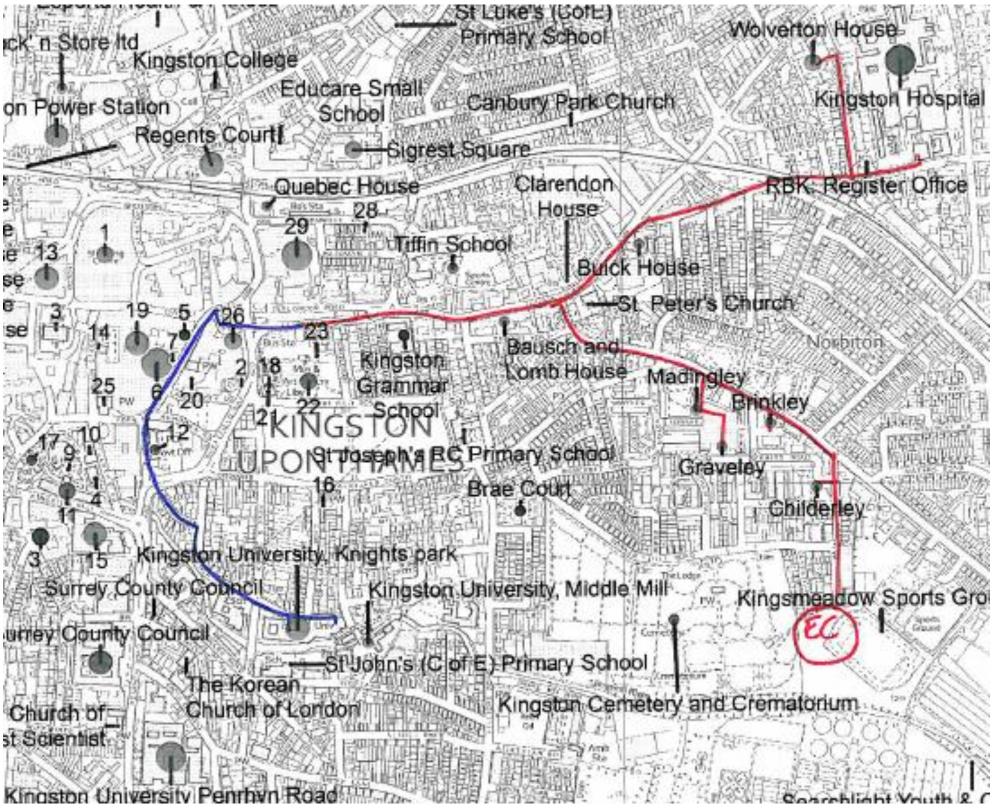


Figure 40: Schematic of Phase 3 variation 3 with the south-east section removed (NB: branches are not shown in this schematic)

6.6.3 Summary of Phase 3 networks

Table 10 provides a summary of the Phase 3 network options. The capital cost of the baseline scheme is £24M, an additional £18M over the baseline Phase 2 scheme, and the cost efficiency is reduced to £0.28 per kWh, around half as efficient as the Phase 1 scheme. This is due to a lower heat density, and a higher proportion of larger diameter pipes due to the ring main.

The energy density of the Phase 3 network is higher than for Phase 2 shown by the higher line loads which are similar to Phase 1. However the increase in DHN cost due to the large investment in the ring means that the cost efficiency is lower than for Phase 2.

Table 10: Summary of Phase 3 Baseline and Variation DHNs (please note that capital costs include the DH network pipework only. The total scheme costs are provided in section 8).

	Baseline	Network Variation 1	Network Variation 2	Network Variation 3
Pipe length (m)	9,655	10,555	8,475	7,285
Total network capacity (kW)	94,500	97,200	49,970	93,400
Line load (kWh/m)	8260	7760	5221	10,940
Capital cost of pipe (£million)	16.1	17.1	13.3	11.9
Capital cost per metre (£/m)	1665	1620	1573	2207
Capital cost per kWh (£/kWh)	0.18	0.19	0.27	0.18

Figure 41 shows a summary of the pipe sizes required for the Baseline and variation Phase 3 DHNs. This demonstrates the impact of the ring main with large amounts of pipework at 300mm.

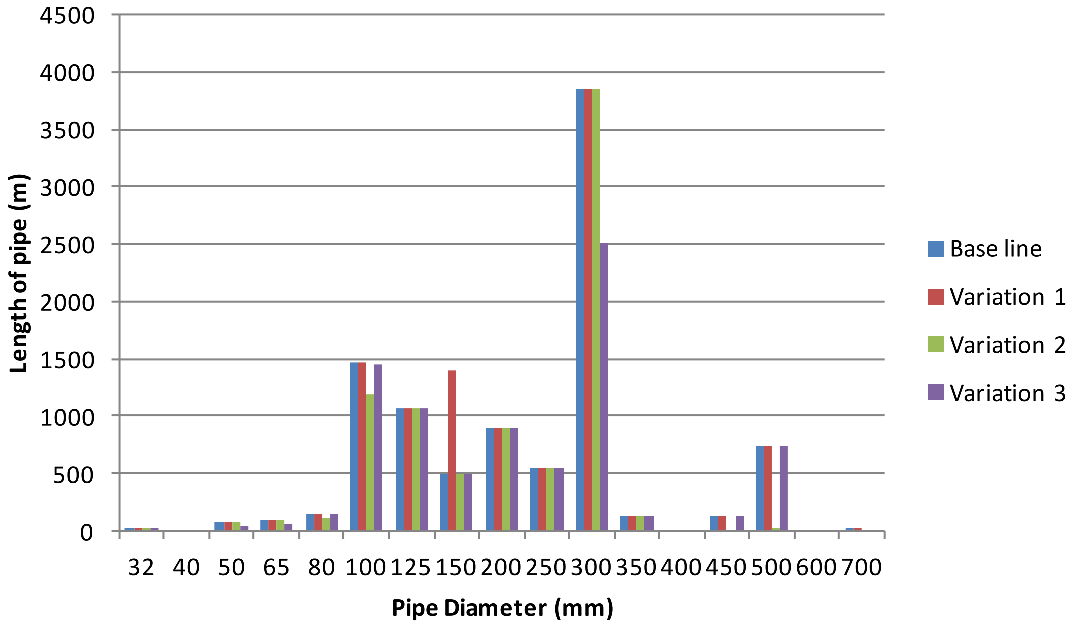


Figure 41: Summary of pipe sizes in the baseline and variation options of Phase 3.

6.7 Summary

This section identifies a number of options for DHN schemes split into early, mid, and long term development ambitions.

A Phase 1 scheme is identified along the Penrhyn Road area with a baseline capital cost of £2.2M and 16.8MW of connected load. The assessment of various options and sensitivities shows that the change in cost efficiency is relatively small due to the relatively efficiency layout. Locating an energy centre on the network within the customers, rather than on a branch at the Eden Quarter provides the largest cost reduction and most cost effective network. However cost reduction also needs to be balanced against future flexibility and the highest cost option is incurred when the central spine is oversized to allow additional future loads to be connected.

The Phase 2 baseline network costs an additional £3.9M over phase 1 and is less cost efficient in terms of £/kWh due to the more dispersed nature of the buildings. This suggests that additional customers need to be identified in the phase 2 area as shown in variation 2 where re-development of the Edenwalk area and the Kingfisher Leisure Centre provide additional load.

The Phase 3 network presents a long term vision, and as such, there is much uncertainty over the loads which may connect. It would probably develop over a number of intermediate phases. The additional cost of the baseline Phase 3 network is around £18M with a total network value of £24M. Whilst the Phase 3 ring concept does provide a degree of flexibility, particularly with uncertainty around energy centre location, it does come with a cost penalty, and the removal of a section of the ring reduces the investment cost by around £5M. This shows the importance of identifying and allocating a site early in the delivery of an RBK DE scheme to allow optimisation of future network phases.

7 Energy sale

7.1 Introduction

This section describes the options for selling both heat and electricity from DE schemes in the Borough. It looks at the price at which energy can be sold and the mechanisms by which it can be sold. The ability to maximise revenue from electricity is of great importance to the overall economic performance of CHP based DH, and an overview of the proposed “licence lite” electricity regime is provided.

7.2 Heat sales

The prime purpose of a DH network is to distribute heat to customers, and where necessary to charge for the heat use. There are a number of considerations when setting the price for heat:

- Whether heat is metered or not.
- The cost of heat production
- What is included in the heat provision contract
- The customer’s current / baseline costs of heat provision
- Contract structures and terms

7.2.1 Heat metering

Heat meters operate by measuring the flow of hot water, and flow and return temperatures in the customers heat off take pipes. The combination of temperature difference and flow allows the calculation of how much thermal energy has been extracted from the DH equivalent to the heat used by the customer.

The use of heat meters on a DHN allows the billing of customers for the amount of heat used, and also monitoring of heat consumption to help assess the performance of the system. Modern heat meters typically have automatic meter reading (AMR) functionality such that they can be read remotely, preventing the need for access to individual customer’s buildings, and allowing lower cost monitoring of consumption.

The information provided by heat meters can be used to bill customers according to the amount of heat used, although there are a number of ways in which the tariff can be structured (see below).

Whilst heat meters are recommended for the majority of customers, especially where new heating systems are being installed, there are cases where heat meters may not be used. Some historic DH schemes in the residential sector have not used heat meters, but simply charge a fixed rate for heat provision, particularly in the social housing sector. An argument could be that the relatively small levels of heat consumption in flats combined with the costs of metering, meter reading, and billing, means that better value could be offered from a meter-less solution. AMR systems combined with improvements in heat meter accuracy means that this may no longer be true, and the added benefits of customers being able to understand consumption and control their bills promotes the use of meters . However there may be retrofit applications where the existing heating systems (mainly in direct systems) means that the installation of meters could be difficult. This is most likely in Kingston if areas of existing flats which currently have communal heating systems are to be connected to the network.

7.2.2 Cost of heat production

The heat sales need to be sufficient to cover the costs of producing the heat and allowing the scheme to operate in an economically viable manner, taking into account the other revenues which may also be received (for example through the sales of electricity from a CHP scheme).

The cost of producing the heat depends on both the heat generation plant, and the energy or fuel it consumes, and also the cost of distributing the heat to the customers.

Where the operation costs are strongly influenced by energy or fuel costs, but less so on capital investment and fixed annual costs, then the heat tariff structure is likely to have a large variable element. However if the capital investment and fixed annual costs dominate, then the tariff structure is more likely to have a large fixed standing charge element, and a lower variable element. Examples of the latter occur where the heat source is effectively low cost or free, for example geothermal systems or waste industrial heat, but where the cost of capturing this is high.

7.2.3 Level of provision of heat and services included in the heat contract

The price charged for heat will need to consider the items which are included in the heat supply contract.

In general the heat supply contract will cover all heat for the customer. However if local generation is included on the customer's site (for example existing boiler plant), then the DH scheme may only provide a fraction of the annual heat demand. The price for this heat will therefore reflect this partial provision, and may be strongly based on the capacity of heat (for example a 1 MW limit) rather than the annual provision. The overall cost benefit of this approach means that less centralised heat generation plant is required, and the DHN can be sized for baseload rather than peak load to individual customers.

The HIUs or heat substations on a network will typically be owned and operated by the network operator. This is important because they form part of the network and any malfunction or failure could have an adverse impact on the network. Therefore the heat price will need to be sufficient to cover the operation and maintenance costs of these items. In some circumstances, additional infrastructure (for example secondary networks or even heating circuits) may also fall under the ownership or operation of the network and the heat price will also need to allow for these.

7.2.4 The customer's current / baseline costs of heat provision

Without regulation in favour of DH the DH supply will need to be priced competitively against the alternative form of heating. For existing customers, this will be the incumbent heating system (or any replacement if required), and for new customers, it will be the proposed heating system that would be required to meet relevant regulations and planning policy.

The baseline heating cost will consist of:

- Provision and replacement of heat generation plant.
- Maintenance and operation of heat generation plant
- Fuel / energy provision for heat generation.

The combination of these costs can provide a baseline heating cost which can be expressed as an effective heat cost in terms of p /kWh.

For a DHN to be commercially viable, customers will generally only connect if the DHN can offer a heat tariff which is equivalent to or better than their current / proposed baseline rate. This means that understanding the customers' baseline costs is important when setting customer specific heat tariffs.

A common option is to base the starting point heat tariff price on the customers baseline cost with a discount applied. This tariff will then track a basket of energy prices over time to ensure that price changes are linked to alternative heating fuels, but with a discount applied. This provides customers assurance that the DHN heat prices will not increase more than the alternative baseline options, and that the price will remain competitive. For DHN operators, it provides assurance that customers will hopefully commit for the long term, and that whilst they get a good price, it never has an excessive discount.

7.2.5 Contract structures and terms

Like any service, the price of heat depends on the contract structure and terms. This will need to consider the aspects discussed above including the level of service and agreed heat capacity, and the tariff structure and pricing.

An important element will be the length of contract. In general, commercial customers wish to see a good discounted tariff combined with flexibility in the form of shorter contract periods and termination allowances. There is a balance for the network operator to provide a price which is good enough to encourage longer term connections to reduce the risk of investment, whilst maintaining an economically viable scheme. Public sector bodies are likely to accept a smaller discount, if any, on the heat tariff and long term contracts – periods of 10 or 20 years are common on scheme where the public sector is a key stakeholder.

A further element is whether there is a minimum heat take within the contract which provides for a ‘take or pay’ arrangement thus reducing the risks to the DH company with respect to volume of heat sales.

7.2.6 Heat sales for DE in Kingston

A DE scheme in Kingston is likely to contain a wide range of customers, albeit with a public sector dominated first phase. Therefore the structure of heat prices, tariffs, offered, and contract terms offered will need to take into account all of the variables described in this section.

During the business case development for Phase 1, heat prices will need to be accurately calculated to allow investment decisions to be taken, and provide the public sector buildings with a contract price to sign up to. It is recommended that given the likelihood of the public sector being a key stakeholder in the scheme, and the importance of Phase 1 being successful for further expansion, a tariff structure is used which ensures the scheme is low risk, can be operated economically, and ensures long term heat purchase and connection. This could be through 20 year contracts to all the public sector bodies.

If the scheme expands further, heat prices will need to be evaluated based on the additional development costs of expanding the infrastructure, and the type of customer. Outside of phase 1, a large number of the customers are existing commercial buildings, and so a more attractive heat tariff will need to be offered to encourage connection.

For new developments, planning policy can be used to enforce connection where a viable option exists. For this to be economically viable, the price offered will need to be comparable or better than any alternative options open to the developer which can provide the equivalent level of heat and meet the necessary regulations and policies.

It is recommended that all customers have provided with heat meters with AMR capability. An exception to this may occur in areas of retrofit to existing flats which have existing communal systems. The most notable area of existing flats is the Cambridge Road estate, but since these have recently been retrofitted with wet heating systems and individual boilers, a metered strategy should be viable.

7.3 Electricity sales

Where electricity is generated as part of a DE scheme, the revenue from sales of the electricity will be important in ensuring the scheme is financially viable, and for gas CHP schemes, is often the most critical factor.

7.3.1 Electricity sale for retail value

When the electricity can be sold directly to a customer, the highest revenue can be obtained due to the electricity being sold at retail value (or with a small discount). This situation often occurs when there is a single, or small number of large customers which are capable of purchasing the majority of the electricity. In many cases, the electricity purchaser is also the generator, or a stakeholder in the DE scheme, such that the electricity simply offsets their grid supply.

The value obtained for electricity will depend on the customer’s existing retail price, but will typically be around 8 p / kWh or more, and there are no additional administration or billing costs.

7.3.2 Electricity sale for licence exempt generators

If the electricity is to be sold to a wider number of customers (either domestic or commercial) who are not owners or stakeholders in the scheme, then the electricity license regime needs to be considered. In general, this requires all electricity suppliers to be licensed unless they meet certain exemptions (as set out in “The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001”). The exemptions are relatively complex, but in essence exempt suppliers must have a generation capacity of less than 5 MW total, and a limit of 2.5 MW for domestic customers.

For licence exempt suppliers, there are two options for the distribution and sales of the electricity:

i) Over the existing electricity grid. A generator may distribute and supply electricity of the existing electricity grid by making a payment for Distribution Use of System (DUOS) charges to the Distribution Network Operator (DNO). The retail price which can be offered to customers therefore will depend on these additional costs which the supplier will need to pay. As a supplier of electricity, the generator will be responsible for the customer’s entire supply, and will therefore need to purchase additional electricity as required at times when the generator is not meeting demand.

ii) Over a private wire network. A generator may distribute electricity over a privately owned network to a number of customers, thus removing the need to pay DUOS charges. However the costs of developing a private wire network can be significant and outweigh the benefits of increased electricity sales value and reduced DUOS. In addition the “Citiworks” case (a European Court of Justice ruling in 2008) has resulted in the requirement for private wire networks to be opened to alternative suppliers in an open market to prevent monopoly supply. This effectively removes any benefit. One area where private wire networks may provide a benefit is where a network exists on a complex site (for example a hospital or university campus) and a single customer can be contracted.

In light of the complexities and restrictions of being a licence exempt supplier, the cost benefit in terms of electricity revenue can often be minimal, and rendering this option unfavourable.

7.3.3 Electricity sale at wholesale value

Perhaps the simplest solution for a small scale generator is to sell electricity to a large licensed supplier who will then re-sell to their own customers under their licence. This means that the small scale generator is effectively competing against large scale generation on the national grid, and only receives a wholesale value for the electricity. This may typically be around 5 p / kWh – 6 p / kWh depending on the size of generation, and output profile.

A wholesale revenue value may have an adverse impact on CHP schemes and render then uneconomic.

7.3.4 Electricity sale under licence conditions

An option could be for the DE electricity supplier to become a licensed electricity supplier, allowing sales of electricity over a private wire network, or over the local distribution network to a wider number of customers. However this is not a practical option for small suppliers - the licensing requirements, in particular the Balancing and Settlement Code and the Master Registration Agreement, are designed for, and suited to, large national suppliers who have a significant capacity. The costs, risks, and complexities of becoming a licence supplier are too great for smaller electricity suppliers, such as DE schemes, and therefore effectively prevent DE schemes from benefiting from a good price for electricity unless specific direct sales circumstances exist.

This has been major hurdle to the development of DE, and has led to the concept of “licence lite”.

7.3.5 Licence lite – an introduction

In recognition of the problems faced by small electricity suppliers, the 2007 Energy White Paper announced the intention to provide a mechanism for schemes to sell electricity. The final proposals were published by Ofgem in 2008 and consisted of changes to the licensing regime such that small suppliers do not need to be licensed, but need to be covered by a larger supplier’s licence. This means that smaller supplier effectively “piggy back” on a large suppliers licence, and thus have a “lite licence”. Whilst the Ofgem proposals provide the mechanism for doing this, they do not provide the detailed framework in which the scheme can operate.

The benefits of a licence lite system are that a licence lite DE supplier can sell electricity directly to customers over the existing public electricity network without having to be involved in balancing and settling in the electricity market. The licence lite holder will be responsible for metering and billing and therefore incur administration costs. It will also (as any supplier on an open market) need to provide an attractive price to ensure customer interest, which may mean tracking the price at or below market averages or best performance levels. This will mean the eventual price received is likely to be less than a retail prices, but better than a wholesale price.

In return for being a licence lite supplier, and making use of another organisations licence, it is likely that the licence holder will require a payment for the service which will equate to a p / kWh cost. The amount of this charge is therefore likely to be critical to the success of licence lite.

7.3.6 GLA and licence lite

The ambitions of the GLA DEPDU are closely linked to the ability to develop economic schemes, and the electricity value obtained by DE suppliers is therefore critical across the city. Given the lack of precedence, the development of a licence lite framework is extremely complex and potentially costly, and likely to be unviable for individual schemes or Boroughs. Therefore the GLA has decided to become a pan-London Licence Lite supplier under which a number of different schemes can operate.

Over the last few years the GLA has conducted analysis on the potential financial benefits to ensure the process is effective, followed by developing a legal framework for a licence lite contract, working closely with Ofgem. This has culminated in a formal application from the GLA to Ofgem in early March 2013. The GLA is currently in the process of going to market and is issuing a PQQ followed by a tender to the licenced suppliers to gauge interest and hopefully find a partner with the intention of a 7 year agreement. It is important to recognise that given the lack of precedent, the level of interest which may be obtained from licensed suppliers is uncertain, and indeed it may be the case that there are no opportunities.

It is hoped that a licence will be obtained and a licence partner procured by Spring 2014.

The framework proposed by the GLA has the following basic function:

- A number of individual DE schemes across London will sell electricity for a fixed price to the GLA licence lite organisation.
- The GLA will aggregate the electricity from all the schemes for subsequent sale.
- The electricity will be sold to a small number of customers.
- The GLA will aim to balance the supply and demand although there will probably be a small net export to grid.
- The full licence holder will be responsible for providing the net balance.

In the first instance, the GLA is intending to sell electricity to TFL. The policy of TFL to purchase DE sourced electricity provides a ready market of sufficient size. The GLA is also keen to ensure that customers are public sector to ensure that DE schemes and the GLA licence lite organisation are acting in the public interest. Once the system develops, additional public sector organisations may also become customers.

It is the intention that DE electricity suppliers will be able to influence where some of the electricity is purchased. For example a borough owned DE scheme may request that the Borough itself becomes the customer allowing the electricity to be used in local authority buildings. All customers will be required to commit to a reasonable length contract (say 3 years) to provide certainty to the GLA when purchasing electricity.

7.3.7 How licence lite could be used by Kingston.

As a London Borough, a DE scheme developed in Kingston has the opportunity of making use of a potential GLA licence lite regime. The process is simple for the Borough and will require the scheme to be a contracted electricity supplier to the GLA without having to find and deal with customers.

The DE scheme / Kingston Borough may also have the desire to purchase the electricity from the GLA across their estate if this is economically attractive.

In return for this service, the DE scheme will effectively pay a licence lite charge through the revenue which is received. The GLA do not intend to make a profit from the electricity but will incur administration charges, billing and metering charges, and the licence lite charge. The price received by DE scheme for selling electricity will therefore equal the retail value (as sold to customers by the GLA) minus these charges. Financial modelling by the GLA suggests that this will result in a revenue for DE schemes which is approximately 20% higher than if they sell directly to the grid at wholesale prices. Once the tender returns from licensed suppliers have been received, the GLA will be able to provide a more accurate price for electricity.

7.4 Summary

This section provides an overview of the energy sales options open to Kingston. Achieving a good revenue for the sales of heat and electricity will be vital for the economic viability of a DE scheme, and should be central to all further work on technical, financial, and delivery options.

The sale of heat needs to ensure that a wide range of customers are attracted to ensure a high uptake of heat off take, and that this provides a long term low risk through encouraging long contract periods. In phase 1, the emphasis is on the public sector and the scheme should aim for long heat supply contracts, typically 10 years or more. As the scheme expands into the commercial sector, a combination of attractive prices combined with suitable contract lengths will be needed to both encourage connection and maintain connection.

For electricity sales, it is recommended that RBK continue to work with the GLA to further explore the opportunities for making use of the GLA Licence lite regime. This could offer a relatively simple solution for improving the revenue for electricity. In addition, opportunities for exporting electricity directly to large electricity consuming customers should also be considered and monitored so that the revenue can be maximised where possible. Such opportunities may have an impact on the governance model for the scheme to allow licence exempt supply.

8 Analysis of options

8.1 Introduction

This section provides an overview of all of the outputs from modelling the District Heating Network in short, medium and long term layouts. The base line option and a number of variations have been identified for each of the phased network layouts, as discussed in 6.3.

8.2 Economic analysis

This section provides an assessment of the economic performance potential DE schemes in the Borough. A lifecycle cost model has been used which takes into account capital and operational costs and revenues, comparing them with alternative baseline options to assess the economic benefit.

The baseline economic analysis is based on a 25 year discounted cashflow and includes the following:

- Capital expenditure of DH network, CHP and boiler plant, energy centre and utilities connections. Capital expenditure incurred 2 years before scheme is operational.
- Replacement costs of CHP plant and boiler after 15 years.
- Energy costs based on customers current energy prices. Modelled as indexed (rising in line with the UK Government's IAG projections[29]), and flat rate.
- Electricity sales revenue based on sales to the grid at 6p / kWh.
- On-going costs for administration, network and CHP operation included
- Development costs at 5% of the capital cost. These are included as an allowance for activities post feasibility work including commercial, legal, and procurement activities. This is indicative and the actual costs will depend on the nature of the scheme, and procurement and governance options selected. An example of the development process is illustrated in Figure 48.
- CO_2 valued at CRC levels for all customers[30].
- CO_2 content of the electricity grid at 15 year average, then in line with the UK Government IAG marginal projections[31].
- Discount rates for calculation of Net Present Value are based on 6%.

The value of heat for the DE scheme is based on a 5% reduction in heat price compared with a business as-usual case of individual gas boilers, including the replacement and maintenance of the gas boilers.

