BUROHAPPOLD ENGINEERING

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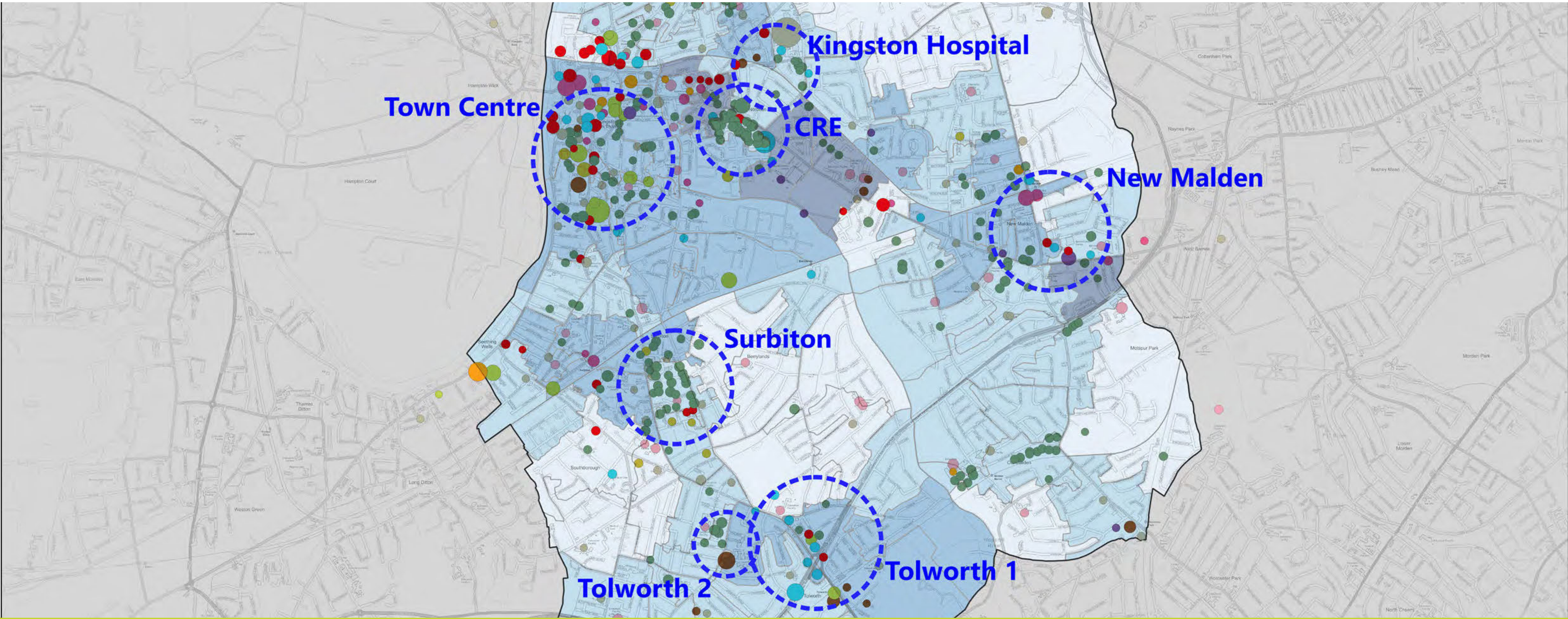

ENERGY MASTER PLAN REPORT

REVISION 03

SUPPORTED BY
MAYOR OF LONDON

European Union
European Regional Development Fund

22 JUNE 2022

Revision	Description	Issued by	Date	Checked
00	EMP Draft for review	IH	11/03/2019	BW
01	EMP Final Draft	IH	12/04/2019	BW
02	EMP Final Draft revised	IH	14/01/2020	BW
03	EMP Final Draft revised (redacted to remove sensitive Stakeholder information)	IH	22/06/2022	BW

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CONTENTS

GLOSSARY

Term	Definition
ASHP	Air source heat pump
BEIS	Department for Business, Energy and Industrial Strategy
BUROHAPPOLD	BuroHappold
CAPEX	Capital costs
CHP	Combined heat and power
DE	Decentralised Energy
DEC	Display Energy Certificate
DEEP	The Decentralised Energy Enabling Project
DHN	District heat network
DHW	Domestic hot water
EC	Energy centre
ECO	Energy Company Obligation
EPC	Energy Performance Certificate
GSHP	Ground source heat pump
HIU	Heat interface unit
HNDU	Heat Networks Delivery Unit
HNIP	Heat Networks Investment Project
HSTW	Hogsmill Sewage Treatment Works
LCOH	Levelised Cost of Heat
LTHW	Low temperature hot water
MoU	Memorandum of Understanding
OPEX	Operation costs
RBK	Royal Borough of Kingston upon Thames
REPEX	Replacement costs
RHI	Renewable Heat Incentive
TEM	Techno-economic modelling
WSHP	Water source heat pump

1 EXECUTIVE SUMMARY

A long term strategic district heat network (DHN) is proposed for The Royal Borough of Kingston upon Thames (RBK) based on the outcomes of this energy masterplan (see Figure 1.1). This network serves low carbon heat to ~3,800 homes and a range of RBK owned and private commercial assets, Cambridge Road Estate (CRE) and Kingston Hospital.

The proximity to the River Thames to Kingston Town Centre (KTC) cluster presents the opportunity to utilise the secondary heat from this large resource. An outline cost of [redacted] *is estimated for such a scheme, with a* [redacted] *% Internal Rate of Return (IRR) at 30 years with 20% capital grant funding. Implementing this scheme could save an average of 2,740tCO2e per year; the equivalent carbon emissions of heating 3,300 homes using individual gas boilers.*

The second cluster of interest identified centres around the CRE; a large RBK owned housing estate located near the secondary heat supply source of Hogsmill Sewage Treatment Works. With construction on the site's 2,000 home redevelopment due to start in 2021, CRE presents a timely opportunity to implement a DHN that utilises local waste heat. An estimated [redacted] *initial investment is required; achieving a 5.2% IRR at year 30 with 40% capital grant funding. The scheme has a yearly carbon saving that equates to the CO2e produced by heating 1,200 homes with gas boilers (1,000tCO2e) in one of the most