8.3 Phase 1 – Short Term

8.3.1 Baseline design

The baseline option for Phase 1 is identified in Section 6.4 and considers an initial scheme along Penrhyn Road linking the following buildings:

- Kingston University Penrhyn Road campus

[29] Valuation of Energy Use and Greenhouse Gas Emissions. Interdepartmental Analysts Group (IAG), DECC.
[30] Currently valued at £16 per tonne CO_2. This reflects uncertainty in carbon pricing, but suggests that increasingly some form of carbon pricing will be applied to all larger consumers of energy. Due to the period over which the IRR is calculated the inclusion of carbon pricing at this cost has very little impact on IRRs.
[31] The 15 year average emission factors are taken from the latest Standard Assessment Procedure values. http://www.bre.co.uk/filelibrary/SAP/2012/Emission-and-primary-factors-2013-2027.pdf

- County Hall (Surrey County Council)
- Kingston Crown Court
- Kingston College
- Kingston County Court
- Guildhall, Guildhall 2 (RBK)
- Kingston Police Station

It is assumed that the energy centre is located around the south end of the Edenwalk area which is likely to be redeveloped, as identified in the Kingston TC AAP. This energy centre will provide all of the heat for the development via a centralised CHP plant, with backup boilers and thermal storage appropriately sized to meet the peak heat demand

The key outputs for the Phase 1 baseline scheme are shown in Table 11 and

Table 12 below.

Table 11: Summary of Phase 1 Baseline scheme

Results Summary	Units	Base Case
Network		
First year of operation		2016
Network length	m	1635
Total network capacity	kW	16,820
Energy Centre Size	m^2	500
Economic performance		
Total Capital Cost	£million	8.2
CHP capacity	MWe	3.2
Energy centre boilers capacity	MW	16.9
Gas CHP gas demand	MWh/year	27,000
Peak boiler gas demand	MWh/year	5,850
IRR (Indexed) 25 years	%	3.0
IRR (Flat rate) 25 years	%	0
NPV (indexed) 25 years	£million	-1.6
IRR (Indexed) 40 years	%	5.2
IRR (Flat rate) 40 years	%	0
NPV (indexed) 40 years	£million	--0.6
Effective cost of heat	p/kWh	4.5
Environmental Performance		
10 year carbon saving	tonnes CO_2	9,500
10 year carbon saving	%	26%

Table 12: Summary of capital cost breakdown for Phase 1 Baseline Scheme

Capital costs	£million
DH network capex	2.21
CHP engine capex	1.60
Energy centre boilers capex	0.76
Energy centre building capex	1.00
Thermal store capex	0.38
HIU capex - commercial loads	1.68
HIU capex - domestic loads	0.00
Gas connection	0.10
Electricity connection	0.10
Development costs	0.39
Total capital costs	**8.23**

For the baseline scheme, the impact of two key sensitivities has also been assessed:

- Capital cost. DH schemes are capital intensive, and reductions in capital cost through optimisation can have a beneficial impact. Conversely, increases in costs can have a detrimental impact on schemes. The impact of capital on the IRR can be either though actual cost adjustments in the scheme, or though a reduction in the amount required for investment, for example with additional grant funding.
- Electricity revenue. The sale of electricity from the CHP system is the largest revenue to the scheme, and thus important in determining the IRR. The electricity revenue prices assumed in the modelling at £60 per MWh are reasonably conservative allowing for some sale at retail prices or use on-site, but assuming that the majority of electricity is sold to the grid. Therefore increases in this revenue through greater direct electricity sales, or improvements through licence lite, may provide a benefit.

The impact of a plus and minus 20% adjustment of the capital costs and electricity revenues are shown in Table 13 below. The results show that the IRR is more sensitive to the electricity revenue, but both sensitivities show that over 6% IRR can be achieved through a single input parameter adjustment. The compound effect of these (for example both a lower capital cost AND higher electricity revenue) would have a larger impact.

Table 13: Sensitivity of IRR and NPV to capital cost assumptions and electricity revenue value for the baseline Phase 1 scheme.

Variance from central assumption	Capital costs			Electricity revenue value		
	Capital cost	IRR	NPV	Revenue value (£/MWh)	IRR	NPV
-20%	£6,585,000	6.6%	-£127,000	£48	-1.7%	-£3,763,000
-15%	£6,996,000	5.8%	-£507,000	£51	-0.1%	-£3,234,000
-10%	£7,408,000	5.1%	-£887,000	£54	1.4%	-£2,705,000
-5%	£7,819,000	4.4%	-£1,268,000	£57	2.6%	-£2,177,000
0%	£8,231,000	3.8%	-£1,648,000	£60	3.8%	-£1,648,000
5%	£8,642,000	3.2%	-£2,028,000	£63	4.8%	-£1,119,000
10%	£9,054,000	2.7%	-£2,408,000	£66	5.8%	-£591,000
15%	£9,465,000	2.2%	-£2,789,000	£69	6.8%	-£62,000
20%	£9,877,000	1.7%	-£3,169,000	£72	7.7%	£467,000

8.3.2 Variations

1. Centralised CHP and boiler plant located on the baseline Phase 1 network, located at Kingston College

Variation 1 requires only a small difference in the model of the scheme, for this variation the length of pipe from the energy centre to the main branch is shortened from 175m to 10m. The result of this is that the largest diameter pipe on the network is reduced, therefore the cost is reduced, and to some extent the losses in the pipes, as the energy centre is closer to the heat loads. The most noticeable difference from the base case is financial, the IRR improves from 3.0% to 4.1%. This is a large change for a relatively minor variation and shows the importance of locating the energy centre close to the network, reducing the length of the largest diameter pipes.

2. Centralised CHP and boiler plant located on the baseline Phase 1 network, with flexibility of location, therefore all pipes along the main branch are sized for total load

Variation 2 considers the effect of increased flexibility of the network. If the location of the energy centre were uncertain or not fixed throughout the schemes lifecycle, the pipes would have to be sized to allow for all possible variations. The result of this is that all of the pipes along the main branch are all oversized to 300mm. The cost of flexibility and uncertainty of design for this initial phase is approximately £0.4m, therefore there is a cost saving associated with a more fixed plan for future development.

3. Centralised CHP plant as for baseline, with localised boiler provision

Variation 3 models the situation where all of the buildings connected to the main baseline network retain their own boilers to meet the peak heat demand, but the base level is provided by a centralised CHP plant as determined for the baseline. By not having to pay for centralised boiler plant up front, and by spreading the replacement of the replacement distributed boilers out over a period of years (to reflect the current variation in ages), the IRR of the scheme is increased slightly to 4.9%. This is the most economic case for Phase 1.

4. Kingston University Penrhyn Road campus not connected

Variation 4 is carried out to determine the effect of reducing the heat demand and the network length, and the sensitivities to the size of the network. This is modelled by not connecting to the Kingston University site. As expected the capital cost is a lot smaller due to the reduction in length of the network, smaller CHP engines and less connection equipment, however the heat demand has shrunk to match this resulting in IRR that is similar to that for the base case.

5. Connection of additional loads

Variation 5 is similar to 4 in that it is changing the total heat demand and the network length, however it is adding to rather than subtracting from the baseline. There is also an increased domestic load on the network, which provides a more variation in heat demand profile from building to building, but requires a greater capital cost for HIU in each dwelling. The IRR for this variation is about 0.7% points higher than that for the baseline. There is also a greater reduction in CO_2 emissions by connecting to a greater number of properties, which would otherwise use boilers.

8.3.3 Phase 1 Summary

The result of the Phase 1 Baseline model and all variations can be seen in

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Building Engineering

Table 14.

Table 14: Summary of key results for Phase 1 Baseline and variations

Results Summary	Units	Base Case	Variation 1	Variation 2	Variation 3	Variation 4	Variation 5
Network							
First year of operation		2016	2016	2016	2016	2016	2016
Network length	m	1635	1370	1635	1635	1090	2045
Total network capacity	kW	16,820	16,820	16,820	8,410	10,330	21,803
Economic performance							
Total Capital Cost	£million	7.7	7.6	8.7	5.6	5.7	10.8
CHP capacity	MWe	3.2	3.2	3.2	3.2	2.4	4.5
Energy centre boilers capacity	MW	16.9	16.9	16.9	0.0	10.4	21.9
Gas CHP gas demand	MWh/year	27,000	27,000	27,000	27,000	18,900	37,500
Peak boiler gas demand	MWh/year	5,850	5720	5900	5780	2570	6570
IRR (indexed) 25 years	%	3.0	4.1	2.3	4.9	2.4	3.7
NPV (indexed) 25 years	£million	-1.6	-1.0	-2.1	-0.4	-1.4	-1.7
Environmental Performance							
10 year carbon saving	tonnes CO_2	9,500	9,800	9,450	9,108	6,820	13,400
10 year carbon saving	%	26%	26%	25%	25%	30%	28%

The highest IRR is seen in variation 1, showing that the location of the energy centre can make a large difference and that is it important to locate any plant close to the main network. Therefore locating the plant in one of the building connected may offer a reasonable saving for the first phase, although later phases would have to take this design into consideration.

Variations 4 and 5 illustrate the importance of the length of pipe in relation to the heat load. As long as the change in length of pipe is proportional to the change in heat demand there is little change in the IRR of the scheme. The greater the increase heat demand, in comparison to the increase in pipe length, the better the financial returns are expected to be, as can be seen for variation 5, so it is recommended that large nearby sources should always be considered for connection, but as the sites get further from the network, more research is required to determine the financial viability of this extension. This rule may vary for larger changes to the network where the average diameter of pipe may be significantly altered by the addition of large heat loads, such as Kingston hospital.

The lowest IRR is given in Variation 3 which examines the use of distributed boiler provision. This results in higher capital, replacement, and operation costs for the smaller distributed boilers, but provides greater resilience for customers. It also can result in a smaller land requirement for an energy centre.

All NPVs are predicted to be negative at the assumed 6% discount rate – this is due to the IRRs being less than 6%. This means that for an investor who assumes a discount rate of 6%, the investment to them is assumed to have made a loss over the investment period, i.e. has a negative value.

8.4 Phase 2 – Medium Term

The methodology for the modelling of Phase 2 remains the same unless otherwise stated. The analysis is carried out based on a cumulative model of Phases 1 and 2, assuming that the first year of operation is 2020. This is the first year of operation for each and every part of the network.

The extensions to Phase 1, which connect to a number of multi address buildings are included in this second phase model.

8.4.1 Baseline design

The second, medium term phase for this scheme entails extending to the north, connecting to major loads across Kingston TC and beyond, and extending south east towards the Kingston University Knights Park campus. This extension to the Phase 1 network is be set out as two additional branches connected directly to the energy centre, so that Phase 1 remains an independent branch.

Rather than one main line, Phase 2 is considered to be made up of a number of branches which are spread out to reach all of the larger energy customers in the town centre. The buildings are mostly private commercial properties which may require some incentives for connection. A well established Phase 1 scheme based around the public sector may also encourage connection for commercial customers by demonstrating costs and reliability.

The energy supply for the Phase 2 baseline model is from a centralised CHP and boiler plant located at the south end of the re-developed Edenwalk area, as for Phase 1 base line. The heat loads for all proposed redevelopments are included except Edenwalk shopping centre and the Leisure Centre redevelopments which are more uncertain. A list of all of the heat customers considered for connection to Phase 2 (which includes all Phase 1 buildings) can be found in Table 6.

The location and layout of this medium term scheme is shown in blue in Figure 42.

Please note that all capital costs presented unless otherwise stated are for the entire Phase 2 scheme (including the phase 1 components). In reality, some of these costs will have been incurred during the development of phase 1, and partially paid off, and so the IRRs presented may be improved through optimisation of the phasing and expenditure.

Capabilities on project:
Building Engineering

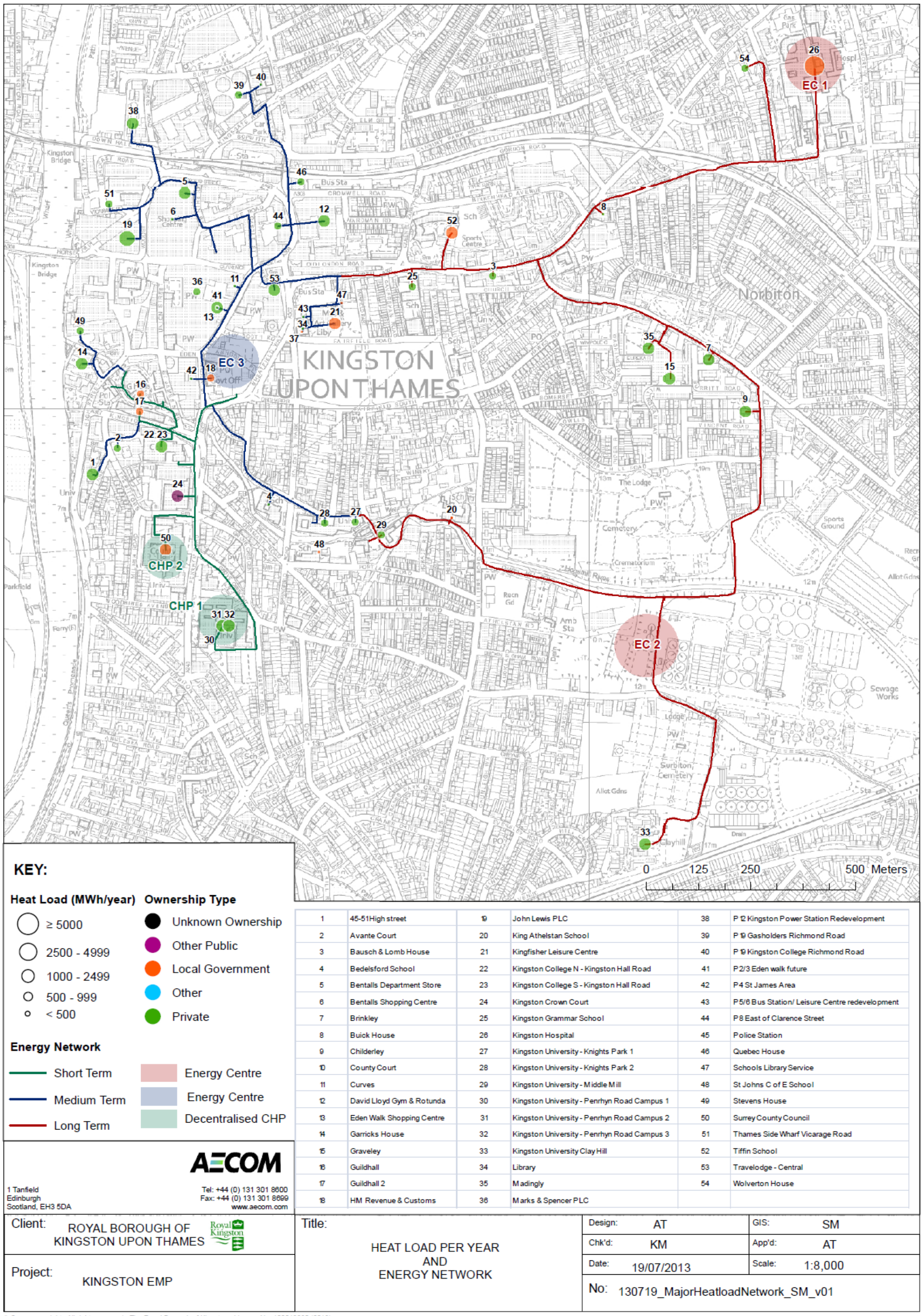

Figure 42: Proposed layout showing short, medium and long term phases

The key outputs for the Phase 2 baseline scheme are shown in Table 15 below.

Table 15: Summary of Phase 2 Baseline scheme

Results Summary	Units	Base Case
Network		
First year of operation		2020
Network length	m	5245
Total network capacity	kW	42,850
Energy Centre Size	m²	750
Economic performance		
Total Capital Cost	£million	22.2
CHP capacity	MWe	7.9
Energy centre boilers capacity	MW	43.1
Gas CHP gas demand	MWh/year	77,400
Peak boiler gas demand	MWh/year	12,200
IRR (Indexed) 25 years	%	3.9
IRR (Flat rate) 25 years	%	0
NPV (indexed) 25 years		-3.0
IRR (Indexed) 40 years	%	5.7
IRR (Flat rate) 40 years	%	0
NPV (indexed) 40 years	£million	-0.6
Effective cost of heat	p/kWh	5.6
Environmental Performance		
10 year carbon saving	tonnes CO_2	11,500
10 year carbon saving	%	12%

Table 16: Summary of capital cost breakdown for Phase 2 Baseline Scheme

Capital costs (including Phase 1)	£million
DH network capex	6.6
CHP engine capex	3.9
Energy centre boilers capex	1.9
Energy centre building capex	1.5
Thermal store capex	1.0
HIU capex - commercial loads	3.3
HIU capex - domestic loads	2.7
Gas connection	0.1
Electricity connection	0.1
Development costs	1.1
Total capital costs	**22.2**

8.4.2 Variations

1. <u>Ring is sized at 300mm</u>

The first variation is selected to determine the effect of designing for possible connection to a later, long term phase, which would form a large ring shaped network, rather than optimising the phase for the loads present during Phase 2. To allow for future connection, the pipe that is likely to form part of the ring is modelled to be 300mm pipe – this is the typical diameter for network of this size, it large enough to carry high loads, but also allows for diversity and the possibility of multiple energy centres. A constant size is selected to allow for flexibility of location of an energy centre. The additional capital cost of designing for extension for a later phase is £0.7m, this result in an IRR of 3.4%, compared to a base line value of 3.9%. If this design consideration is not taken into account, and the network is optimised for Phase 2, the cost of retrofitting the pipes for a later phase would be much greater. There therefore needs to be some consideration of the likelihood of extending the network, to determine if this additional cost is worthwhile to maintain flexibility.

2. Redevelopment of Edenwalk and Kingfisher Leisure centre

The purpose of variation 2 is to determine the change in cost if the network were designed to meet the demands of a large scale redevelopment of the Edenwalk area. The increase in cost is approximately £1million for the oversized pipes, this is a relatively small price to pay (less than 5% increase) for additional flexibility, and if the redevelopment goes ahead as modelled the resulting network will achieve a higher IRR. Part of the reason for this relatively small increase in cost is that the proposed energy centre is located near to the redevelopment, so a larger diameter is only needed for a short length of pipe. If the Energy Centre were further away from Edenwalk the IRR would be smaller as the length of oversized pipe increases.

3. No network development north of the railway

Similar to variation 4 for the initial Phase 1 scheme, this variation examines the effect of cutting off a section of the network. This variation is considered as it may not be possible to connect beyond the railway, depending on the routes over/under. The expense of crossing a railway may not be outweigh the benefit of connecting.

The capital cost of connecting beyond the railway can be seen to be £2.5m, and by not connecting to the northern section, the scheme has a higher IRR and NPV over a 25 year life. There may however be some benefit to connecting to these sites in terms of possible locations for energy centres – CHP or other technologies which make use of the proximity to the Thames. The predicted load may also change, so that if the load increases, extension of the network in this direction becomes more viable. This area should therefore still be considered for connection, in particular in the context of any other railway redevelopment which may reduce the installation costs or increase the heat load available.

4. Alternative town centre layout

Variation 4 proposes an alternative layout for the northern section of the network from level with Clarence Street northwards. This is a densely packed area with lot of commercial units and some pedestrianised streets. Any routes selected for this area will cause disruption and it uncertain which streets would be most suitable for installation of a DH Network. The results for this variation show that there is little change in the finance or the CO_2 savings for the scheme. This shows that the general form of the layout can vary without significant changes, therefore other considerations outside of the modelling should be used to determine the exact route the pipe takes, assuming it is approximately the same length and meets the same loads.

5. Heat pump as energy source

Variation 5 considers the effect of an alternative technology, this would be a heat pump using water from the Thames as a heat source. The location of the heat pump is unknown so a nominal length of pipe of 500m at a 300mm diameter, to match the main ring is included. The heat pump is sized for a total capacity of 10MW, made up of No2 x5MW heat pumps.

Heat pump schemes currently receive funding from the Renewable Heat Incentive, for large river source heat pumps as proposed for this variation, the funding would be 3.5p/kWh of heat delivered to buildings. This has been included in the model as a sensitivity. Whilst there is no long term certainty over incentive schemes, it could promote the use of heat pumps in the near term.

The model result gives a negative IRR for the use of heat pumps at this stage without RHI, and an IRR of 0.45% with RHI, however a higher, positive value could be achieved if there were a CHP present to meet the summer base load and meet some of the electricity demand for the heat pumps. This cost saving would have to be balanced against an increase in the CO_2 emissions compared with the heat pump only situation, using grid electricity. This situation is examined further for Phase 3 variation 5

The reduction in CO_2 emissions is approximately 4 times greater for heat pumps than for the baseline CHP option, so this offers the most environmentally sustainable option for the period 2020 to 2030 and using average grid emissions.

8.4.3 Phase 2 Summary

The result of the Phase 2 Baseline model and all variations can be seen in Table 17

Table 17: Summary of key results for Phase 2 Baseline and variations

Results Summary	Units	Base Case	Variation 1	Variation 2	Variation 3	Variation 4	Variation 5
Network							
First year of operation		2020	2020	2020	2020	2020	2020
Network length	m	5245	5245	5250	4675	5380	5245
Total network capacity	kW	42,850	42,850	45,400	39,188	42,850	42,850
Economic performance							
Total Capital Cost (including Phase 1)	£million	22.2	23.0	23.4	19.7	22.3	19.5
CHP capacity	MWe	7.9	7.9	8.9	7.9	7.9	N/A
Energy centre boilers capacity	MW	43.1	43.1	45.6	39.4	43.1	43.1
Gas CHP gas demand	MWh/year	77,350	77,400	83,700	71,100	77,400	0 (9,100 electric)
Peak boiler gas demand	MWh/year	12,200	12,200	12,600	10,400	12,200	10,900
IRR (indexed) 25 years	%	3.9	3.4	4.3	4.2	3.9	0 (0.45 with RHI)
NPV (indexed) 25 years	£million	-3.0	-3.8	-2.6	-2.3	-0.3	-6.4 with RHI
Environmental Performance							
10 year carbon saving	tonnes CO_2	11,500	11,400	12,400	10,600	11,400	44,300
10 year carbon saving	%	12%	12%	12%	12%	12%	45%

The reason for the lower carbon savings than expected compared with Phase 1 is that the date for the start of operation is later resulting in a lower average electricity grid emission factor over the 10 year period. This means that gas fired CHP systems save less CO_2 than in Phase 1, but heat pumps can save more CO_2 than they would do earlier.

8.5 Phase 3 – Long term

The modelling of the three network includes all other parts of the earlier schemes proposed in Phase 1 and 2. For the purpose of the model it is assumed that this is all installed at the same time, rather than installed phase by phase over a long term plan.

8.5.1 Phase 3 baseline

The Phase 3 network represents the full extent of the town centre DE scheme. It includes connection to all sites listed in below, with energy supply from a centralised CHP and boiler plant located at Hogsmill Sewage works. For the main ring network, the pipes are sized at 300mm to allow for diversity of heat supply. This allows for future flexibility of the networks as an energy centre as constant sizing allows for an energy centre to be located anywhere on the ring. Figure 42 above shows the proposed layout for all phases. A list of all of the heat customers considered for connection to Phase 3 (which includes all Phase 1 and 2 buildings) can be found in Table 6.

The key outputs for the Phase 3 baseline scheme are shown in Table 18 below.

Please note that all capital costs presented unless otherwise stated are for the entire Phase 3 scheme (including the phase 1 and 2 components). In reality, some of these costs will have been incurred during the development of phase 1, and partially paid off, and so the IRRs presented may be improved through optimisation of the phasing and expenditure.

Table 18: Summary of Phase 3 Baseline scheme

Results Summary	Units	Base Case
Network		
First year of operation		2025
Network length	m	9655
Total network capacity	Kw	94,000
Energy Centre Size	m²	2500
Economic performance		
Total Capital Cost (including Phase 1 and Phase 2)	£million	49.7
CHP capacity	MWe	20.1
Energy centre boilers capacity	MW	95.5
Gas CHP gas demand	MWh/year	180,000
Peak boiler gas demand	MWh/year	29,300
IRR (Indexed) 25 years	%	4.9
IRR (Flat rate) 25 years	%	0
NPV (indexed) 25 years		-3.4
IRR (Indexed) 40 years	%	6.6
IRR (Flat rate) 40 years	%	0
NPV (indexed) 40 years	£million	2.6
Effective cost of heat	p/kWh	5.2
Environmental Performance		
10 year carbon saving	tonnes CO2	-73,500
10 year carbon saving	%	-29%

Table 19: Summary of capital cost breakdown for Phase 3 Baseline Scheme

Capital costs (including Phase 1 and Phase 2)	£million
DH network capex	16.1
CHP engine capex	10.1
Energy centre boilers capex	4.3
Energy centre building capex	2.5
Thermal store capex	2.3
HIU capex - commercial loads	7.9
HIU capex - domestic loads	4.1
Gas connection	0.1
Electricity connection	0.1
Development costs	2.4
Total capital costs	**49.7**

8.5.2 Phase 3 Variations

1. Connection to Kingston University Clayhill Campus

The connection to the Clayhill Campus, for student accommodation, requires a long length of network of around 900m, which may cancel out the benefit of connecting to the site as a heat customer. This variation allows assessment of the cost effectiveness of this connection.

2. No connection to Kingston Hospital

Kingston Hospital accounts for a significant proportion of the heat load for the network, however it also requires a relatively long length of pipe to connect to the network. The hospital may be better off maintaining its own CHP plant to meet its demand, this variation is carried out to examine the viability of the Phase 3 networks, it if did not connect to Kingston Hospital.

3. Removal of south-east corner of ring main

The location of an energy centre at Hogsmill Sewage Works requires long lengths of pipe to reach the customers identified, and there are few customers on the south east section of the ring main. Therefore an alternative scheme is proposed which removes this section of the ring. The details of this layout are given in section 6.6.2. This variation is modelled by subtracting the capital cost of the pipes required from the overall cost.

The carbon saving and cost savings listed in the result table would actually be larger than given as the model only considers reduction in capital cost to the network. Maintenance cost and pipe losses are not considered for this variation, but would have some effect on the result.

The carbon saving is not included for this variation as the model does not give a representative value, however the saving will be greater than for the base case as there will be less heat losses due to a shorter length of pipe between the energy centre and the heat loads.

4. Capital costs for Phase 3 only included in economic assessment

This variation is not listed in the previous section as it has no effect on the layout of the network. This variation considers only the costs associated with the new Phase 3 pipes and energy centre, by subtracting the capital cost of Phase 1 and 2 from the model. In this situation, it is assumed that the costs for Phase 1 and Phase 2 are paid off.

This is an optimistic scenario, and in reality, the operation of Phase 3 will also have to pay back an element of the Phase 1 and Phase 2 investment.

This version gives the cost of extending the network beyond Phase 2, by only considering the capital cost of additional pipework. The annual costs modelled are for the whole network, including the earlier phases. This cost is taken from the Phase 2 baseline case where the capital cost of the network is £6.6m.

5. Heat pump as energy source

Variation 5 considers the effect of an alternative technology, this would be a heat pump from the Thames and from the sewage works. The two locations would each be sized for 10MW, using No.4 x5MW heat pumps in total. The location of the heat pump is unknowns so a nominal length of pipe of 500m at a 300mm diameter, to match the main ring.

This variation is modelled with just heat pumps and with a CHP engine (capacity 3MWe) to provide some of the electricity and meet the base load. Both of these options are detailed in Table 20 below.

The results show that heat pumps do not provide a rate of return without the RHI, but in combination with a 3MWe baseload CHP unit and the RHI, can provide a 3% IRR.

8.5.3 Phase 3 Summary

The result of the Phase 3 Baseline model and all variations can be seen in Table 20

Table 20: Summary of key results for Phase 3 Baseline and variations

Results Summary	Units	Base Case	Variation 1	Variation 2	Variation 3	Variation 4	Variation 5	Variation 5
Network							No CHP	CHP
First year of operation		2025	2025	2025	2025	2025	2025	2025
Network length	m	9,700	10,600	8,500	7,285	9655	9800	9800
Total network capacity	kW	94,500	97,200	50,000	93,400	94,500	94,500	94,500
Economic performance								
Total Capital Cost (including Phase 1 and Phase 2)	£million	49.7	51.0	33.5	45.5	43.1	43.7	45.3
CHP capacity	MWe	20.1	20.1	9.7	20.1	20.1	N/A	3.0
Energy centre boilers capacity	MW	95.5	98.3	50.9	95.5	95.5	95.5	95.5
Gas CHP gas demand	MWh/ year	180,000	182,000	95,300	2025	180,000	0 (18,700 electric)	41,600 (16,200 electric)
Peak boiler gas demand	MWh/ year	29,300	31,900	16,700	9655	29,300	27,400	18,900
IRR (indexed) 25 years	%	4.9	4.6	0.5	6.1	6.9	0 (0 with RHI)	0 (1.2 with RHI)
NPV (indexed) 25 years	£million	-3.4	-4.5	-10.8	0.3	2.5	-17.2 with RHI	-13.1 with RHI
Environmental Performance								
10 year carbon saving	tonnes CO_2	-73,500	-74,800	-41,400	-73,500	-73,500	127,300	95,000
10 year carbon saving	%	-29%	-33%	-34%	-33%	-33%	58%	43%

8.6 Financial and Environmental benefits for developers

The use of DH, and connection to wider DH schemes may be of benefit to developers through providing a low carbon heat source, and potential economic benefits. A full discussion of future Building Regulations standards and GLA policy standards is provided in Appendix 3: Impact on new development, with an assessment of how these standards may or may not promote the use of DH in new development. This appendix provides a summary of:

- An outline of the proposed zero carbon standards relating to Part L of the Building Regulations (Conservation of Fuel and Power), future policy thinking, and the GLA policy relating to CO_2 emissions on new development.
- An assessment of how future Part L standards and the GLA policy may promote the use of DH schemes, and the benefit this may provide to developers.
- Examples of cost and environmental modelling on a range of building types to demonstrate the performance of DH against alternative solutions to meeting the standards.

Under the current Part L 2010 and the proposed 2013 standards (to be introduced later in 2013), the CO_2 targets do not necessitate the use of a DH scheme and alternative lower cost options are open to developers. However under the GLA's energy hierarchy, the use of a district heating system is required where viable. Without the GLA policy, it is unlikely that developers would make use of DH on new development due to the lower targets.

For "zero carbon" regulations (2016 for domestic and 2019 for non domestic) there is much uncertainty around the technical standards, the level of carbon compliance, and the allowable solutions mechanism. This means that it is (a) not possible to state how well different technologies will perform in relation to targets (which are currently uncertain, and (b), it is not possible to make an assessment of the economic viability, especially due to the lack of clarity around the costs of allowable solutions. However in line with current Government thinking, it is unlikely that future standards will be set at a level which require off-site connections and complex site-wide strategies, and more likely they will be developed around using building scale solutions such as PV. In high density developments, the lack of roof space for PV may be one trigger for including low carbon heating from DH, but changes to the future regulations and standards for high rise flats may remove this advantage for DH.

The costs of achieving CO_2 reductions on site can not consider only capital investment, but also need to take into account lifecycle revenues and costs, and the balance of investment from different parties. The ability of developers to capitalise future revenues, either through increased building value, or reduced capital investment, depends on the strategy and delivery mechanism. For DH, the costs to developers will depend very much on the cost effectiveness of DH on each scheme, and the level of investment the DH scheme operator is willing to provide. This needs to be balanced against the alternative solutions and delivery mechanisms.

Full details are provided in Appendix 3: Impact on new development.

8.7 Summary

This section provides an assessment of the economic and environmental performance of the three phases of DE scheme under a number of sensitivities.

The results demonstrate that a Phase 1 scheme could provide an IRR of up to 4.1 % and CO_2 savings in the order of 25%. Whilst these IRRs are not commercially attractive, they could be potentially improved through optimisation at detailed feasibility stage to a level which can attract public sector investment, or even commercial investment. Sensitivity analysis on the baseline results shows that a 20% increase in electricity revenue price (equivalent to 1.2p / kWh extra) could increase the IRR to around 7.5% which would attract public sector investment.

The phase 2 schemes all provide IRRs of around 4% except for the river water heat pump option which drops to 0.45% even with RHI income. These IRRs include investment in the entire network, and so if the phase 1 component is considered to be partially paid back, then the effective IRR would increase further. The stability of the IRRs across the variations demonstrates that the Phase 2 options are not critical when defining phase 1 of the network.

The IRRs for the long term Phase 3 network improve over the initial 2 phases with up to around 6% if the layout is changed to remove the poorly utilised section of the ring main. As with Phase 2, some of the capital for Phase 2 and 1 will have been paid off and therefore the effective IRRs of this later phase will be higher. The heat pump options are not predicted to be cost effective without additional generation, but when a 3MWe CHP system is included in the scheme, (a relatively small contribution), an IRR of 3% is achieved with RHI income.

These results all demonstrate that there are potentially viable short, middle, and long term DE options in Kingston Town Centre. Phase 3 demonstrates that the viability of the scheme improves with size, and whilst the phase 1 scheme gives low IRRs, it is anticipated that optimisation of the network at the detailed feasibility stage combined with improvements to the electricity revenue (though either on-site electricity sales, or improved licence lite rates) could increase the IRR to public sector investment levels. One option for phase 1 is to develop a scheme with distributed boilers which remain in the operation of customers, and only sell baseload heat. Whilst this does not offer such a large discount on the customers overall heating bill, it provides an economically attractive scheme which could act as a catalyst.

9 Risk assessment

9.1 Introduction

The development of DE schemes can be complex and requires the collaboration of a number of parties. During all stages of the scheme development, from feasibility to operation, a number of risks may be encountered which will need to be overcome. The lack of regulation of heat supply can be a particular issue, alongside the perceived immaturity of DE schemes in the UK. The risk analysis presented here identifies key project risks in the delivery of the proposed DE scheme (technical, economic, legislative, and consumer issues) and suggests mitigation measures and action holders. Project risks have been ranked in order of their importance and potential impact.

9.2 Types of risk

The risks associated with developing a DE scheme can be categorised a number of ways depending on the focus of the risk assessment process. The following categories of risk are assessed in this section:

- **Technical viability.** Risks associated with identifying and delivering a scheme which is technically viable.
- **Economic viability.** Risks associated with the economic performance of a scheme, and the ability to deliver a rate of return.
- **Commercial.** Risks associated with customers, lease agreements, and suppliers.
- **Regulatory / policy.** Risks associated with uncertainty around future regulation and policy at national and local level.
- **Development and construction.** Risks associated with the development and construction of a scheme – these may cover a range of technical, economic, and commercial issues.
- **Future strategy.** Risks associated with the ability of the scheme to be future proof and have a long term strategy.
- **Other** general risks. Any other risks not falling into the above categories.

9.3 Measuring risk

The consideration and measurement of risk requires an understanding of two properties:

- **Impact.** The impact of the risk is the outcome that may occur if the risk is not properly managed. For example, if sufficient economic analysis is not conducted and sensitivities assessed, the impact of economic viability risk may be that a scheme is not economic once developed.
- **Probability.** This is the chance that a risk may occur and is independent of the impact.

The outcome of impact and probability is an overall measure of risk. If the impact and probability are both deemed to be high, the overall level of risk is high. If the impact and probability are both deemed to be low, then the overall risk is low. For intermediate situations, a matrix is used to assess the overall risk. For example a high impact combined with a low probability results in a medium risk. Figure 43 shows the risk assessment matrix used in this study.

Rating		Probability				
		1	2	3	4	5
Impact	1	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

Figure 43: Risk assessment matrix taking into account probability and impact.

9.4 Assessment of risk for RBK

Table 21 provides an initial risk assessment for DE schemes in RBK. For each identified risk, the impact, probability, and overall measure are given along with mitigation measures and organisation responsible.

It should be noted that this is a first stage risk register based on the masterplanning work, and this will need to be continually updated if any project proceeds. The risk register is provided in spreadsheet format for this purposed alongside this report.

At this initial high level masterplanning / feasibility stage, the project ownership and control lies almost entirely with RBK, and so the current risk owner for all items is identified as RBK. As the scheme progresses, some risks will transfer ownership to other responsible parties.

Capabilities on project:
Building Engineering

Table 21: Risk assessment of DE schemes in RBK

Risk category	Risk ID	Project Risk	RBK Risk register				
			Prior to mitigation				
			Probability	Impact	Rating	Mitigation	Owner
Commercial	19	Failing to attract a high uptake of customers willing to commit prior to construction	4	4	16	Communications strategy, regular contact with key stakeholders required.	RBK
Commercial	20	Heat sale price not yet known and needs to be competitive to secure customers.	4	4	16	Phase 1 feasibility work needs to examine the heat sales price further to provide indicative costs for customers. If not competitive, network unlikely to be developed.	RBK
Commercial	21	Willingness of customers to accept long term contracts and long term stability of customers	4	4	16	Close engagement is required with customers to promote the economic and other benefits DH can provide.	RBK
Commercial	22	Delivery and governance structures not agreed	4	4	16	RBK need to assess potential options for the delivery of the scheme. Engagement at Chief Exec level in the Borough will be essential.	RBK
Commercial	24	Failure to secure project funding	3	5	15	RBK need to assess potential funding and deliver options to ensure that this can be obtained.	RBK
Commercial	23	Ability to retain customers on shorter term contracts	3	4	12	Heat sales prices and contracts will need to be robust and attractive.	RBK
Commercial	18	Ability of economic performance to allow discounted heat sales	3	3	9	This is of lower risk to phase 1 due to the larger public sector involvement and likelihood of accepting a smaller discount.	RBK
Commercial	25	Potential lease agreements needed for energy centre location, agreements for access to distributed boiler rooms etc.	3	3	9	Explore further once location of plant established at phase 1 feasibility stage.	RBK

Capabilities on project:
Building Engineering

Development and construction	30	Impact on road transportation. Development of the DHN may cause disruption to key or busy roads, and impact on traffic.	3	4	12	It is likely that the installation will cause disruption. Once exact routes are known, coordination with the Council transport department is required to ensure that the works are conducted in a way which causes minimal disruption.	RBK
Development and construction	32	Existing buried services. The extent of existing utilities may impact on the routing of the DH network and cost of installing.	3	3	9	Detailed review and survey of existing utilities will be required during the design and construction stages.	RBK
Development and construction	33	Programme delays giving increased costs	2	3	6	Careful management during the development and construction phases will be necessary to ensure any delays are managed and minimised	RBK
Development and construction	29	Lack of integration with existing and planned works	2	2	4	No major existing or planned works have been identified which require coordination. However the EMP can be used to help identify where future works may have an impact.	RBK
Development and construction	31	Land ownership constraints for routing of DH network.	2	2	4	Explore in more detail at feasibility stage. No major issues identified in the EMP.	RBK
Economic viability	17	The rate of return is too low to attract investment	4	4	16	It is possible that the rate of return is to low to be of commercial interest, but options using public sector funding (eg PWLB) may be used.	RBK
Economic viability	13	Achieving a reliable and sufficient electricity revenue	3	5	15	This EMP assesses the option of using License Lite, but the viability of this is uncertain. RBK need to keep engaged with the GLA over License Lite options, and also examine further options for maximising electricity revenue.	RBK / GLA
Economic viability	16	Uncertainty over capital cost	2	4	8	Further feasibility work needs to examine captial costs in more detail, including for energy centre development	RBK
Economic viability	14	Uncertainty over future energy prices for development of business plan	2	3	6	The future of energy prices is uncertain, and so further economic viability work for phase 1 needs to examine sensitivies to energy prices	RBK
Economic viability	15	Uncertainty over future operation and maintenance costs of energy plant and	2	2	4	The phase 1 scheme proposes a gas CHP unit which is reliable and mature technology.	RBK

		network					
Economic viability	12	Achieving an acceptable debt rate with customers for heat sales	1	3	3	In the first phase, the majority of customers are public sector and so this should be limited. For private sector customers, robust contracts are required.	RBK
Future strategy	36	Level of control over future strategy of network by council, such that network will expand as desired.	3	3	9	This is dependent on the governance and delivery structure. If the scheme is delivered with strong council control / ownership, then control will be retained. If a commercial deliver route is taken, this control may be reduced.	RBK
Future strategy	37	Limited identification and encouragement of future connections to the network with existing buildings and new developments.	3	3	9	RBK need to keep a watching brief to identify, and engage with, any new potential customers.	RBK
Future strategy	34	Lack of flexibility in phase 1 network for future expansion	2	4	8	The EMP considers options for providing additional capacity in the phase 1 network.	RBK
Future strategy	35	Technical capacity of energy centre to expand for future extensions to network including the provision of additional plant and capacity of utilities connections.	2	4	8	The EMP provides a number of phased options, which rely on both phase 1 plant and additional plant for future phases.	RBK
Future strategy	38	Capacity of network to integrate technically and commercially with other networks where potential exists.	2	3	6	The network proposals for DH schemes across London are based on similar operation parameters. However any connection issues will need to be dealt with on a case-by-case basis.	RBK / GLA
General / miscellaneous	2	Local political risk. Changes to council administrations results in lower priority for DH schemes or even abandonments through removal of resource.	3	4	12	Engagement with the Council and Exec and Director level is essential for the scheme to be given the resources and priority required.	RBK
General / miscellaneous	3	National political risk. Changes to national administration or strategy results in move away from DH, or powers which allow local authorities to develop and invest in DH schemes.	2	3	6	This may place a greater emphasis on schemes being economically attractive for commercial investment.	RBK

Regulatory / policy	28	Regulated incentives for gas CHP are not favourable reducing viability of the scheme.	2	4	8	RBK need to monitor incentives for gas CHP and DH to monitor the impact this may have on a scheme.	RBK
Regulatory / policy	26	Energy centre environmental impacts e.g. air quality	2	3	6	This needs examining further at phase 1 feasibility stage. No immediate specific issues have been identified as part of this EMP.	RBK
Regulatory / policy	27	Energy centre can not obtain planning permission due to nature and size of building and associated flues.	2	3	6	The energy centre will need careful design consideration but following consultation with the planners, there are not believed to be any fundamental constraints.	RBK
Technical viability	8	Identification of an energy centre location for phase 1	3	5	15	The sites in the EMP need to be examined further and engagement commenced with other parts of RBK and third parties to ensure a location can be identified.	RBK
Technical viability	5	Existing heating systems are not suitable for connection to a DE scheme	3	4	12	Review existing plant in buildings at the feasibility stage to assess the high level viability of connection.	RBK
Technical viability	4	Lack of suitable loads for producing a diverse heat load profile for a DE scheme.	3	3	9	Assess the viability of loads at the technical feasibility stage, including sensitivity of including each load.	RBK
Technical viability	7	Flexibility of the network to future energy supply options to allow operation at low temperatures	3	3	9	Any designs need to be future proofed to ensure the network has the capacity to operate at lower temperatures.	RBK
Technical viability	6	Suitable routes can not be found for the network due to other constraints	2	4	8	Further feasibility work needs to identify the routes in detail and examine constraints such as existing utilities.	RBK
Technical viability	9	Availability of suitable gas and electricity infrastructure connections at the energy centre site.	2	4	8	These need to be assessed at the detailed feasibility stage for each phase of the network.	RBK
Technical viability	11	Ability of the network to provide CO_2 reductions in the longer term	3	2	6	The EMP identifies that heat pumps can provide longer term CO2 savings, but this requires the network to be operated at lower temperatures, and a suitable source of secondary heat found.	RBK
Technical viability	10	Ability of network to give required CO_2 reductions in the short term	2	2	4	The EMP identifies that gas fired CHP can provide large CO2 savings in the short term.	RBK

10 Delivery plan and next steps

10.1 Introduction

This section provides an overview of a delivery plant for taking forwards DE in RBK. It addresses the key areas of project governance and structure, a programme for the delivery of a project, and next steps.

10.2 Project governance and structure

10.2.1 The balance of risk

The fundamental issue facing local authorities is whether they are willing to invest directly in the DH scheme and what the relationship is with the private sector. The evaluation of the options usually revolves around a number of considerations:

- The balance between taking on project risk and having control over project outcomes;
- The rate of return for the project will actually support and the recognition that the *cost* of capital or the required rate of return for the private sector is generally greater than for the public sector which on a capital intensive project has a major impact on viability; and
- The *availability* of capital to both public and private sector is limited but is also closely linked to the degree of risk involved and the organisations' understanding of the risks involved.

Figure 44 and Figure 45 illustrate some of the above issues.

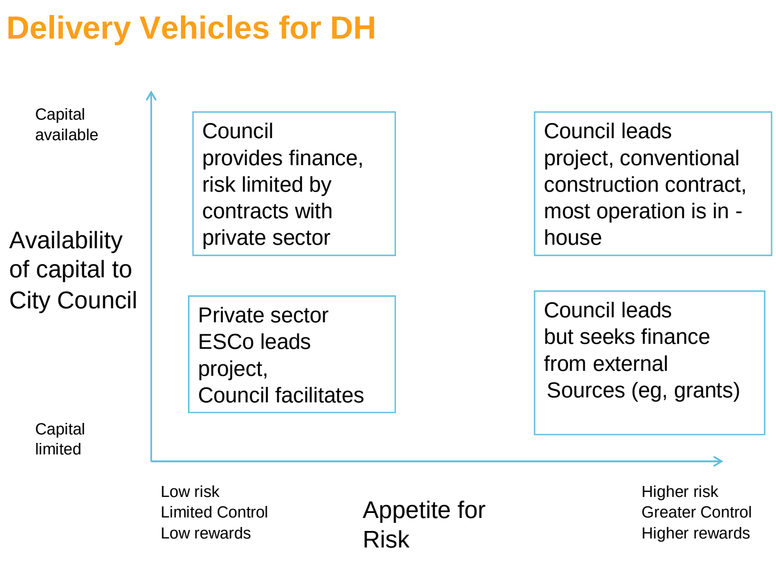

Figure 44: Appetite for risk and reward against availability of capital

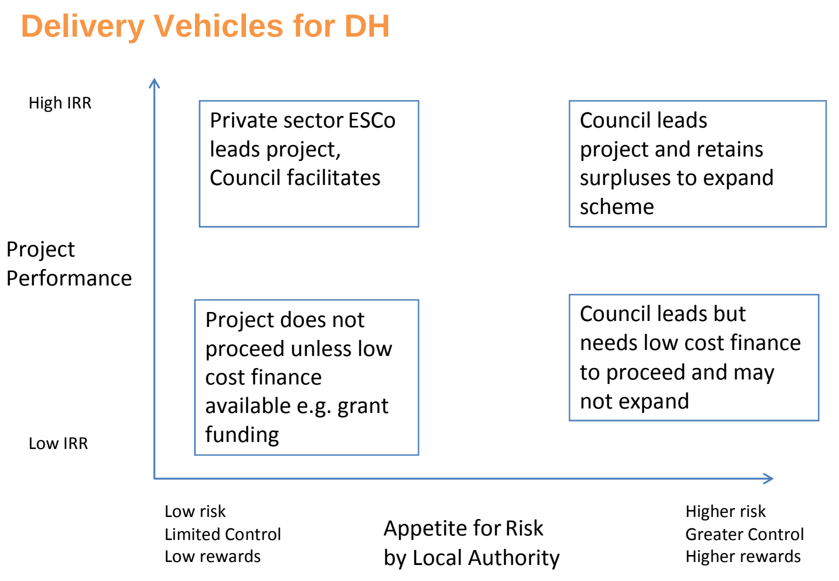

Figure 45: Appetite for risk and reward against project performance

Governance means the structure by which control is exercised over an operation which follows the decisions around business structures.

Procurement means the process by which services from the private sector are contracted by the public sector.

Both of these issues are subsidiary and subsequent to taking decisions on the more fundamental question of delivery structures.

10.2.2 Typical energy scheme governance structures

As for the privatised electricity and gas industries there are three clearly identifiable businesses in a district heating scheme:

- A generation business producing the heat and selling electricity (GenCo).
- A distribution business distributing heat through the district heating network (DistCo).
- A supply business buying heat from the producers, selling energy to customers and paying the distribution company for the transport of energy (SupplyCo).

The separation of these three businesses would potentially enable competition between heat generators and competition in the supply of energy to customers on the network as for electricity. The distribution business is a natural monopoly and if privately owned would ideally be subject to regulation to protect customers and to ensure open access for suppliers in a similar way to the gas and electricity networks.

In many cases, particularly small schemes, all these businesses have been combined as a vertically integrated organisation partly to reduce risk and partly for simplicity, although this may change as larger systems develop and grow. However it is helpful to consider each element separately when evaluating options for a scheme.

It is also important to recognise the differing characteristics of these three businesses:

- The heat generation plant typically has a shorter technical operating life and a higher requirement for operation and maintenance. Once built it is unlikely to require additional investment until plant replacement or major overhaul. The major contracts will be for purchase of fuel and selling electricity.
- In contrast the DH network has a very long life and is likely to require regular small additional incremental investments as it expands to serve new customers.
- The supply business will need to be customer focused able to manage a large number of small contracts with a wide range of requirements.

In the other utility markets where natural monopolies exist a Regulator has been appointed to ensure that capital investments

Energy supply is regulated by OFGEM and it is likely that if heat supply (currently un-regulated) becomes a regulated business, then OFGEM or a similar Government body would be responsible for overseeing the process.

At a local level, Local Authorities involvement in schemes can help provide a degree of certainty and confidence to customers, but this would not “regulate” heat supply.

The DistCo business may be divided into two levels – the distribution network which supplies energy to customers and the transmission network which will generally only supply energy to the more local distribution network.

The SupplyCo is responsible for reading meters, billing and debt collection although this may be sub-contracted out to a separate company. The ownership of meters at the customer locations may be with either the SupplyCo or the DistCo.

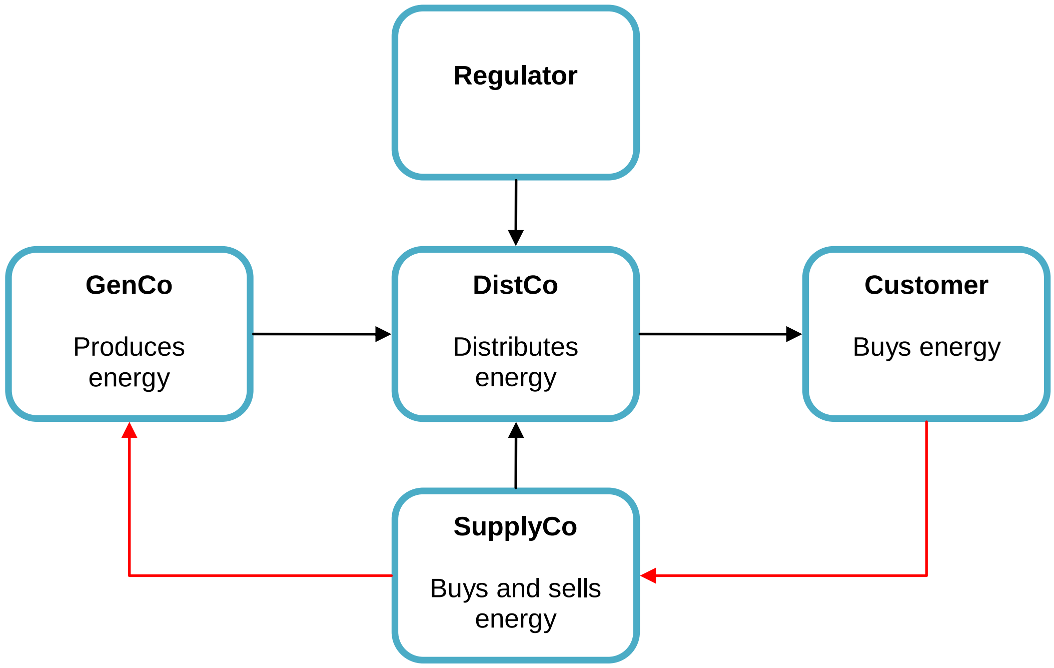

Figure 46: The basic elements of a delivery and governance structure for a district heating scheme.

10.2.3 Structure for district heating companies

The structure previously described was developed when established large-scale businesses in electricity and gas were privatised. The development of district heating as a new energy infrastructure has a number of characteristics which mean a direct transfer of the above concepts may not be realistic.

These differences are:

- The district heating networks will be more local than the national electricity or gas grid. In the early days of a heat network or on small schemes, it may not be practical or possible to have multiple energy suppliers who compete to supply a heat market; a single heat energy source is more likely;
- There is currently no system of regulation for the heat network so there is limited consumer protection. As a result there is a stronger desire by the Local Authority to own the network to provide some protection;
- The district heating network enables strategic objectives including CO_2 emissions reductions, affordability, resilience and energy security to be met and these will be realised through taking a wider strategic view that may go beyond the obligations and economic considerations of a private company;
- There is a critical need to measure and confirm that the benefits of the heat network are being achieved and delivered over time and a detailed metering and data gathering strategy at the consumer's sites will be required; and
- Existing utilities have ownership in perpetuity and an obligation to connect customers. A DH scheme set up as a concession agreement for a finite period raises questions as to what happens at the end of the period. There is a risk also that investment becomes progressively more limited as the time left to recover that investment decreases. This may be the opposite of what is desirable for the project.

Typically, the options evaluated for DH schemes are:

- Fully private sector model – selecting an Energy Services Company (ESCo) to deliver the scheme;
- Fully public sector model – setting up an internal department to deliver the project;
- A hybrid ("joint venture") scheme where an ESCo is set up as a special purpose vehicle (SPV) with the local authority as one of the stakeholders and other public and private sector partners.

Further variations within the hybrid scheme may have benefits depending on the circumstances and political aims. For example an option might be to include: replacing shareholder ownership with a membership scheme that receives a dividend for investment into the scheme or a limited liability partnership; or creating a not-for-profit co-operative scheme. Creating a mutual or co-operative allows an asset lock to be place on the distribution of surpluses which are instead either re-invested in the business, shared with customers through lower heat prices or channelled into adjacent activities eg Green Deal.

The three main options of private, public or a private/public partnership can be applied to all of the three businesses together or each business could be treated separately.

In addition the development of the project can be further subdivided into the construction, ownership and operation. In many cases the construction and operation will be taken forward through sub-contracts with specialist organisations.

Figure 47 shows a number of delivery options based on taking the three businesses (generation, distribution, supply), the three ownership options (public, private and partnership) and the three functions of construction, ownership and operation and combining these in various combinations. The matrix is not exhaustive but it does cover the most commonly found arrangements used so far in the UK.

OPTION	Heat generation			District Heating Network			Supply of heat
	Build	Own	Operate	Build	Own	Operate	
A	PSC	PSC	PSC	PSC	PSC	PSC	PSC
B1	C	C	C	C	C	C	C
B2	C	C	PSC	C	C	PSC	C
C1	PPP	PPP	PPP	PPP	PPP	PPP	PPP
C2	PPP	PPP	PSC	PPP	PPP	PSC	PPP
D1	PSC	PSC	PSC	C	C	C	PSC
D2	PSC	PSC	PSC	C	C	C	C
E1	C	C	C	PSC	PSC	PSC	PSC
E2	C	C	C	PSC	PSC	PSC	C

Key

C = Council
PSC = Private sector energy services company
PPP = Joint private/public sector company

Note: Where C is indicated as responsible for any of the functions, this does not preclude contracting with the private sector for actual delivery of this function.

Figure 47: Possible options for delivery structures for DH

Comparisons of the options and solutions are outlined below

A. All private sector. A private sector company constructs, owns and operates the CHP and the new heat network and sells heat to each customer on the new network at each building connection. There is no public sector involvement.

B. Predominantly public sector. The Council (C) constructs, owns and operates the CHP and the new heat network, and sells heat to customers on the new network (Option B1) with no private sector involvement. The day to day operational risk to C can be reduced if the operation and maintenance of the CHP and DH network are contracted to experienced private sector companies (Option B2).

C. Public private partnership (PPP) ownership. A PPP is formed between C and a private sector company to jointly build and own the scheme and sell energy to customers. To reduce the public sector risk in operation, a private sector company could be contracted for the on-going operation requirements (option C2).

D. Split assets – network in public ownership. A private sector company constructs, owns and operates the CHP plant. The heat network is constructed, owned, and operated by C who either sell heat directly to the customers (option D1), or who charge the private sector company a rental on the network on the basis of capacity and units of heat transferred in return for the private sector company selling heat to the customers (option D2).

E. Split assets – network in private ownership. C constructs, owns and operates the CHP plant, whilst a private sector company constructs, owns, and operates the heat network. The private sector company can purchase heat off C and sell to customers over the network (option E1) or alternatively, C can sell heat to customers by paying the private sector company network owner/operator a distribution charge (option E2).

In addition to the above options and as detailed in Figure 47, there are many other theoretical options. However we believe the above options represent the most practicable, and are the most fruitful to pursue further for RBK.

10.3 Project plan

This EMP sets out a high level vision for DE across the Kingston Town Centre area, with potential for connection to neighbouring schemes and areas. A project plan needs to consider both the near term and long term delivery of this vision. These are discussed further below.

10.3.1 Near term project plan and next steps

The project plan for the near term needs to consider the stages of work required to deliver the first phase of a scheme, including from initial engagement and strategy (which this EMP is part of), through viability assessment and development of business plans, to the delivery a scheme.

Key early phase actions are as follows:

- On the back of this EMP, engage with relevant decision makers within RBK including at Director and Executive level to ensure the outputs from this work are understood and develop a strategic vision and vehicle for taking forwards DE schemes in the Borough. This process must consider the potential governance models available to ascertain the Councils willingness to accept risk, the level of control desired over a scheme, and the ability of the Council to raise finance.
- Identify sources of funding for further development work for the phase 1 scheme to cover further viability work and business case development. It is suggested that this may cost circa £200k over the next two years.
- Procure more detailed feasibility work for a Phase 1 scheme. This EMP suggests that there may be an economically viable phase 1 scheme which warrants further investigation. This needs to examine in further detail the energy loads and profiles, locations for an energy centre, network routes, and conduct a more detailed costing exercise.
- Engage with the potential customers on a Phase 1 scheme, in particular with Kingston University. Whilst no information can be provided initially on exact heat costs, these discussions should aim to develop a good working relationship to ensure further information exchange and data collection is possible, and an understanding of potential contract terms (including length) can be developed.
- Work with the planning department and potential customers to identify suitable energy centre locations. In particular, there needs to be strong representation of the DE scheme within the Kingston Futures group as this appears to be a major opportunity.

Once these early stage actions have been completed, the programme until construction is expected to be circa 3 years although this clearly depends on the complexity of the scheme and how it is delivered. Figure 48 provides an indicative development programme for phase 1.

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Figure 48: indicative project plan for phase 1 of the scheme.

10.3.2 Mid-term project plan and next steps

The work required in the mid-term depends on the outcome of the phase 1 scheme. However the following items will need to be considered:

- Identification and engagement with key potential customers to develop a robust potential customer base for further feasibility and business case work.
- (Further) development and implementation of planning policy to ensure that developments in areas mentioned in this EMP, and other developments in the DH network areas, are designed and built such that they are suitable for connection. RBK will need to work strategically with landowners and developers to ensure that this is achievable, including how the scheme will be managed.
- Identification of sites for future energy centres, including engagement with Thames Water over the Hogsmill STW, continued engagement with Kingston Futures, and identification of river-side sites.
- Consideration of heat pumps as a heat provision technology to provide long-term carbon savings. This will need to influence the future network design, and potentially customers on the existing network.
- Close engagement with the Hospital to ensure that future renovation and re-development facilitates connection to a site-wide DH scheme, and identification of opportunities for locating additional plant at the hospital site.

10.3.3 Long-term project plan and next steps

The long term plan is clearly loosely defined at present and subject to many influencing factors relating to the scale of the Phase 3, and outcome from earlier phases. However at a strategic level, the following need to be considered:

- Continued identification and engagement with potential customers, and ensuring new development can connect.
- Assessment of performance of existing phases and environmental performance, and ensuring that technology strategies (eg gas CHP or heat pumps) can deliver the required economic and environmental performance.
- Engagement with the GLA and neighbouring Boroughs to ensure opportunities for wider connections are identified and facilitated.

10.4 Phasing considerations for DHN development

The proposal for a 3 phase system in this EMP is based on the short, mid, and long term opportunities for DE development. In reality following an initial first phase, the scheme is likely to expand in a number of smaller phases with larger more strategic extensions being added as and when required. However the 3 phase model allows a simple outline of phasing considerations to be developed as shown in

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Table 22 below:

Table 22: Phased feasibility considerations for the DHN development

	Timing for considerations at feasibility stage		
Relevant Layout	**Phase 1 feasibility period**	**Phase 2 feasibility period**	**Phase 3 feasibility period**
Phase 1	• Identification and assessment of which buildings to connect to; load, type of customer • Energy centre location: space/availability, temporary or permanent, suitable for connection to phase; flexibility to vary location • Retained boilers; in which buildings and for how long (i.e. permanent or temporary) • Network route; connection details; • Flexibility for future development; connection to a later phase; extension in other directions - south or west		
Phase 2	• EC location and size; use same location for Phase 1&2 – may also retain engines, or use a second energy centre. • Location of connection of Phase 2 network to Phase 1 and identification of suitable capacity in Phase 1 proposals. • Identify other planned infrastructure works to coordinate with phase 2.	• EC location; one or more? Use of existing phase 1 energy centre? • Technology – gas engine CHP or heat pumps? • Which sites to connect to: load, customer type. • Size for future redevelopments • Network route; connection details; phase with other works • Difficult routes – over railway and river, can these be phased with other works; are these sites worth connecting with. • Phasing of installation: all at one; main line and then additional extensions at later date.	
Phase 3	• Ensure phase 1 network proposals reflect ongoing engagement with future customers and energy centre locations, eg Hogsmill STW.	• Number of energy centres – retain phase 2 EC or develop additional capacity. • Differing technologies – WSHP from river Thames, design layout to account for this • How and where to connect to Phase 2 • Compatibility of Phase 2 with Phase 3 – pipe sizing for appropriate future load • Phasing of connection; joining a number of smaller networks (Hospital, Cambridge Road etc) or extending out ‘from scratch’	• Energy Centre location – land availability, fixed or variable location • Network route and layout (including decision for ring or branches. • Identification of phase 3 customers and engagement.

11 Conclusions and recommendations

11.1 Introduction

This section sets out the conclusions and recommendations relating to the potential to develop DE schemes serving two locations in Kingston-upon-Thames, taking into account existing and future public sector, quasi-public sector and private sector energy demands, existing heating installations, and clustering of energy loads. Potential network routes and energy sources have been considered. This has enabled the economic feasibility, environmental benefits and a wide range of risks to be assessed, so that the overall feasibility and likely location and phasing of DE schemes can be set out. A project plan has been prepared which will be owned by RBK and updated by the Council in line with any changes to the project elements. The next steps are also noted.

The information used for this report is based on a number of sources. The most significant dataset is from the RBK heat mapping study which is used for the basis of the EMP. This identifies the key loads, and proposes areas of interest for DE scheme development, mainly the KTC area. The datasets from the RBK study are assessed and amended where required. For core sites including redevelopment opportunities and possible energy centre locations, additional information was collected from site visits and more detailed discussion where necessary.

11.2 Review of Information

The town centre contains a number of large energy users in close proximity, which offers a significant opportunity for a DH network to be established. Further out from the Kingston Town Centre there is a large housing estate on Cambridge Road and Kingston Hospital which have potential to be future heat customers.

The scope of a DH network in the Tolworth areas appears limited. The only site that is deemed possible for connection is Tolworth Tower as the major ‘Tesco site’ nearby already includes a CHP plant sized for the whole development. Unless a number of smaller customers can be found that are able to connect, the most viable scheme is to provide for Tolworth Tower only and not connect to other customers.

11.3 Energy Production

Analysis of the available technologies identified two possible heat sources as gas fired CHP systems and large scale heat pumps. Finding land for an energy centre is critical to the development of the network. For the short term, the Phase 1 network could make use of distributed boiler plant and a central energy centre as land becomes available. The main long term option for an energy centre is the Hogsmill valley area, as there are some areas of unused land, which is less likely to be developed for other purposes. This site also provides an opportunity for secondary heat from the STW outlet using a large heat pump for future phases.

In addition to this site there may also be potential to use heat pumps to take secondary heat from the river Thames. This requires a site along the river bank, therefore suitable locations, including potentially as a future addition to the power station site, need to be identified and promoted through planning.

11.4 Energy distribution

It is proposed that the network develop in 3 phases

- Phase 1 – Short term – comprising of a small group of council owned buildings the Courts, the police station, Kingston College and Kingston University
- Phase 2 – Medium term – extension northwards into the town centre and up to level with the railway, connecting to the larger retail units throughout the town.
- Phase 3 – Long term – extending east to the Cambridge Road estate and to Kingston Hospital to form a ring with an energy centre located at the sewage treatment works.

For each of these phases a number of variations are proposed to find an optimal configuration. Table 23 summarises some of the key details for the baseline schemes as well as the range of IRR calculated from the proposed variations

Table 23: Summary of three phase plan for Kingston Town Centre DHN for the base case scenarios

	Phase 1 Short Term	Phase 2 Medium Term	Phase 3 Long Term
Capital cost (£million)	8.2	22.2	49.7
New DHN capital cost (£million)	2.2	4.4	11.7
Heat load (MW)	16.8	37.9	94.5
Annual average CO_2 saving (tonnes)	9,500	11,500	*up to 127,300
Annual average CO_2 saving (%)	26%	12%	*up to 58%
IRR (indexed, 25 years) for variations	2.3 - 4.9%	0.5 – 4.3%	0 – 6.9%

*The carbon savings of the long term phase 3 network are highly dependent on the future mix of grid electricity.

The results demonstrate that the baseline Phase 1 scheme with a central energy centre located in the Eden Quarter on existing RBK land (currently surface car parking) providing all of the schemes heat could provide an IRR of 3%. By locating the energy centre closer to the customers (and therefore reducing the DH network length), the IRR is increased to 4.1%. The highest IRR of 4.9% is obtained when the DH network provides baseload heat only (Variation 3) and peak and back-up heat supply is from the customer's existing boilers.

Whilst these IRRs are not commercially attractive, they could be potentially improved through optimisation at detailed feasibility stage to a level which can attract public sector investment, or even commercial investment. It should be noted that the assumptions used in this EMP are purposely conservative to reflect the high level nature of the analysis, and therefore it is possible that optimisation could be beneficial. Sensitivity analysis on the baseline results shows that:

- a 20% increase in electricity revenue price (equivalent to 1.2p / kWh extra) could increase the IRR to around 7.5% for the baseline Phase 1 scheme. This would attract public sector investment.
- A 20% reduction in capital costs (representing either a real cost reduction, or input of funding from grants of local sources such as CIL) would result in an IRR of 6.6% for the baseline Phase 1 scheme.

The phase 2 schemes all provide IRRs of around 4% except for the river water heat pump option which drops to 0.45% even with RHI income. These IRRs include investment in the entire network (including the Phase 1 components), and so if the phase 1 component is considered to be partially paid back, then the effective IRR would increase further. The stability of the IRRs across the variations demonstrates that the Phase 2 options are not critical when defining phase 1 of the network.

The IRRs for the long term Phase 3 network improve over the initial 2 phases with up to around 6% for an optimised network (this includes removal of a section of the ring main which is poorly utilised - variation 3). As with Phase 2, some of the capital for Phase 2 and 1 will have been paid off and therefore the effective IRRs of this later phase will be higher – if is assumed that only the network costs for Phase 3 need to be paid off then the IRR increases to 6.9% (variation 5). The heat pump options are not predicted to be cost effective as a single heat source, but with additional CHP generation included in the scheme (a relatively small contribution), an IRR of 3% is achieved with RHI income.

These results all demonstrate that there are potentially viable short, middle, and long term DE options in Kingston Town Centre. Phase 3 demonstrates that the viability of the scheme improves with size, and whilst the phase 1 scheme gives lower IRRs, the assumptions used in this EMP are conservative and it is anticipated that optimisation of the network at the detailed feasibility stage combined with improvements to the electricity revenue (though either on-site electricity sales, or improved licence-lite rates) could increase the IRR to public sector investment levels or better.

A phase 1 scheme is connected to primarily public sector customers which helps de-risk the initial investment and should allow the establishment of long-term heat supply contracts. The scheme could make use of a centralised energy centre providing all heat, potentially based on the RBK owned land in the Eden Quarter which allows for future expansion. Alternatively it could make use of existing boilers for peak and back-up heat supply with a smaller energy centre for the CHP and associated equipment. The latter could be a temporary solution prior to a longer term central energy centre, and have the plant located at potentially the County Hall or Kingston University Penrhyn Road site amongst others.

Future phases of a DE scheme have a number of options which will need further investigation following the establishment of a phase 1 scheme. A key issue to address for future phases is the transition in heat supply technologies from gas-fired CHP to heat pumps. Future work is required to examine in more detail the feasibility of heat pumps taking secondary heat from the Hogsmill outlet and the river Thames, and this will also need to consider the future changes in the electricity grid carbon intensity. Alongside the transition of heat supply technologies, future phases of a network will also need to consider lower temperature regimes to allow the distribution of the lower temperature heat from heat pumps, whilst meeting the customers heating demands.

11.5 Energy Sale

The sale of heat needs to ensure that a wide range of customers are attracted to ensure a high uptake of heat off take, and that this provides a long term low risk through encouraging long contract periods. In phase 1, the emphasis is on the public sector and the scheme should aim for long heat supply contracts, typically 10 years or more. As the scheme expands into the commercial sector, a combination of attractive prices combined with suitable contract lengths will be needed to both encourage connection and maintain connection.

For electricity sales, it is recommended that RBK continue to work with the GLA to further explore the opportunities for making use of the GLA Licence lite regime. This could offer a relatively simple solution for improving the revenue for electricity. In addition, opportunities for exporting electricity directly to large electricity consuming customers should also be considered and monitored so that the revenue can be maximised where possible. Such opportunities may have an impact on the governance model for the scheme to allow licence exempt supply.

11.6 Risk assessment

An initial high level risk assessment for DE schemes is provided. For each identified risk, the impact, probability, and overall measure are given along with mitigation measures and organisation responsible. This risk register will need to be continually updated if any project proceeds

11.7 Recommendations

The report recommends that following:

Short term

- The Council review the report’s findings and decide whether there is sufficient evidence for taking the next steps in its development
- If positive the Council should undertake more detailed feasibility studies for Phase 1 and examine the various business structures available to them to implement the project, including the use of their own capital resources or borrowing facilities

- A full business plan should then be established for which backing can be sought from all stakeholders within the Council and outside
- Work with the planning department and potential customers to identify suitable energy centre locations
- A Programme Board should then be established to take the project forward.

Medium term

- Identification and engagement with key potential customers to develop a robust potential customer base
- (Further) development and implementation of planning policy to ensure that developments in areas mentioned in this EMP, and other developments in the DH network areas, are designed and built such that they are suitable for connection.
- Identification of sites for future energy centres, including engagement with Thames Water over the Hogsmill STW, continued engagement with Kingston Futures, and identification of river-side sites.
- Consideration of heat pumps as a heat provision technology to provide long-term carbon savings.
- Close engagement with the Hospital to ensure that future renovation and re-development facilitates connection to a site-wide DH scheme.

Long Term

- Continued identification and engagement with potential customers
- Assessment of performance of existing phases and environmental performance, and ensuring that technology strategies (eg gas CHP or heat pumps) can deliver the required economic and environmental performance.
- Engagement with the GLA and neighbouring Boroughs to ensure opportunities for wider connections are identified and facilitated.

Appendices

Appendix 1: Site visits

Appendix 2: Energy demand analysis

Appendix 3: Impact on new development

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Appendix 1: Site visits

Introduction

Site visits were made to some of the major town centre loads on 18th March 2013. The sites were selected based on their size, the opportunity they present for connection to a DE scheme, and on the basis that some energy users may be more complex, requiring a more in-depth understanding.

The following sites were visited:

- RBK Guildhall buildings
- Kingston College
- County Hall
- Kingston University Penrhyn Road site
- Kingston University Knights Park site
- Bentalls shopping centre
- Edenwalk shopping centre
- David Lloyd gym

The aim of the visits was to obtain information on:

- The location of existing plant and distribution around sites
- Access potential for a DHN connection
- The type of existing heating system.

This section provides a summary of information gathered.

RBK Guildhall

The RBK offices comprise of the original 1930s Guildhall, a smaller modern (circa 1970s) additional building (Guildhall 1), and a larger modern addition (Guildhall 2) which provides the majority of administrative accommodation.

- The Guildhall has a single boiler room which provides space heating to the entire building. There are 6 boilers totalling 756kW feeding a common heating header which connects to the separate heating circuits. The boilers are around 14 years old with no short term need for replacement. The boiler plant is typically switched off during April – October. The boiler room is located in the semi-basement to the right of the Guildhall's main entrance, affording a simple connection opportunity. The flow and return temperatures taken from the BMS are 80°C and 56°C respectively. The plant room is well laid out and relatively spacious, enabling further modification and the addition of small items of plant. There are independent point of use water heaters serving the toilets.
- Guildhall 1 is the smallest of the RBK offices and has a small 4th floor plant room with no spare space. The plant comprises two 'Regency 4' boilers totalling 812 kW which provide space heating to a new radiator system in the building. The gas connection is up a riser on the southern corner of the building. This may offer opportunity for a DHN connection. The long term future of Guildhall 1 is uncertain and there is a possibility the building will be sold or rented.
- Guildhall 2 is the largest of RBK's offices. All plant is located in the roofspace with 6 areas of air handling equipment, but all fed by a single set of gas boilers. There are 8 gas boilers totalling 960 kW, 4-5 years old, feeding a common header operating at a flow and return temperature of 74°C and 71°C (at the time of

visiting, there had been a problem with the system which may have impacted the flow and return temperature levels). In addition to the gas boilers, there are 3 relatively small gas-fired calorifiers. A riser up the south side of the building is used for the gas connection. Whilst not seen, it was suggested this riser has a large amount of space which could be used for a DHN connection.

County Hall

County Hall is the main administrative centre for Surry County Council and comprises a large courtyard structure building, and a newer smaller wing used for IT services. The original parts of the building date from 1893, with a number of subsequent alterations and extensions cumulating in the IT services wing in 1982.

A single boiler plant room is located in the basement in the centre of the complex and feeds two separate heating circuits for the original building and new wing. Three 1.16 MW boilers are used for space heating, and two additional boilers are used for a centralised DHW supply. The plant room is large and well laid out, but with limited spare space for new major plant.

The space heating circuits are set to operate at 82°C and 71°C flow and return. It is thought that lower operating temperatures may not be achievable due to the inefficient nature of the building combined with the original cast iron radiators.

There are no short term plans for any plant replacement.

It is believed that the plant room can be accessed from the northern site using a vehicular entrance from The Bittoms under the new wing which passes through the northern courtyard. This is the route used by the existing gas connection. Access to the basement plant room could be via an underground route, or make use of above grade access though a series of removable concrete slabs forming part of the plant room roof in the car park area.

Kingston College

The Kingston College site comprises four sets of buildings named stage 1 – 4.

- Stage 1 and Stage 2 are the original (estimated 1960s / early 1970s) buildings heated from a single boiler room located on the ground floor at the northern side. Stage 2 is an 11-storey block which has a separate heating circuit via a Plate Heat Exchanger (PHE) for floors 5 and above. The boilers comprise four 650 kW units, although in general only 2 or 3 are used at any one time to allow for cycling. The boilers are circa 10 years old and are expected to operate for at least another 10 years before replacement. Flow and return temperatures are typically 80°C and 75°C respectively. The boiler plant is generally switched off each year from April to October. In addition to the space heating, there are three 75 kW Calorifiers (335 litres each). Access to the plant room is very good with a ground floor location adjacent to a car park entrance and close to Kingston Hall Road.
- Stage 3 is a more modern 4-storey building with a single boiler room. There are 7 boilers of circa 70 kW each, with three providing heat for AHUs, and 4 providing heat for radiators. The boiler room is located at ground level next to the College's rear service road, off Penrhyn Road. There is one direct fired DHW boiler that serves the kitchen.
- Stage 4 is a new building (the 'Arena') used for sports and leisure. The boiler room was not visited, but comprises 2 small boilers for space heating connected to AHUs. It is not believed that the heating loads are high.

Kingston University – Penrhyn Road Campus

The University's Penrhyn Road Campus is the larger of the two central sites examined in this study. It is predominantly used for science, engineering, and computing teaching and research activities. There are a number of plant rooms on the campus, although the majority of the heating load is fed by a small number of main boilers.

- Plant 1 (Main builing). This feeds the majority of buildings 1 and 2, and comprises three 1,050 kW boilers, one 600 kW boiler and two 194kW calofiers. The boilers feed a common header of 200mm diameter The plant room is at ground level, relatively large and spacious, and can be easily accessed from the on-site road.
- Plant 2 (Sopwith Building). This plant room feeds the Sopwith Building, and comprises two Ideal F480 boilers giving a total of 1000 kW heat output. The plant room is at ground level and easily accessed from the University car park.
- Plant 3 (Learning Resource Centre). This is a smaller plant room located on the roof of the Learning Resource Centre (LRC). It consists of three packaged boilers totalling circa 300 kW. The location of risers and access to the plant room is uncertain.
- Plant 4. This plant room provides heat to the C-Scaipe facility[32], part of the main building, and comprises five boilers totalling 500kW. The equipment is relatively old and inefficient, and it is thought that the heating systems supplied from it will be connected to the main system instead. This plant room will therefore become redundant.
- Plant 5 (Townhouse). This ground floor plant room provides space heating for the 'Townhouse' and comprises circa 500 kW capacity of boilers which are old and due for replacement. The Townhouse is a temporary structure which is long past its original expected life and it is likely this will be redeveloped in the short term.
- Plant 6 (Tower block). This plant room is newly refurbished and provides heat for the tower block building. The heating plant consists of four Bugens GB312 boilers totalling 1,040 kW, operating at flow and return temperatures of 80°C and 70°C. The plant room is large, spacious, and easily accessible.

It is thought that the most suitable plant rooms for connection to a DHN are Plant 1, 2, and 6. The others are either too small, or likely to become redundant.

Kingston University – Knights Park Site

The Knights Park site is north east of the Penrhyn Road Campus and is used for Arts and Architecture. Similarly to the Penrhyn Road Campus, the site is relatively complex, with a number of buildings interconnected. There are three main plant rooms:

- Plant 1 (Quad building). This is a newly refurbished building with replacement plant. There are eight modular boilers totalling circa 800 kW (estimated) operating at 80°C and 60°C flow and return providing space heating and DHW. The plant room is not spacious, but it is thought that a PHE could be accommodated with careful design. The plant room is at a basement level and whilst no obvious connection routes were observed, it is believed that a suitable option can be found with further investigation.
- Plant 2 (Tower Block). The tower block has a relatively small net floor area, and therefore the heating loads are correspondingly low. The boiler plant is located in a roof top plant room and is made up of circa 300 kW (estimated) of boiler plant for space heating and DHW. These boilers feed a common header of 100mm diameter. Access to the plant room with a DH network would be via existing risers (which were not viewed), although a more suitable option may be to connect with the heating system, if viable, at a lower level.
- Plant 3 ("New Extension"). This building lies to the east of the site, and has a 4th floor plant room. There is a total of 1,200 kW of boiler plant (in four 300 kW units) for space heating and DHW. The plant room is spacious with adequate space for a PHE. Access would be via existing risers.

[32] C-Scaipe = Centre for Sustainable Communities Achieved through Integrated Professional Education

Bentalls shopping centre

The Bentalls shopping centre (not to be confused with the adjacent Bentalls Department Store) consists of a central atrium area, central services, and a number of retail units.

The retail units are all responsible for their own services and make use of separate electric heating systems. This means there is no potential for connection of the retail units to a DH network without significant refurbishment of the centre. This is deemed unviable.

The central atrium / circulation area is heated and ventilated using a number of direct fired AHUs. No information was available on the site visit of capacity or annual gas consumption, but it is believed that the AHUs could be modified into an indirect system for connection to a DH scheme. All the AHUs are located on the roof, and access would need to be via existing risers. There appeared to be adequate space on the roof for installation of the PHE, with adequate access around the roof to individual AHUs.

The shopping centre also includes small ancillary heating plant for the management suite, and local DHW generation. These are considered too small for connection to the DH scheme.

Edenwalk Shopping centre

The Edenwalk shopping centre is a large retail complex located in the Eden quarter of the town centre. The centre includes a number of large and small individual retail units totalling 22,000 m^2 (245,000 ft^2).

All retail units have their own separate heating systems, predominantly electricity based. There is no central plant for the retail units and the disaggregated nature, combined with the use of existing electric systems, means that there is little scope for a DHN connection in the short term.

The centre also includes the Millennium House office complex which is heated by central boiler plant located on the roof. This comprises 4 Potterton Prestige boilers, of which 2 or 3 are used at any one time.

Gas and water services are brought up to the roof in a riser adjacent to the Millennium House entrance. It is uncertain whether there is sufficient space for a DHN connection but this could potentially provide a route.

The longer term future of the Edenwalk shopping centre is uncertain. There are plans for re-development of the Eden quarter, although the scale and nature of this is currently uncertain and may range from minor refurbishment to large scale re-development. This could provide the opportunity for the installation of common heating systems making the centre more suitable for DHN connection.

The Edenwalk centre is a joint venture by USS (Universities Superannuation Scheme) and British Land.

David Lloyd Gym

The David Lloyd Gym is located opposite the railway station and is part of the national David Lloyd chain. The gym consists of a number of facilities including a swimming pool and Jacuzzi.

All heating is supplied from two 750 kW Hoval boilers (totalling 1,500 kW) located in a roof top plant room. Two 150mm headers distribute heat from the boilers to separate heat exchangers which feed the pool, space heating, and DHW. A DH connection could be made onto these headers for meeting the loads of the entire gym.

Routes were not identified for accessing the header with the DH connection, but it is believed that a suitable route, either externally, or via internal risers, could be identified with further investigation.

Appendix 2: Energy demand analysis

Review of Existing Information

The RBK Heat Mapping study data has been used as the basis for this study, with additional information obtained on the large loads as described above. . It is important to note that the RBK Heat Mapping dataset contains information for a large number of buildings from a range of sources, and a comprehensive check of this data and verification is beyond the scope of this EMP. Therefore a simple approach was taken to sense-check the information

- Where data is provided and based on data collection from the building occupiers or managers, this is assumed to be correct. It is assumed that no further changes have been made to the buildings which affect heat demand since the original data collection for the RBK Heat Mapping study.
- Where benchmarks have been used for non-domestic buildings, a simple check has been made by dividing the stated annual fuel consumption by the GIA where available. The expected energy consumption varies for different building types so the buildings for connection to the DHN are categorized in terms of building type and checked against the CIBSE Guide TM46 benchmarks.
- For domestic buildings, the gas consumption per dwelling in the RBK heat mapping study ranges from 6.5MWh to 15MWh per year. The assumptions used for the new and proposed developments give a gas consumption of approximately 4.5MWh per dwelling based on a relatively small flat size and current building regulations. Both of these appear reasonable and in line with models of new dwellings and average consumption from existing dwellings. Therefore the data from the RBK Heat Mapping study is assumed to be reliable for flats.

Identified inconsistencies include:

The data for David Lloyd Gym seems too high, at 12,000MWh per year. The site visit confirmed that the peak boiler demand cannot be greater than 1500kW, which is more consistent with a gas consumption of 1700MWh. It is thought that annual data given has been provided for The Rotunda, which includes cinema, bowling alley and restaurants, rather than just David Lloyd Gym. The connection details are only known for the Gym, so for modelling of the network it is assumed that only the Gym will be connected. The model uses an annual gas consumption of 1700MWh, the monthly profile is calculated assuming 40% of the heating is for hot water, which forms the baseload. The remaining load will be estimated using degree day analysis.

The Edenwalk shopping centre data suggests an energy demand of 760kWh/m^2, which is much higher than the benchmark for retail use. CIBSE TM46 Table 1 gives a benchmark of 170kWh/m^2 for typical fossil fuel consumption, of which 55% goes towards heating. Based on the area of 23,181m^2 from the Heat Mapping Study this gives an annual consumption of 2635MWh per year. This figure will be used to model situations where Edenwalk Shopping Centre will be redeveloped, so that it is suitable for connection to DHN.

There is a large range of energy consumption for university and college campuses, however most are closer to the baseline of 240kWh/m^2, with a few outliers. For all campuses data has been collected, so the heat mapping data is not used for these.

RBK Heat Mapping Study

The information on annual consumption for many of the major energy consumers was taken from the RBK Heat Mapping Study carried out by URS. For these consumers the assumptions outlined in section 5 were applied to estimate key information for modelling. Information from the heat mapping study has been used for the following sites.

- County Court
- Police Station
- HM Revenue & Customs
- Curves

- Avante Court
- Travelodge – Central
- Schools Library Service
- Museum and Heritage Service
- Kingfisher Leisure Centre
- Kingston Library
- Quebec House
- Stevens House
- Garricks House
- Bedelsford School
- Kingston University Clayhill
- St John's C of E School
- King Athelstan School
- Tiffin School
- Bausch & Lomb House
- Buick House
- Cambridge Road
- Kingston Hospital
- Wolverton House

The location of plant room for connection to these sites is taken to be the centre of the site for the purpose of modelling pipe lengths.

The Cambridge Road Development is made up of a total of 600 dwellings. These a divided up into consists of 4 high rise blocks, each containing 60 dwellings and 16 low rise blocks containing a total of 360 dwellings. For the purposes of this high level model it is assumed that there will be four connections, each of which will join to one high rise block and a quarter of the low rise blocks, therefore connecting to 150 flats.

The total annual gas consumption is based on an estimated gas consumption of 10.5MWh per flat, therefore 1575MWh for each of the four connections. The monthly profile is estimated using the assumptions in Section 5. The peak demand is calculated using diversity to take into account that all flats will not be using their peak demand at the same time.

Bedelsford School is included in the list above, however the heat mapping study only confirmed that the heating for the site is provided by oil. The school is still included in this study so that it could be connected if it were refurbished. The GIA is given, so benchmarks data from CIBSE Guide TM46 is used to estimate the demand. The CIBSE benchmark for Schools is 150kWh/m^2 and the school has a GIA 2275m^2, therefore the annual demand is 341MWh. This annual figure is used to model the site for connection to DHN, using the assumptions in Section5.

Key sites

Kingston College, Kingston Hall Road & Richmond Road

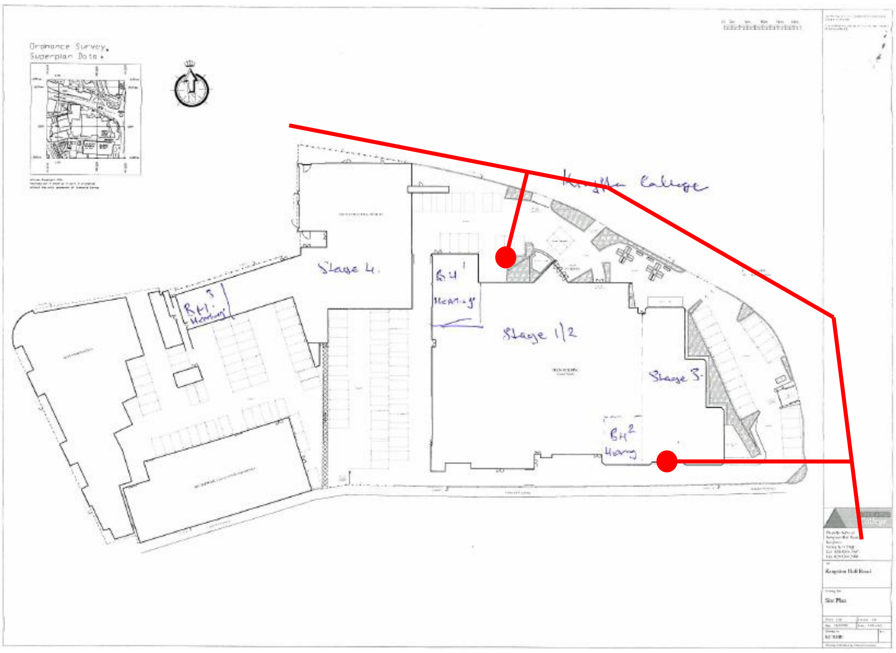

Figure 49: Connection to Kingston College main site

This site is considered for connection to Phase 1 of the DHN.

Connection to DHN is likely to be from 2 separate branches from the main Phase 1 line, as shown on the plan above.

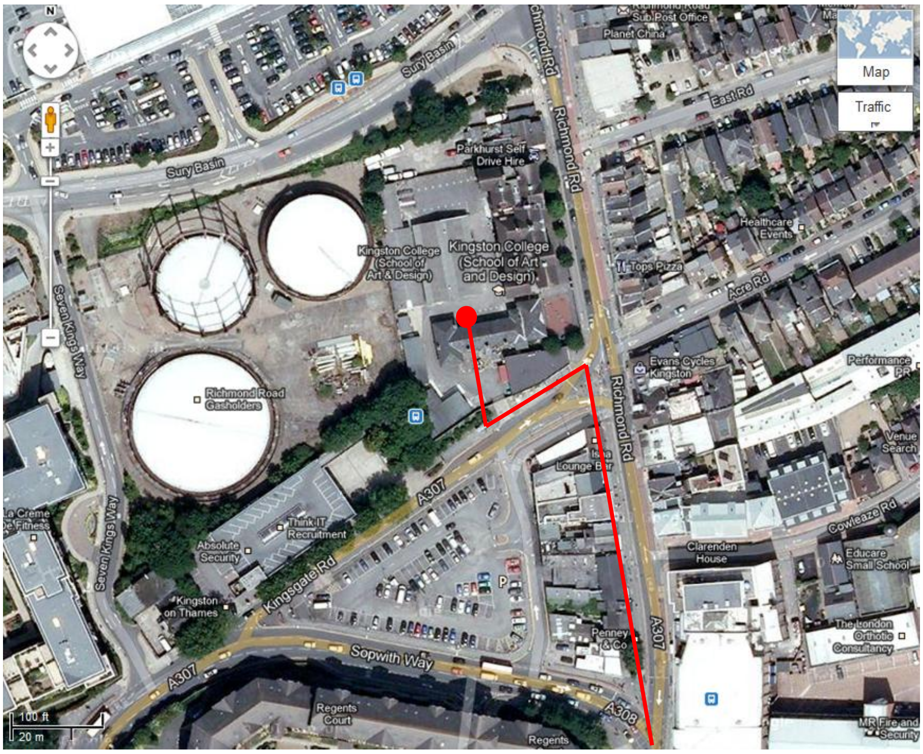

Figure 50: Connection to Kingston College Richmond Road Site

The DHN connection to the Richmond Road campus would form the end of a Phase 2 branch, the location of the plant room on this site is unknown.

Information provided

Annual Gas consumption total for all three sites

Monthly gas consumption from August – December 2012 for each site

Annual Electricity consumption total for all three sites

No cooling demand

No plant replacement planned in the next few years

Modelling assumptions/DHN implications

The site of interest for the DHN is the main Kingston Hall Road Site, pictured above in Figure 49. The monthly data confirmed the ratio of gas consumption between sites, with Kingston Hall Road accounting for 84% of the total. This relationship is used to find the total annual consumption per site.

Monthly gas consumption data was only provided from August to December, so the other months were estimated. The August load is taken to be the base load, so is applied to June and July. The remaining months' profiles are determined by using degree day analysis to reach the total annual demand.

The DHN layout assumes that there are two separate connections to Kingston College branching directly from the main Phase 1 line; a north connection to Boiler House 1, and a south connection to Boiler house 2.

The monthly load is divided equally between the two connections. The peak load is based on the boilers identified during the site visit;

Boiler House 1: No.3x75 kW Calorifiers, No.4x650 kW boilers, of which 3 are use at any one time, therefore peak = 2175kW

Boiler House 2: No.7x70 kW boilers, therefore peak =490kW

Boiler House 3 contains small boilers and would not be considered for connection to the DHN.

Monthly and peak gas demand was calculated for the Richmond Road site by the same method as for Kingston Hall Road.

Kingston Crown Court

No site visit carried out

Information provided

No information provided on request, and not in URS or RBK database

Modelling assumptions/DHN implications

Assume load of 2000MWh per year and peak of 2000kW.

Surrey County Council

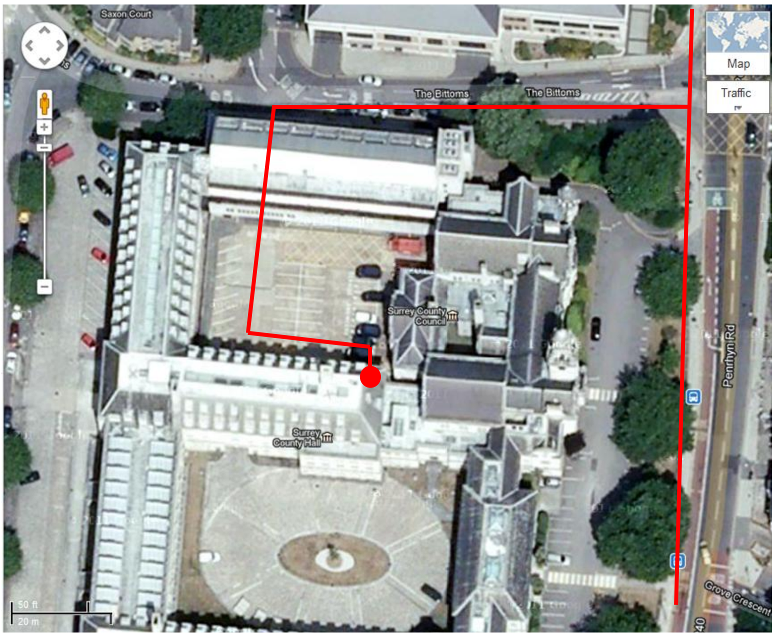

Figure 51: possible access to Surrey County Council plant room indicated on google maps image

This site is considered for connection to Phase 1 of the DHN.

Connection to DHN is likely to be from a branch along The Bittoms, entering the site from the north, as shown above.

Information provided

Annual Gas Consumption

Annual Electricity Consumption

Peak demand = 3000kW from 2 out of 3 1500kW boilers

Monthly gas consumption

5% hot water for kitchens

Energy cost – gas = 2.443p/kWh, electricity = 10.625p/kWh

Covered by CRC

No major cooling demand

No plant replacement planned in the next few years

Modelling assumptions/DHN implications

All required information provided therefore no assumptions were required for modelling.

Kingston University Penrhyn Road

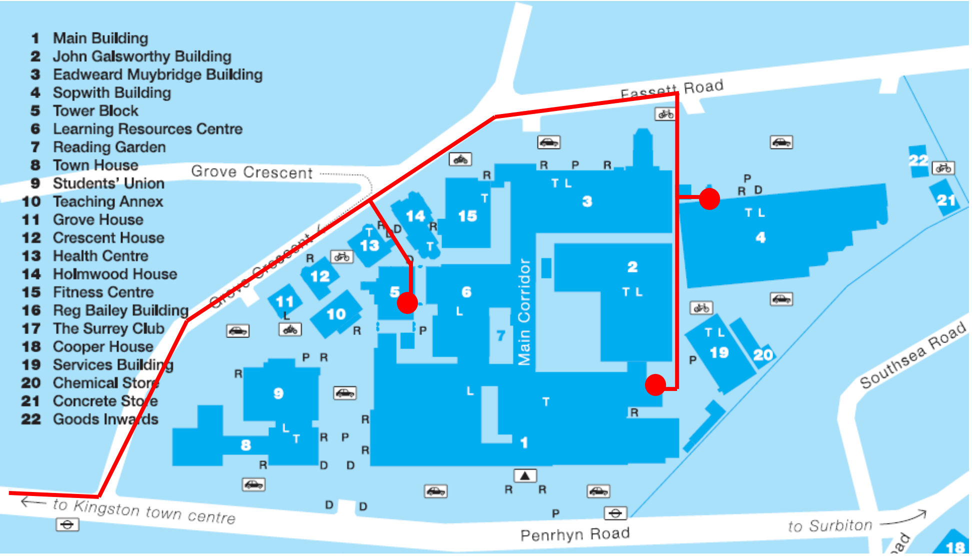

Figure 52: possible access to Penrhyn Road Campus plant room indicated on site plan

This site is considered for connection to Phase 1 of the DHN.

Connection to DHN is likely to be from 3 separate branches forming the southern end of the main Phase 1 line, as shown on the plan above.

Information provided

Annual Gas Consumption

Annual Electricity Consumption

Monthly gas consumption from various meters across the site for 11 months

Energy cost – gas = 2.63p/kWh, electricity = 10.00p/kWh

Covered by CRC

No major cooling demand

No plant replacement planned in the next few years

Modelling assumptions/DHN implications

Meter readings were provided from the end of August 2011, to the end of July 2012, which gives 11 month worth of data, missing out August, so the data for August was assumed to be the same as that for July.

The monthly load is divided equally between the three connections, as it is not known which meters are connected to which plant rooms. The peak load is based on the boilers identified during the site visit;

Connection 1: C-Scaipe faculty and Tower block No.1x400kW, No.4x260kW, therefore peak =1.44MW, the efficiency of these boilers is assumed to be 85% as they are relatively new.

Connection 2: Sopwith Building No.1x1MW boiler

Connection 3: Main Buildings and Learning Resource Centre No.3x1,050kW boilers, No.1x600 kW boiler, No. 3x100kW, therefore peak = 4.05MW

Kingston University Knights Park and Middle Mill

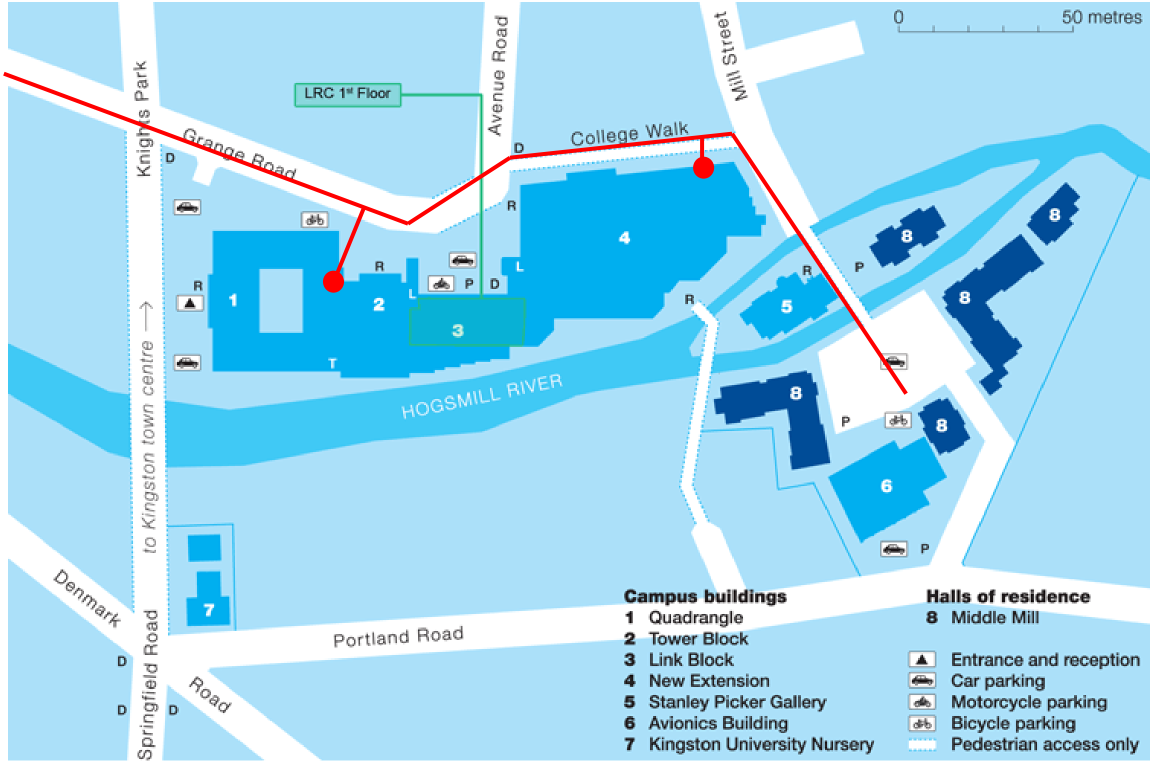

Figure 53: possible access to Knights Park and Middle Mill plant room indicated on site plan

This site is considered for connection to Phase 2 of the DHN.

Connection to DHN is likely to be from 3 separate branches forming the end of the Phase 2 network, as shown on the plan above. The plant room locations for the Middle Mill site are not known, so connections are not shown.

Information provided

Annual Gas Consumption

Annual Electricity Consumption

Monthly gas consumption from various meters across the site for 11 months

Energy cost – gas = 2.63p/kWh, electricity = 10.00p/kWh

Covered by CRC

No major cooling demand

No plant replacement planned in the next few years

Modelling assumptions/DHN implications

Meter readings were provided from the end of August 2011, to the end of July 2012, which gives 11 month worth of data, missing out August, so the data for August was assumed to be the same as that for July.

The monthly profile for the Knights Park site is divided equally between the two proposed connections, as it is not known which meters are connected to which plant rooms. The peak load is based on the boilers identified during the site visit;

Connection 1: Quadrangle and Tower Block No.8x100kW, No.3x100kW, therefore peak = 1100kW

Connection 2: New Extension No.4x300kW boiler, therefore peak = 1200kW

The peak load for the Middle Mill site is determined using annual consumption and the general assumptions outlined in section 5 to give a peak of 675kW

Guildhall

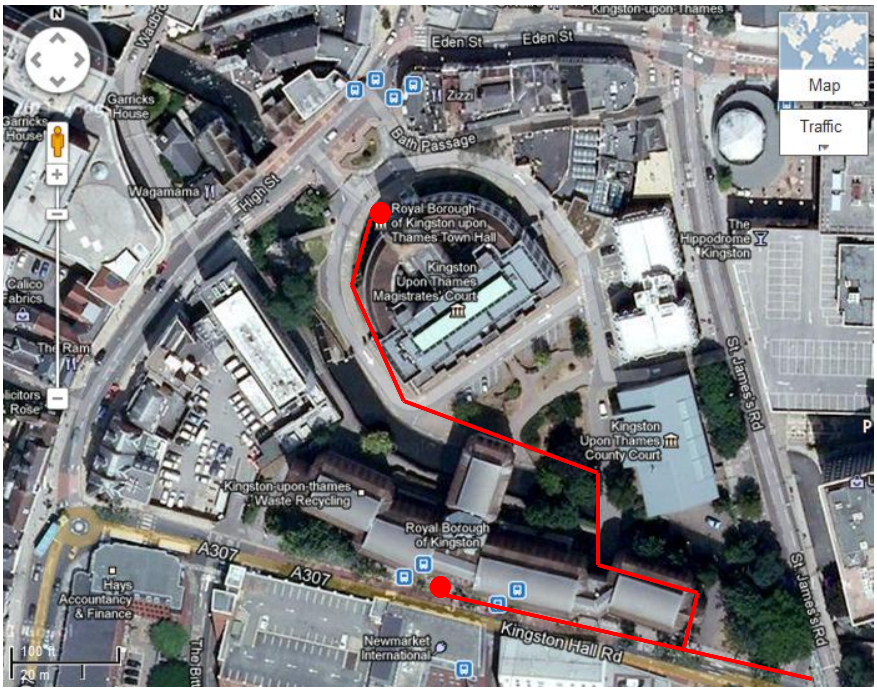

Figure 54: possible access to Guildhall and Guildhall 2 plant room indicated on google maps image

Guildhall 1 has a relatively small heat load and is therefore not considered for connection to DHN. The main Guildhall and Guildhall 2 are considered for connection to Phase 1, by a single connection to each building branching from the northern end of the main Phase 1 line, as shown on the plan above.

Information provided

The following information was provided for the Guildhall, Guildhall 1 and Guildhall 2

Annual Gas Consumption per building

Annual Electricity Consumption per building

Monthly gas consumption per building

Energy cost - Gas Guildhall = 2.92p/kWh, Guildhall 2 = 2.22p/kWh

- Electricity Guildhall = 10.01p/kWh, Guildhall 2 = 9.76p/kWh

Peak heating demand Guildhall = 756kW, Guildhall 2 = 960kW

Participant in Phase 1 of CRC, but not phase 2

No major cooling demand

No plant replacement planned in the next few years

Modelling assumptions/DHN implications

All required information provided therefore no assumptions were required for modelling.

Marks and Spencer

Site Visit

No

Figure 55: possible access to Marks & Spencer plant room indicated on google maps image

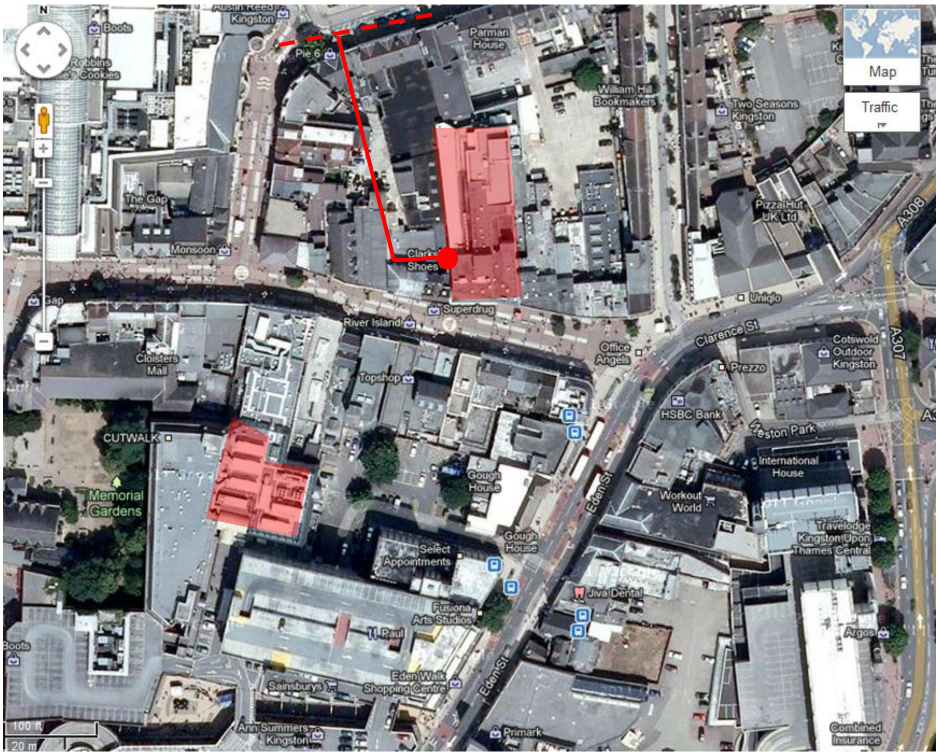

Figure 56: possible access to Marks & Spencer plant room indicated on google maps image

This site is considered for connection to Phase 2 of the DHN.

Marks and Spencer PLC is divided into two sites with the southern building for storage and collection and the northern building as the main shop. The energy data was only provided for the main shop so it is assumed that this would be the main point of connection, as shown in Figure 55 above. The location of the plant room for this site is unknown.

Information provided

Annual and monthly Gas Consumption

Annual and monthly Electricity Consumption

Covered by CRC

Modelling assumptions/DHN implications

The peak load for the Marks and Spencer is determined using annual consumption and the general assumptions outlined in Section 5.5 to give a peak of 1096kW.

The location of the plant room is unknown, so the connection layout is based on images from google maps.

The energy costs are based on a the general assumptions as detailed in Section 5.5

Edenwalk Shopping Centre

Figure 57: possible access to Millennium House plant room indicated on google maps image

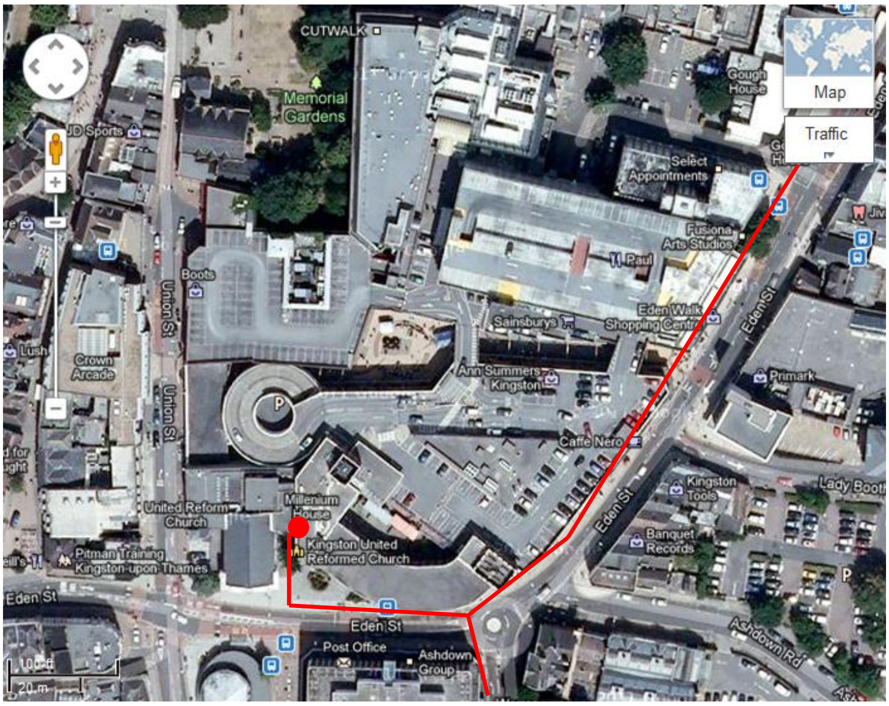

Figure 58: possible access to Millennium House plant room indicated on google maps image

This site is considered for connection to Phase 2 of the DHN.

The retail units in this large shopping centre each have their own heating systems, predominantly electricity based, so offer no scope for DHN connection in the short term. There is a small central boiler plant for management area and Millennium House office complex located on the roof, which may have space for a DHN connection.

Information provided

Annual Gas Consumption

Annual Electricity Consumption

Energy cost - Gas = 3.504p/kWh

- Electricity day rate= 11.07p/kWh, night rate = 7.20p/kWh

No major cooling demand
Covered by CRC

Modelling assumptions/DHN implications

The longer term future for the Edenwalk shopping centre is uncertain, ranging from minor refurbishment to large scale redevelopment. For modelling of the DHN two possibilities are considered for this site; no major change - using current energy data and large scale change - using energy data from RBK Heat Mapping Study.

The monthly profile and the peak loads are estimated using the assumptions outlined in Section XXX, based on the annual consumption.

The cost of electricity used in the model is taken as the day rate of 11.07p/kWh.

Bentalls Department Store

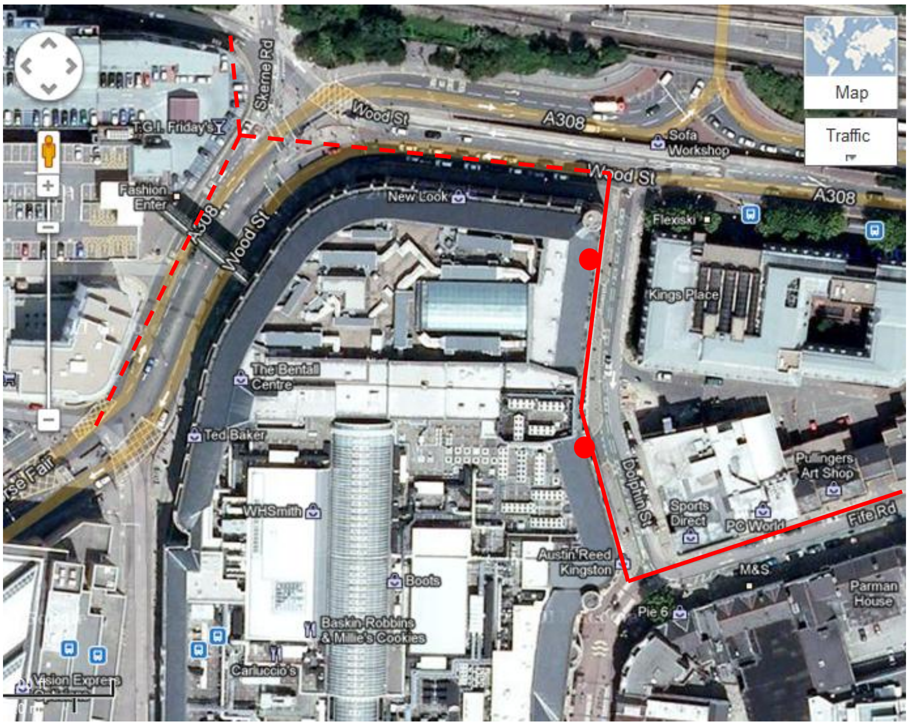

Figure 59: possible access to Bentalls Department Store and Shopping Centre plant room - google maps image

This site is considered for connection to Phase 2 of the DHN.

The Bentalls Department Store boiler house is located in the basement on the corner of Dolphin Street and Wood Street, as indicated in Figure 59 above.

Information provided

Annual Gas Consumption

Annual Electricity Consumption

Energy Cost - gas = 2.084p/kWh, electricity summer = 8.394p/kWh, winter = 8.996p/kWh

Plant Equipment:

- 3 X Hoval SHR 1000 Boilers
- 3 x GT/H Burners
- 1x 40 VAL 600 Boiler
- 1x 105 Burner

No major cooling demand

No plant replacement planned in the next few years

Covered by CRC

Modelling assumptions/DHN implications

The monthly profile for gas demand is estimated using the assumptions outlined in Section 5, based on the annual consumption figure provided for Bentalls Department Store.

The peak demand is estimated based on the rated capacity of the boilers present. The peak is 2.6MW based on the assumption that two out of three of the 1000kW boilers are used at a time and the 600kW boilers is also in use.

The cost of electricity is taken to be the average between summer and winter prices, therefore 8.695p/kWh.

Bentalls Shopping Centre

This site is considered for connection to Phase 2 of the DHN, the possible location of this connection is indicated in Figure 59, above.

The retail units in this large shopping centre each have their own heating systems, which does not allow scope for connection to DHN, however heating of the main atrium is provided by a direct gas fired AHU, which could be connected. The location of the plant room for this site is unknown.

Information provided

Annual and monthly Gas Consumption

Annual and monthly Electricity Consumption

Covered by CRC

Modelling assumptions/DHN implications

The peak load is assumed to be 1MW, based on knowledge of similarly sized shopping centres, which can have high loads for short bursts of time, therefore the general load factor assumption of 10% (see section XX) may not be appropriate.

The energy costs are based on a the general assumptions as detailed in Section 5.

John Lewis PLC

No Site Visit carried out

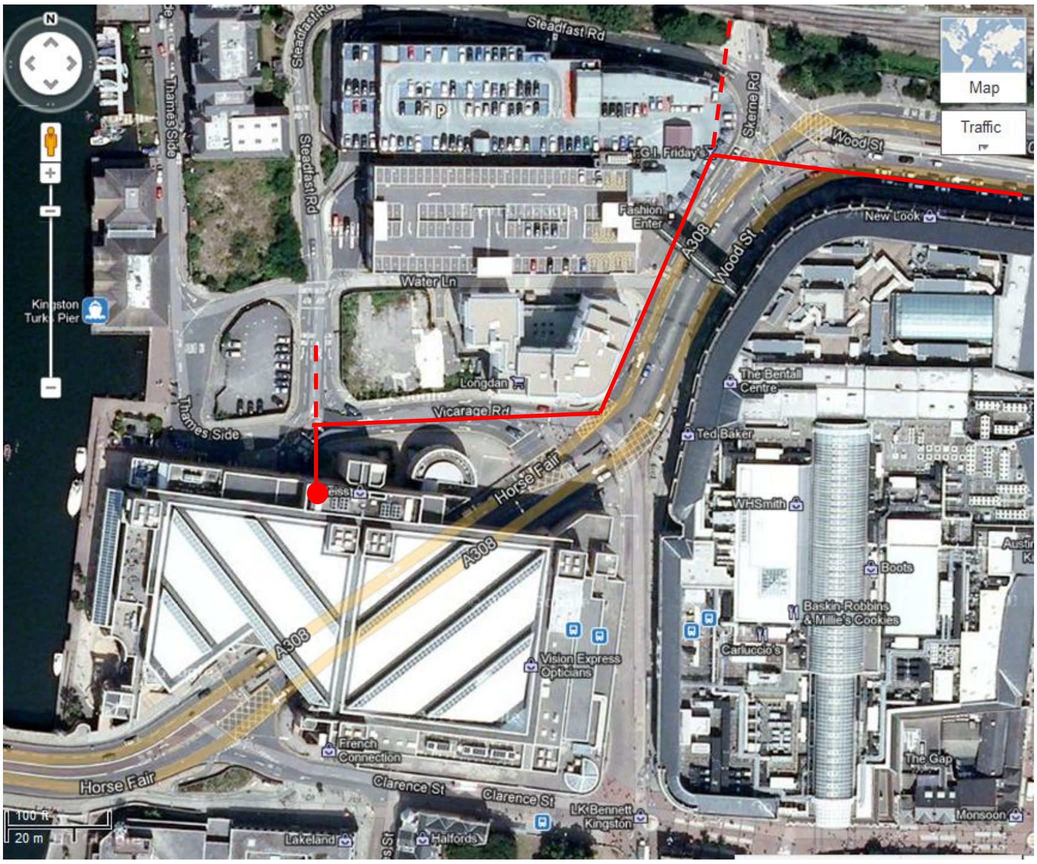

Figure 60: possible access to John Lewis indicated on google maps image

This site is considered for connection to Phase 2 of the DHN.

The location of the plant room for this site is unknown.

Information provided

Annual and half hourly Gas Consumption

Annual Electricity Consumption

Energy Cost – Gas = 3.3p/kWh, electricity = 9.8p/kWh

Covered by CRC

Peak heating demand is1500kW

Peak cooling demand - Department store = 500kW, Waitrose = 300kW

Waitrose will have all major plant replaced by November of this year. John Lewis have no planned replacement.

Modelling assumptions/DHN implications

All required information provided therefore no assumptions were required for modelling.

David Lloyd Gym

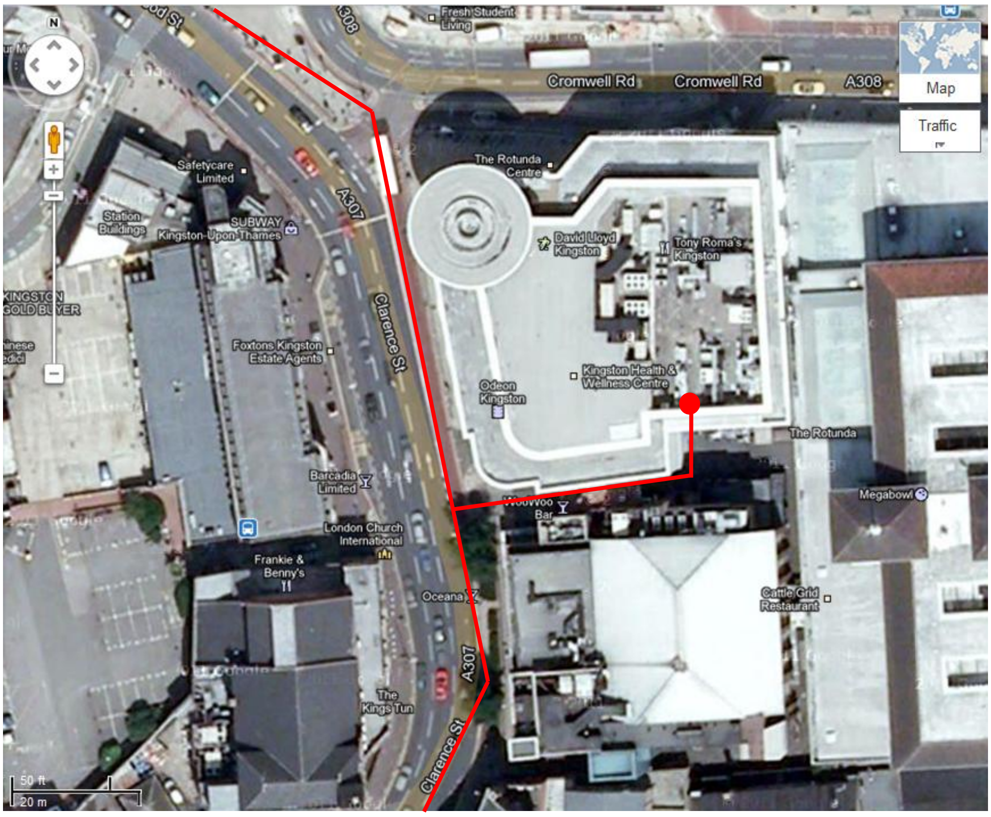

Figure 61: Access to David Lloyd Gym – google Maps image

This site is considered for connection to Phase 2 of the DHN.

Information provided

Site visit confirm that the peak load is 1500kW

No information has been provided by David Lloyd gym.

Modelling assumptions/DHN implications

The monthly profile is estimated using the RBK Heat Mapping Study data and the general assumptions listed in Section 5.

New / Proposed Developments

There are a number of proposed developments in the Kingston City centre area which may be suitable for connection to DHN. The energy use for these sites is less certain so number of assumptions have to be made as follows.

1. Thames Side Wharf – Vicarage Road

SRE sustainability & Energy Statement states that the development will consist of parking, communal space, storage and commercial units on ground floors, and 97 residential units above. The GIA is 10,546m^2 and it is proposed 4 Baxi Dachs MicroCHP engines as part of the communal heating installation.

The baseline energy loads have been predicted from modelling the proposed development. This gives an overall fossil heating and hot water demand of 609,776kWh/year. This annual figure is used to model the site for connection to DHN, using the assumptions in Section 5.

The assumed energy costs per unit are 4.1p/kWh for gas and 13.3p/kWh for electricity.

2. 45-51 High Street

This site is located west of Phase 1, which could be extended for connection to this site and Avante Court nearby. The site comprises approximately 3500m^2 of student accommodation and 500m^2 of commercial space. A communal heating system is proposed for the development, with a 25kWe CHP engine to provide the base heating load.

Benchmarks from CIBSE TM46 have been used to determine the CO_2 emissions for the baseline, and energy modelling to determine the CO_2 emissions for the improved performance case. This reduction over the baseline has been used to determine the annual gas demand. This annual figure is used to model the site for connection to DHN, using the assumptions in Section 5

3. Kingston Riverside & Kingston Heights– Power Station Redevelopment

The site is located to the north of Kingston town centre, over the railway from the Bentalls Shopping centre. The scheme consists of 359 apartments and a 150 bedroom hotel. Kingston Riverside contains 222 apartments. Kingston Heights contains the rest. A separate district heating scheme is proposed for each development, Kingston Riverside will incorporate a 200kW biomass boiler and Kingston Heights a GSHP.

Whitecode Design Associates Energy Strategy Overview, dated June 2012 provides a thermal loadings summary which predicts a demand of 1904MWh per year, with monthly profile given.

4. Eden Walk future

The long term future for Eden Walk Shopping Centre is uncertain, the possibilities range from small refurbishment to large scale redevelopment. For the first case the site would remain the same, so there would remain little in terms of scope for connection beyond current predictions. However if the site were redeveloped, it could be future-proofed to allow for connection during construction to DHN.

As little is known about the possible changes to this area there are no predictions to base assumptions on, so the annual consumption for the site is taken to be the URS figure from the RBK Heat Mapping Study, which is based on the total fuel consumption from all assets. This annual figure is used to model the site for connection to DHN, using the assumptions in Section 5

5. St James area

This area is highlighted in the Kingston Town Centre Area Action Plan, with the potential uses of shops, community facilities and student housing.

AECOM have estimated that for a site of 0.8 hectares, 80 dwellings can be developed (assuming 100 dwellings per hectare). Each flat is 65m^2 and has gas demand of 70kWh/m^2, based on compliant 2010 SAP modelling. Therefore the annual demand for the site is 364MWh. This annual figure is used to model the site for connection to DHN, using the assumptions in Section 5.

6. Bus Station / Leisure centre redevelopment

The current area consists of the bus terminal, car parking, leisure centre, library, museum and open space. The potential uses for redevelopment are likely to include general enhancement of facilities, including open space and possibly some affordable housing, although there is no information on the number of potential dwellings or the area for them.

To account for the possibility of affordable housing AECOM have estimated that 30 dwellings would be built in this area. Each dwelling is $65m^2$ and has gas demand of $70kWh/m^2$, based on compliant 2010 SAP modelling. Therefore the annual demand for the site is 136.5MWh. This annual figure is used to model the site for connection to DHN, using the assumptions in Section 5.

7. East of Clarence Street

This area currently houses a mix of high-street shops, commercial properties and student housing. However there is currently an application to convert the commercial properties on some of the upper floors into student housing, containing 64 bedrooms. If a communal heating system is installed during refurbishment there may be potential for connection to DHN.

Energy use in University accommodation is dominated by domestic hot water. The following benchmarks are taken from best practice literature and 3 University halls of residence built at the University of Nottingham.

Table 24. Energy benchmarks from literature and recently completed University buildings for residential use.

	TOTAL Heat Demand, kWh/m^2	Electricity Demand (including demand for cooling), kWh/m^2
Benchmarks from literature		
CIBSE Guide F	160	50
CIBSE TM 46 (energy benchmarks for DECs)	255	60
ECON 54: Energy Efficiency in Further and Higher Education	204	85
Average	**206**	**65**
Some selected new University Halls of Residence		
Nottingham Jubilee Campus – purpose built low energy campus		
Melton Hall ($3,510m^2$)	212	72
Southwell Hall ($4,035m^2$)	166	59
Newark Hall ($8,082m^2$)	153	61
Average	**193**	**64**

AECOM have estimated that each bedroom would have an area of approximately $20m^2$, with an additional $20m^2$ utilisation area. Based on information in the above table there is a heat demand of $200kWh/m^2$. Therefore the total gas demand for 64 rooms is estimated to be 512MWh. This annual figure is used to model the site for connection to DHN, using the assumptions in Section 5.

AECOM have estimated that each bedroom would have an energy usage equivalent to that of a new flat. The bedrooms will be smaller than a typical flat, but the building fabric will not perform as well for a refurbished building, so the two effects would approximately cancel out. The gas demand per flat is 4550kWh per year, so the total annual gas demand for this redevelopment is 291.2MWh. This annual figure is used to model the site for connection to DHN, using the assumptions in Section 5.

8. Gasholders, Richmond Road

The site is currently in a decommissioned state, there are uncertain plans for redevelopment and it is likely to be 3-5 years before and development commences. Telephone discussions have confirmed that the likely use for the area is mixed, but with potential for 200 flats or student accommodation.

AECOM have estimated that each flat is $65m^2$ and has gas consumption of $70kWh/m^2$, based on compliant 2010 SAP modelling. Therefore the annual consumption for the site is 910MWh. This annual figure is used to model the site for connection to DHN, using the assumptions in Section 5.

Potential Developments

Cumberland House and Kingsnympton Park not considered for connection to DHN as they are too far out from the main network, however they should be highlighted as possible points of connection should the network expand in this direction, towards the new Kingston university development.

Cumberland House and Kingsnympton Park are located north of the Hospital, along Kingston Hill. Cumberland House is made up of 123 flats, divided into 3 low rise blocks and Kingsnympton Park is made up approximately 320 flats divided into 17 low rise blocks. Due to the large density of dwellings these areas may offer some potential for connection to DHN in the future.

Appendix 3: Impact on new development

Future policy and regulation

The *Building Regulations* were first introduced to improve the energy efficiency of buildings in the 1960s and the latest revisions to the Building Regulations Part L (Conservation of Fuel and Power) continue to improve standards. In 2002, the focus started to turn towards reducing CO_2 emissions and further revisions to Part L in 2006 brought the UK Building Regulations in line with the EU's Energy Performance of Buildings Directive (EPBD), introducing, amongst other things, the requirement for Energy Performance Certificates (EPCs).

Following consultation, the Government's *Building a Greener Future: Policy Statement* announced in July 2007 that all new homes will be zero carbon from 2016. In the Budget 2008, the Government also announced its ambition that all new non-residential buildings should be zero carbon from 2019 (with earlier targets for schools and other public buildings). Again, these improvements will be implemented through the Building Regulations and most recently the 2013 budget reiterated the Governments ambitions for zero carbon homes from 2016.

The *Definition of Zero Carbon Homes and Non-Residential Buildings* consultation in 2009 sought to clarify the definition of zero carbon that will be applied to new homes and buildings through proposed changes to the Building Regulations. A statement by John Healey, Minister for Housing and Planning, in July 2009 confirmed the policy to require all new homes to be zero carbon by 2016 and set out the proposals which will be taken forward to implement this policy. This addressed the concern that the original definition, (which followed the definition of Code for Sustainable Homes Level 6 and required both regulated and un-regulated emissions to be off-set on site), would not be feasible or viable on many sites.

The current preferred approach for achieving zero carbon is shown in see Figure 62 .

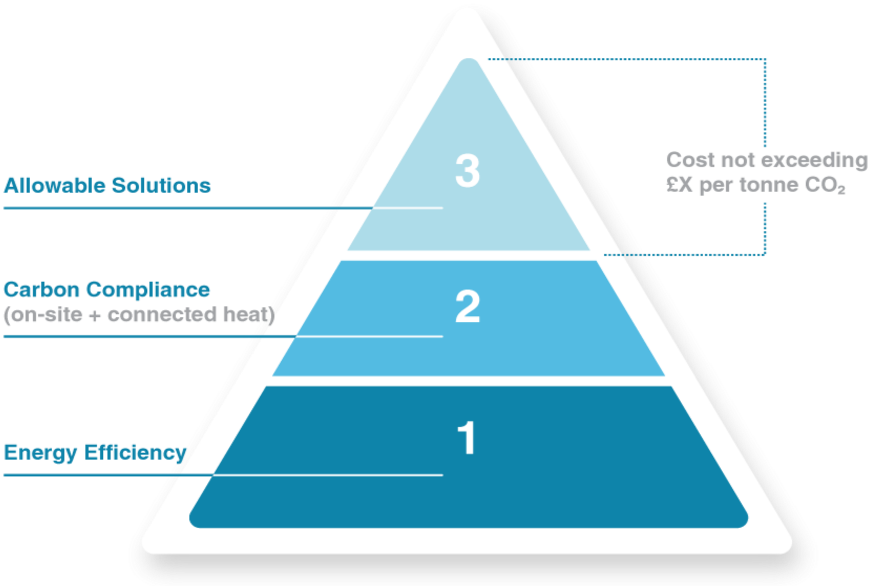

Figure 62: The Government's hierarchy for reducing CO_2 emissions

The hierarchy is base around the following stages:

- Energy Efficiency – which will set minimum standard for the performance of the building fabric;
- Carbon Compliance – which will set a minimum on-site CO_2 reduction target;
- Allowable Solutions – which will require the residual CO_2 emissions from the development to be 'offset' through payment into a fund to be used for CO_2 reductions elsewhere.

Work by the Zero Carbon Hub has been conducted to examine energy efficiency standards for domestic buildings[33]. Through the examination of a number of the performance and costs of different efficiency strategies, proposed Fabric Energy Efficiency Standards (FEES) levels have been identified for total space heating and cooling loads:

- 39 kWh / m^2.yr for flats and mid terraced houses.
- 46 kWh / m^2.yr for end terraced, semi detached, and detached houses.

Part L 2010 is currently in force, and Part L 2013 will be introduced later this year. The government has outlined preferred options for Part L 2013 in its consultation [34]:

- **Domestic:** An 8% reduction in CO_2 emissions over Part L 2010 in the aggregate. This includes the requirement for meeting interim FEES, with different reductions for different dwelling types giving 7% in the aggregate.
- **Non-domestic:** A 20% reduction in CO_2 emissions over Part L 2010 in the aggregate. This is preferred on the basis of providing occupiers with large energy savings.

The options preferred for Part L 2013 are on the basis of technical viability with on-site solutions, and the government's approach appears to be that regulations should not impact on what is built where. Therefore it is unlikely that regulations will require connection to off-site energy schemes.

The Part L 2013 consultation also provides some insight into future changes post 2013. In summary, relevant items include:

- Zero carbon homes. The Government re-iterates its commitment to zero carbon homes from 2016 and outlines the need for further technical analysis. In particular it is concerned over the lack of solutions for high rise blocks of flats (due to a lack of roof space for PV) and suggest introducing new standards to prevent the requirement for off-site solutions (which may limit development).
- Allowable solutions. The document outlines the need to develop the allowable solutions proposals.
- Code for sustainable homes. The document outlines the growing discrepancy between the Code energy standards and the Part L building regulations (which were originally aligned). The document discussed whether Code standards should be reduced to meet the Part L standards, or whether the Code should remain a "gold standard" to encourage innovation.
- Zero carbon non-domestic buildings. The document re-iterates the introduction of zero carbon non-domestic building standards in 2019. The preferred approach is using relative rather than absolute standards due to the range and complexity of non-domestic buildings, and that the CO_2 reduction targets will only include regulatory loads, with non-regulatory loads being covered by other areas of regulation (for example, energy performance standards on appliances).

It is clear from the future thinking section that there is still considerable uncertainty over the future standards.

The impact of regulation on District Heating

The increasing requirements for reducing CO_2 emissions from new buildings may require more efficient building designs and construction, and the inclusion of lower carbon forms of energy generation and supply. In general, a "Fabric first" approach is most cost effective and this is reflected in the potential introduction of minimum FEES in future regulations (and an interim version in Part L 2013).

[33] Defining an Energy Efficiency Standard for Zero Carbon Homes12 (November 2009). http://www.zerocarbonhub.org/building.aspx?page=2

[34] 2012 consultation on changes to the Building Regulations in England Section two Part L (Conservation of fuel and power).

If low carbon forms of energy supply are required, developers generally prefer to use systems which can be linked to, or based on, individual homes or buildings, and which do not require an ongoing operation or management regime. For this reason, PV and solar thermal is probably the most common technology, particularly in housing, due to the “fit and forget” approach. Where higher CO_2 savings are required, or where stand-alone solutions are not viable, then DH could be one method through which lower CO_2 standards can be met.

When assessing the potential for DH to assist with current and future building regulations, the uncertainties around these future standards need to be considered. These uncertainties include:

- At present Part L 2013 has been consulted on, but the final proposals have not been published. The final level of CO_2 reduction above Part L 2010 is not certain and therefore the technical solutions required are not certain.
- The carbon compliance levels for 2016 regulations have not been defined. Early versions of the proposed zero carbon standard set a target initially of all regulated and un-regulated CO_2 to be mitigated on site. This was later reduced to just regulated emissions, and then to 70% of regulated emissions on viability grounds. All of these levels may have required DH in some circumstances. However proposals from the Zero Carbon Hub since have reduce Carbon Compliance proposals to circa 44% and 60% on the basis that carbon compliance should be set at a level which allows the targets to be achieved without communal technologies, i.e. DH [35]. This does not mean that DH is not viable, and may provide a lower cost solution in some cases, but alternative options such as PV may also exist.
- The allowable solutions mechanism for CO_2 reductions above Carbon Compliance has not been defined. Whilst there has been much analysis of how an allowable solutions scheme may operate, there are no final proposals on the costs, or level of carbon compliance above which it will act. If the allowable solutions are set at a level which is not too high, then developers are more likely to select this option over site infrastructure. Thus may in fact benefit DE schemes as the allowable solutions funding could potentially be used to fund the DE scheme development.
- The inclusion of DH in future building regulations has not been defined, and the proposed methodologies and assumptions which are use for DH when calculating Part L compliance can have a large impact on its performance and ability to meet the CO_2 savings.
- The CO_2 savings from DH alongside many other technologies is dependent on the electricity grid emission factors assumed. These have evolved over time, both to reflect the current grid generation, and also changing views on how grid emission factors should be calculated. Therefore until final proposals for grid emission factors for Part L 2016 are known, it is not possible to state how much CO_2 low carbon technologies, including DE schemes, will save in relation to the building regulations.

Due to these uncertainties, it is not possible to state whether for future revisions to the Building Regulations Part L, connection to a DE scheme will be necessary, provide a benefit, or be an economic solution over alternative options. In general, the 2013 consultation on Part L and Government announcements around zero carbon in 2016 suggest that standards will be set at levels which allow developers a choice in strategies and are not deemed to have an adverse effect on the market.

GLA requirements for District Heating

Policy 5.2: Minimising Carbon Dioxide Emissions, of the London Plan sets requirements for major developments. Targets for CO_2 reduction above Part L 2010 are set for periods aligning to revisions in the Part L Building Regulations. Figure 63 and Figure 64 show the standards for Residential and Non-domestic buildings.

[35] Carbon Compliance: Setting and appropriate limit for zero carbon new homes. Zero Carbon Hub. 2011.

Residential buildings:

Year	Improvement on 2010 Building Regulations
2010 – 2013	25 per cent (Code for Sustainable Homes level 4)
2013 – 2016	40 per cent
2016 – 2031	Zero carbon

Figure 63: London Plan Policy 5.2 standards for Residential buildings.

Non-domestic buildings:

Year	Improvement on 2010 Building Regulations
2010 – 2013	25 per cent
2013 – 2016	40 per cent
2016 – 2019	As per building regulations requirements
2019 – 2031	Zero carbon

Figure 64: London Plan Policy 5.2 standards for Non-domestic buildings.

In addition to these CO_2 reduction targets, proposals are required to demonstrate that they have followed the energy hierarchy:

i. Reducing the CO_2 emissions through efficient design of buildings and services

ii. Providing decentralised energy including DH and CHP

iii. Including on-site renewable energy technologies.

The principle of the hierarchy is that more economic and robust CO_2 savings are achieved as a priority which lock in developments to long term CO_2 savings, and provide opportunities through future connections to large scale DH networks.

The intermediate target of 40% CO_2 reduction from Part L 2010 (2013 – 2016) set in Policy 5.2 is more stringent than the proposed Part L 2013 standards, and therefore will require developers to select strategies and technologies which can deliver greater CO_2 savings. It is highly unlikely that fabric efficiency standards alone can achieve a 40% reduction due to the diminishing returns from improving fabric standards further, and so alternative options in the form of DH or renewable technologies will be required. In smaller developments, in particular with individual houses rather than flats, DH may not be economically viable, and there are greater opportunities for installing PV to achieve the required CO_2 savings. However in larger development, and most likely in flats (which are the predominant residential form in London), it is possible that DH will be viable and therefore required under the Mayor's energy hierarchy, even if alternative renewable options could be used.

Post 2016, the Policy 5.2 refers to the national Zero Carbon standards. As discussed earlier, there is little clarity over the levels and costs of this, but it is likely to be set at a level which allows flexibility for developers, and will probably be similar to the Policy 5.2 2013 – 2016 standards. If the energy hierarchy remains active in this period, the requirement to include DH where viable will remain.

The costs of meeting CO_2 targets for developers

The economic viability of meeting future targets for CO_2 reduction in new development will depend on a number of factors:

- The additional capital investment required to install the technologies and infrastructure
- The lifecycle costs of the strategies selected
- The value which may be added to the building for sale or rent.

The initial capital investment varies by the cost of the systems installed, but also by how they are delivered. The developer may bear all of the installation costs, or there may be a third party who invests in the equipment and recoups their investment through future revenues. The level of investment which comes from third parties will vary by development and economic viability.

The lifecycle costs will depend on the technology selected, the impact this has on energy bills and the potential to obtain incentives such as feed in tariffs or the renewable heat incentive. If a third party invests in the systems, these revenues (if they can be obtained by a third party) can be used to pay back the investment and allow a capital contribution to a developer.

The ability of the developer to capitalise on future savings though attracting higher sales or rental values can also impact on the economic viability. Whilst there is some evidence that more efficient building with lower energy bills has some impact on value, the discount rate applied to future savings by occupiers or purchasers is very high, and any increase in value is often insufficient to cover the capital investment.

The outcome from these factors is that the viability of a strategy for reducing CO_2 emissions is dependent on both the minimum savings or standards which much be achieved, but also the relative economic viability of different technology or strategy options. Therefore a strategy which has a lower capital cost is not necessarily the most economically viable option if the future revenues from a higher capital cost option can be capitalised by the developer effectively.

A summary of capital costs and CO_2 savings is provided in Figure 65 to Figure 74 for a sample of domestic and non-domestic building types with a range of strategies for reducing CO_2 emissions. Through examination of the CO_2 savings in relation to the GLA's 40% improvement target over Part L, and the carbon compliance levels proposed by the Zero Carbon Hub, the following can be observed:

- In all house types, there are a number of strategies which can be used to achieve a 40% reduction or carbon compliance, including the stand alone solution of gas boilers, energy efficiency and PV. Gas CHP and DH can also achieve these targets without the use of other technologies. Housing developers therefore have a choice of strategies, providing that sufficient roof area is available for the necessary amount of PV. This is largely determined by the number of storeys which determines the roof area available per unit.
- In the non-domestic buildings, there is a much wider range of energy consumption and profiles and therefore difference in relative performance of strategies. In general there are strategies based around gas boilers and PV which can meet the targets, although for some building types additional technologies such as heat pumps, biomass, or DH is required. Similarly the difference in energy profile means that CHP and DH provides a variable level of benefit: in some buildings with lower heating demands such as retail, the savings from CHP DH are relatively small and unable to meet the targets, whilst in buildings with higher heat demands

Therefore across the range of building types, DH does have a role to play in providing CO_2 reduction, but alternative strategies also exist.

The capital costs presented in Figure 65 to Figure 74 show a wide variation for each building type across the strategies. For the domestic buildings the strategies using heat pumps and DH are generally more expensive than strategies giving equivalent CO_2 reduction using solar technologies. Therefore on a capital cost basis, developers are more likely to select solar technologies where viable. For the non domestic buildings, the capital cost of the strategies is more closely linked to the CO_2 savings, and DH options are competitive with the other options.

Summary

This section provides an overview of the benefits of DH for developers in terms of CO_2 savings and costs.

Under current Part L 2010 and the proposed 2013 standards, the CO_2 targets do not necessitate the use of a DH scheme and alternative lower cost options are open to developers. However under the GLA's energy hierarchy, the use of a district heating system is required where viable.

For "zero carbon" regulations (2016 for domestic and 2019 for non domestic) there is much uncertainty around the technical standards, the level of carbon compliance, and the allowable solutions mechanism which means it is not possible to predict which solutions will be most suitable. However a key factor will be the amount of roofspace available for PV which in turn may trigger the need for an offsite solution such as DH.

The costs of achieving CO_2 reductions on site can not consider only capital investment, but also need to take into account lifecycle revenues and costs, and the balance of investment from different parties. The ability of developers to capitalise future revenues, either through increased building value, or reduced capital investment, depends on the strategy and delivery mechanism. For DH, the costs to developers will depend very much on the cost effectiveness of DH on each scheme, and the level of investment the DH scheme operator is willing to provide.

Cost and carbon performance of different measures – domestic

The following figures show the results of modelling a range of different measures in domestic buildings. These results are based on benchmark performance and costs of technologies in indicative buildings, and should be used for high level guidance only. They should not be used for testing of viability of developments.

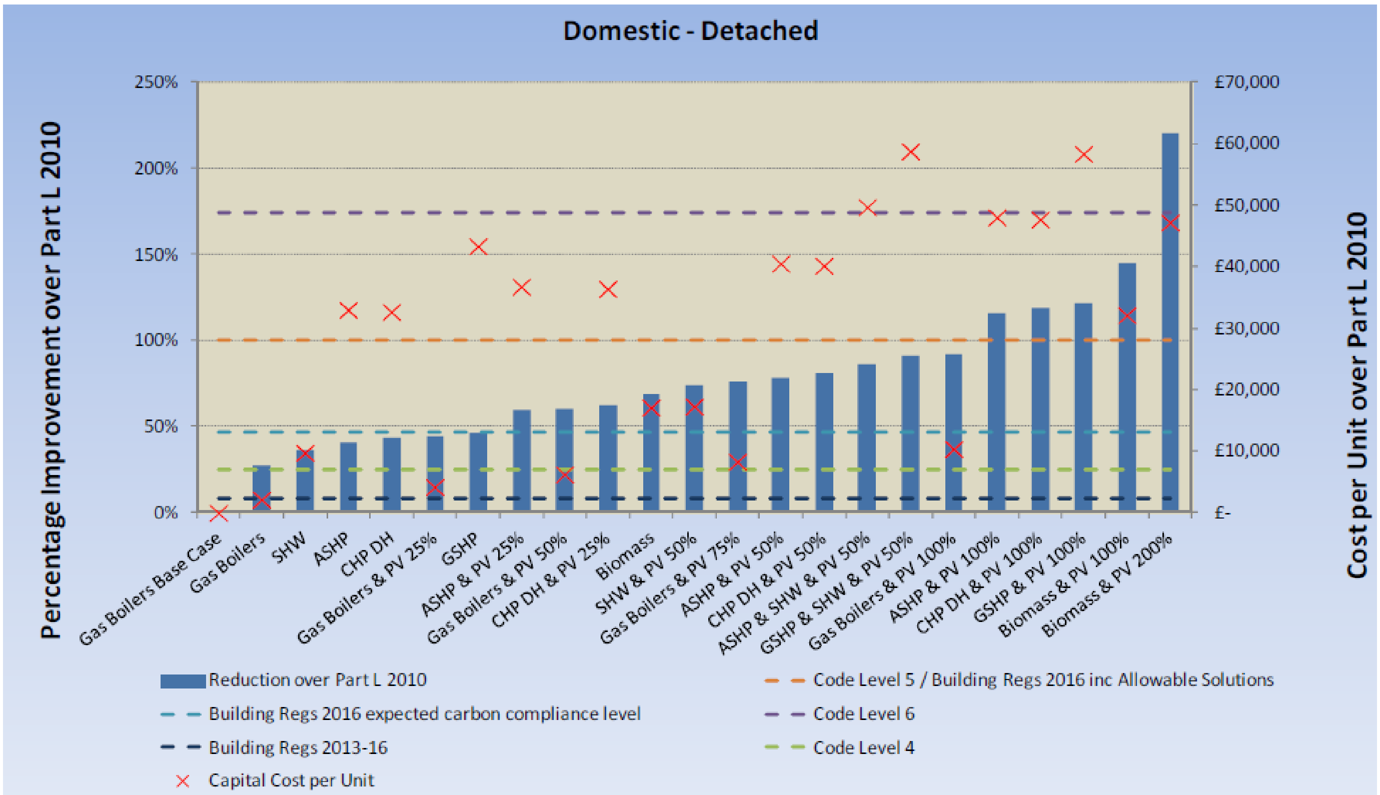

Figure 65: Cost and CO_2 performance of different measures in detached homes

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Building Engineering

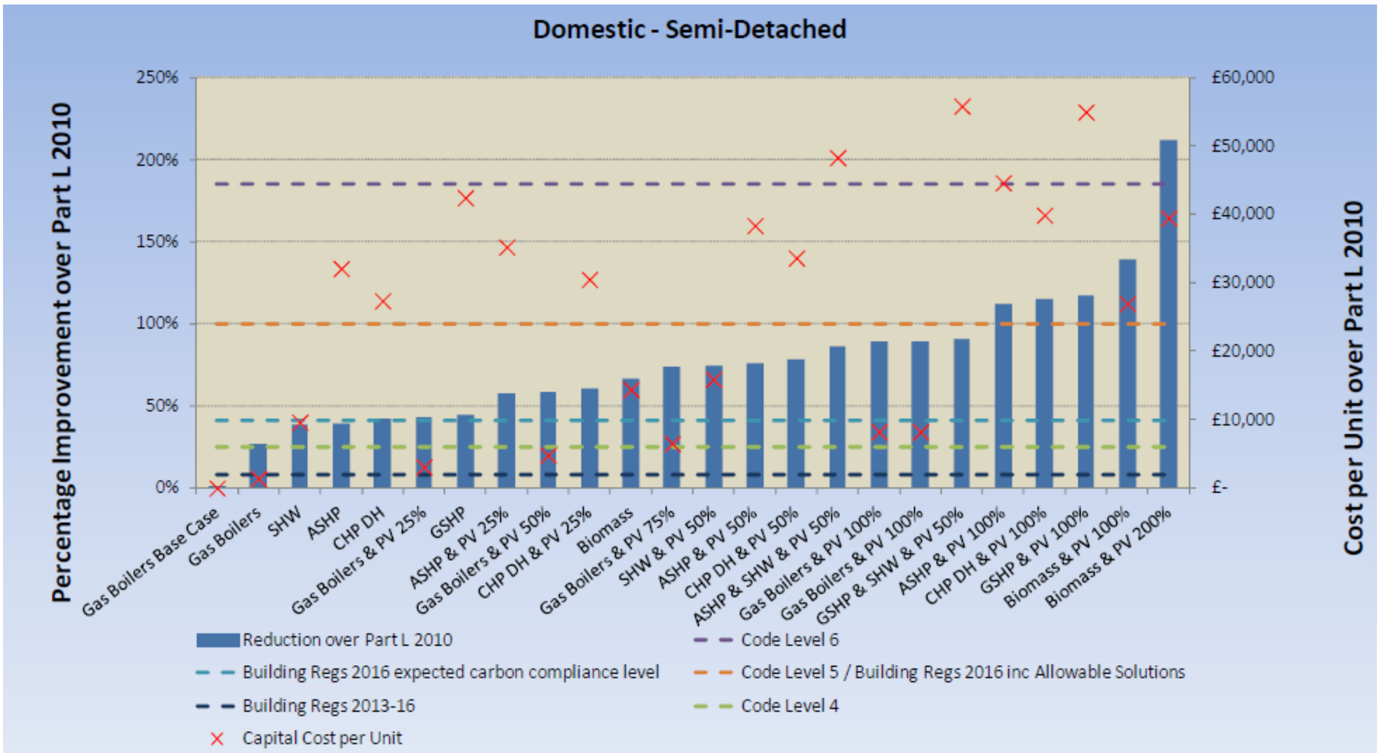

Figure 66: Cost and CO_2 performance of different measures in semi-detached homes

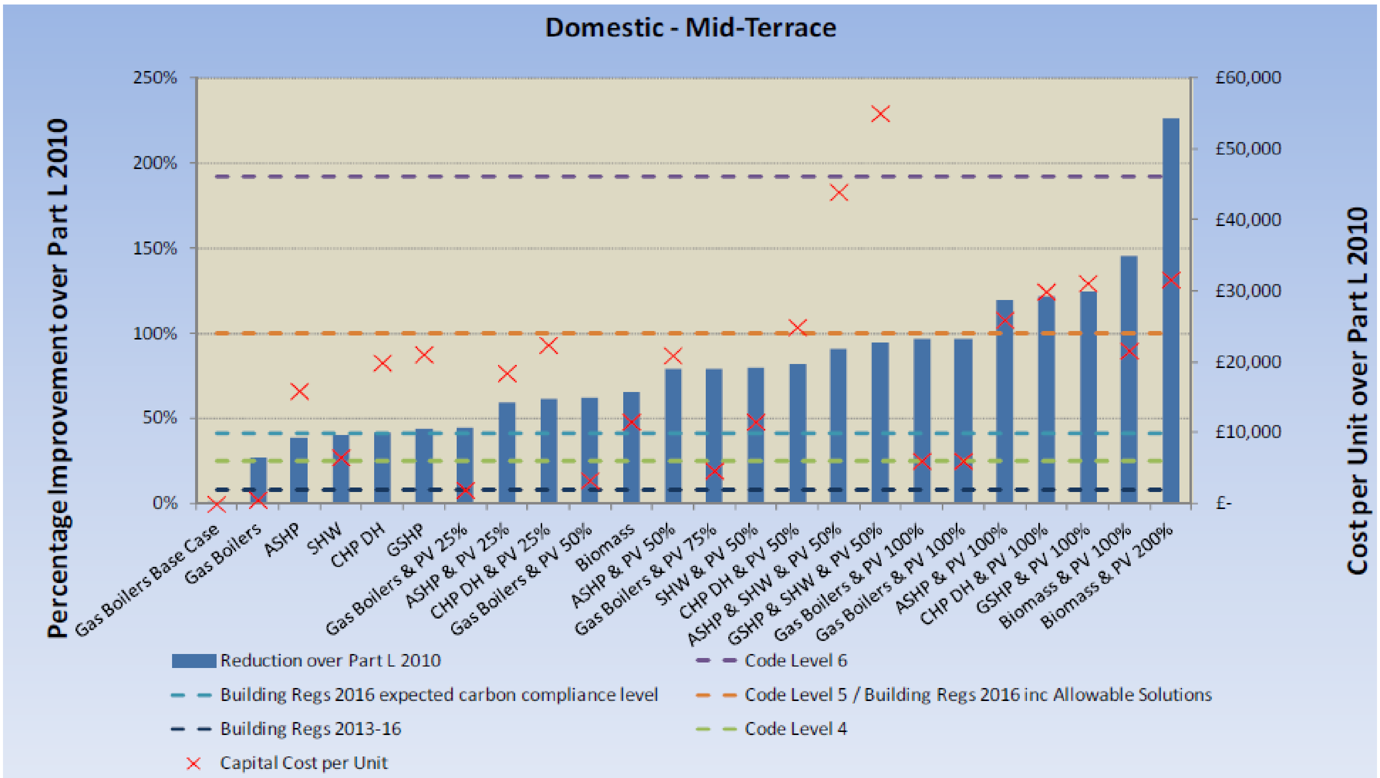

Figure 67: Cost and CO_2 performance of different measures in terraced homes

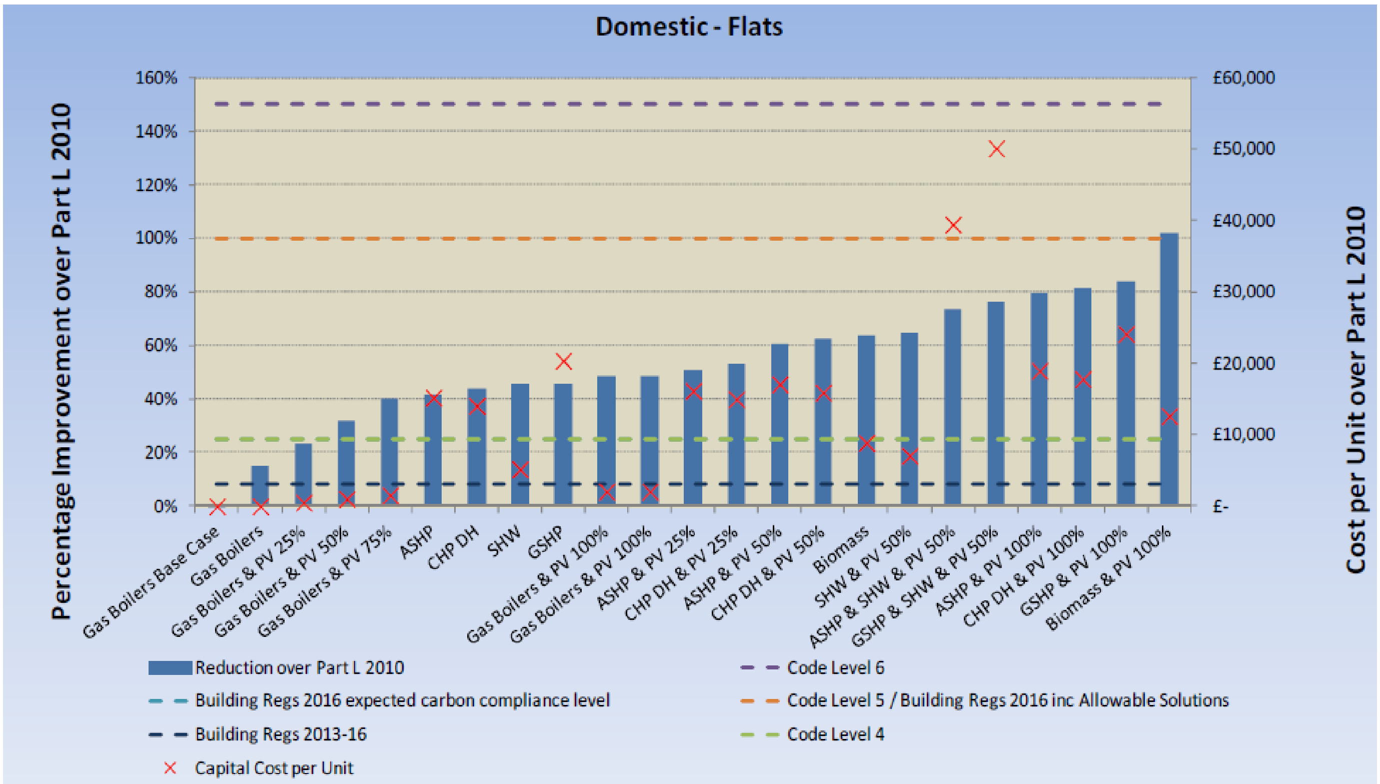

Figure 68: Cost and CO_2 performance of different measures in flats

Cost and carbon performance of different measures – non domestic

The following figures show the results of modelling a range of different measures in non domestic buildings. These results are based on benchmark performance and costs of technologies in indicative buildings, and should be used for high level guidance only. They should not be used for testing of viability of developments.

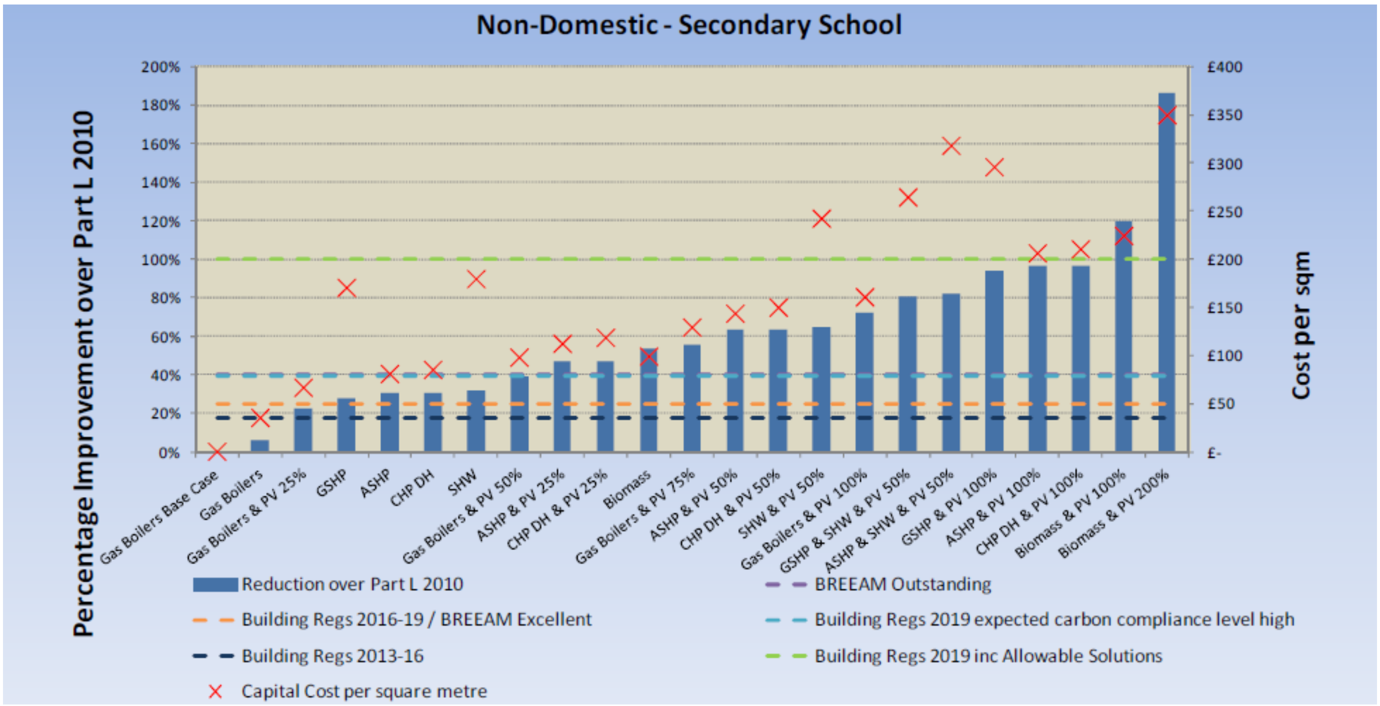

Figure 69: Cost and CO_2 performance of different measures in a secondary school

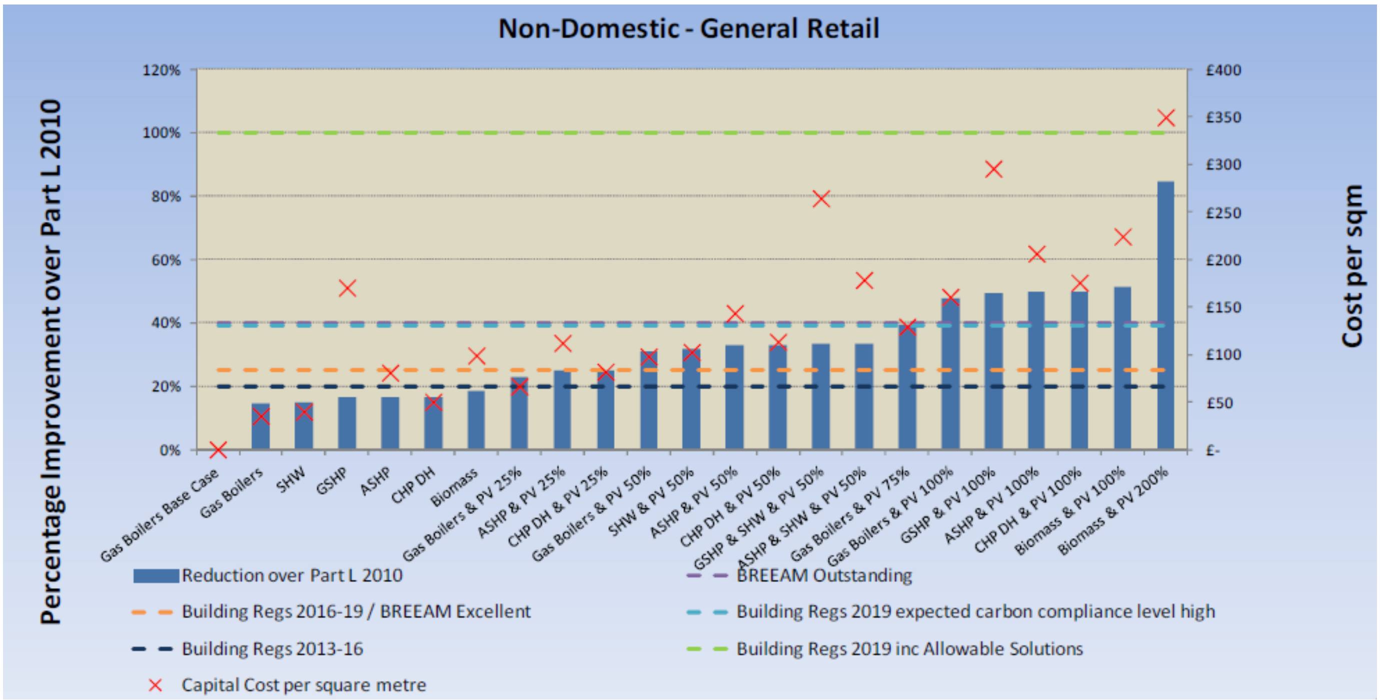

Figure 70: Cost and CO_2 performance of different measures in general retail

Capabilities on project:
Building Engineering

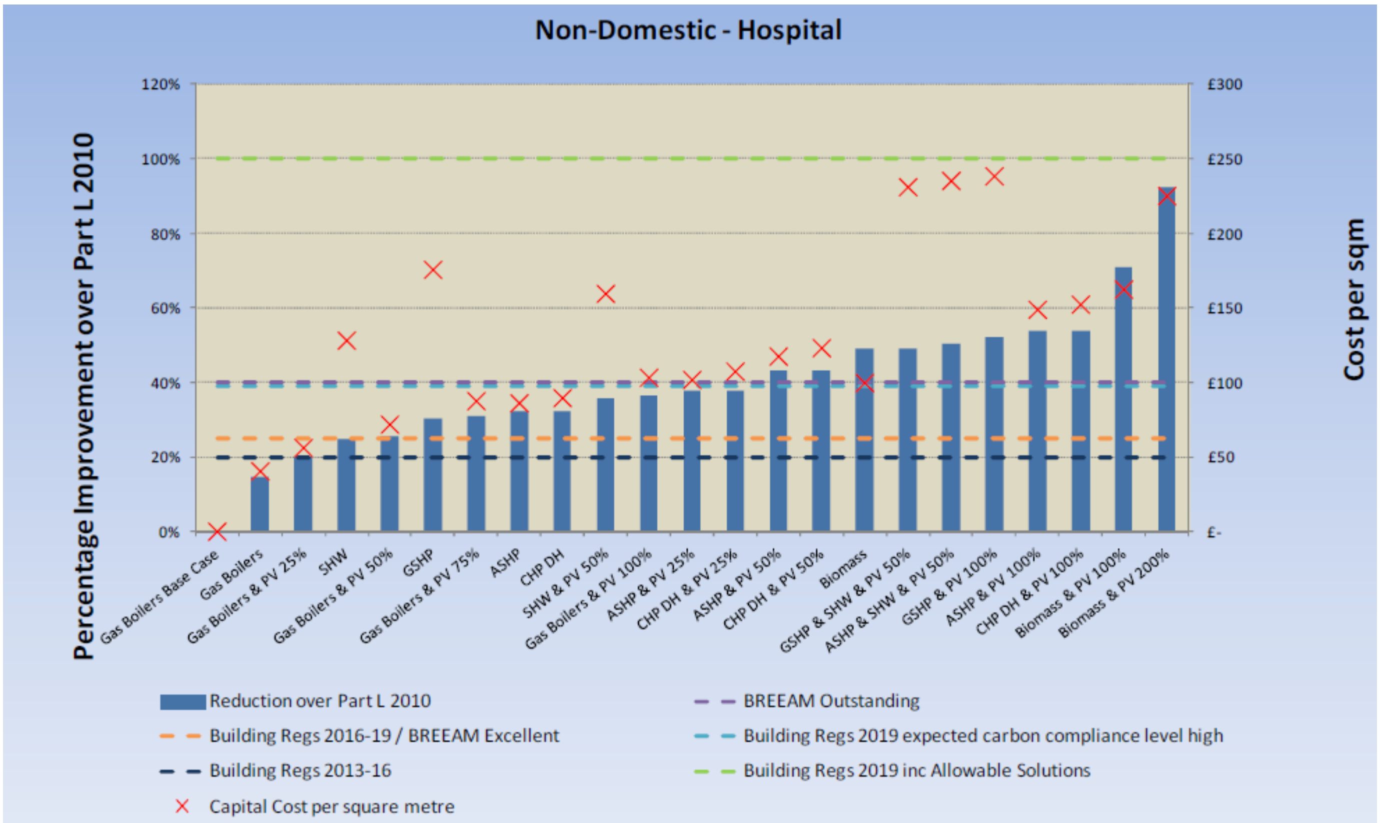

Figure 71: Cost and CO_2 performance of different measures in a hospital

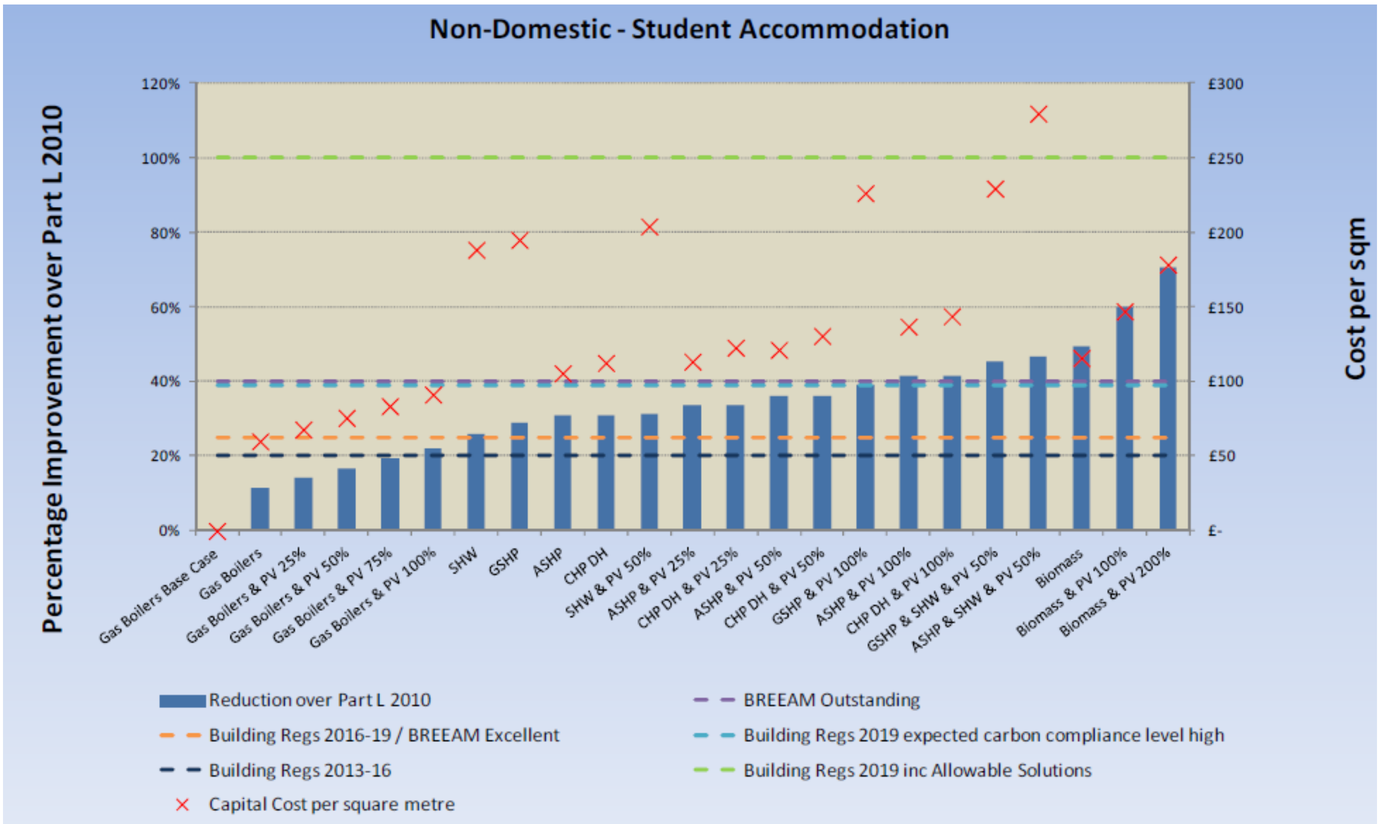

Figure 72: Cost and CO_2 performance of different measures in student accommodation

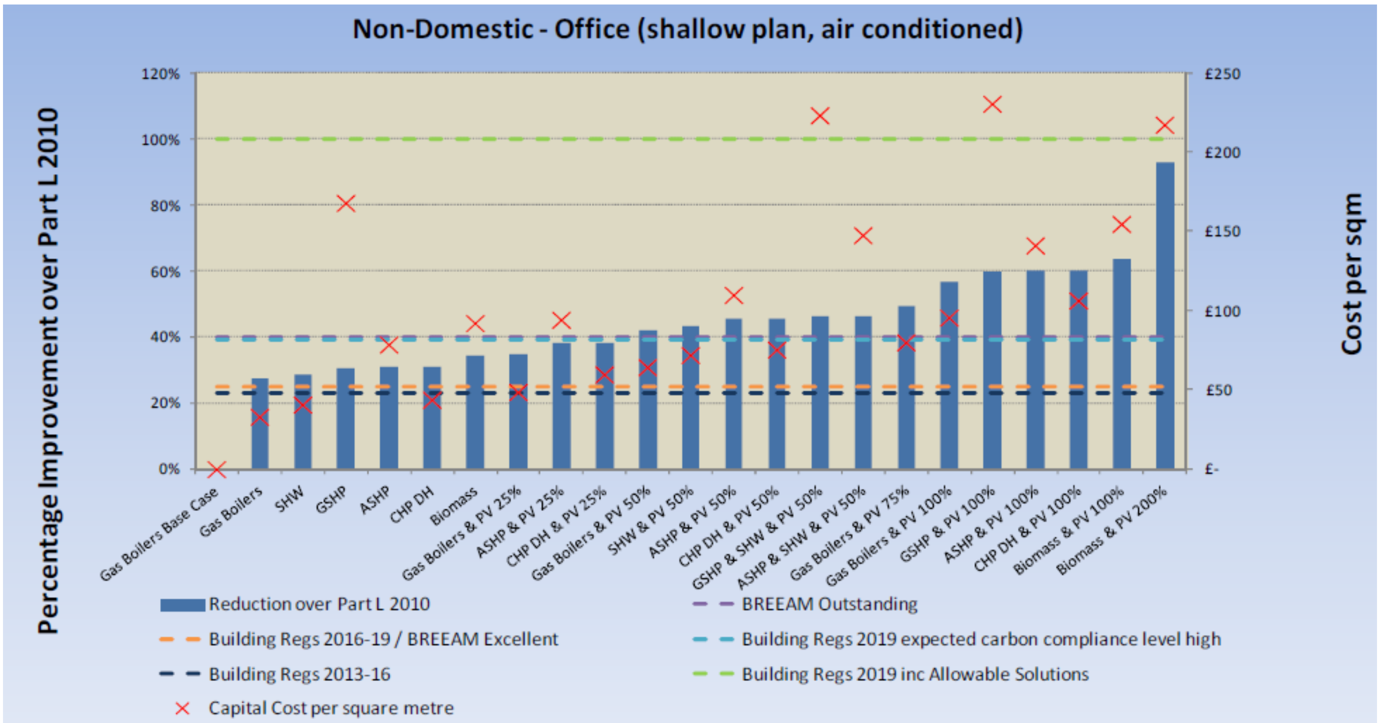

Figure 73: Cost and CO_2 performance of different measures in offices

Capabilities on project:
Building Engineering

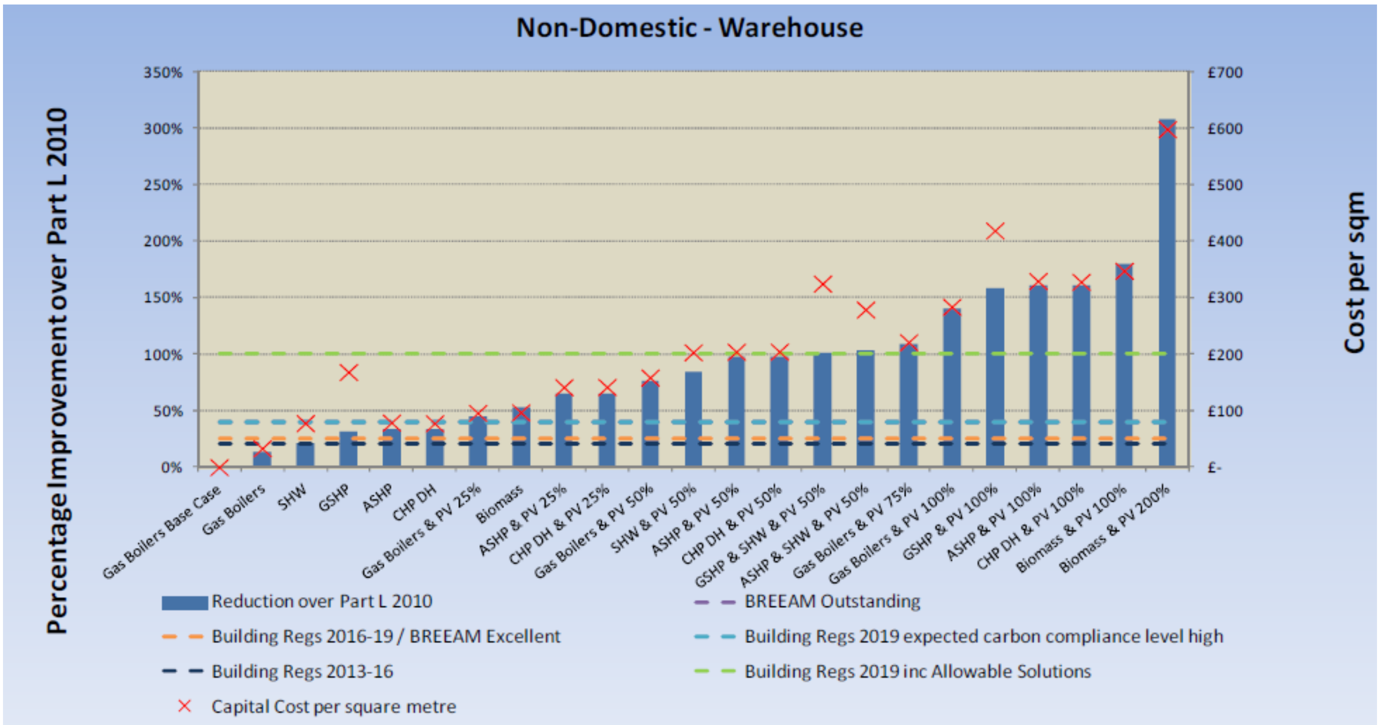

Figure 74: Cost and CO_2 performance of different measures in warehouses

Capabilities on project:
Building Engineering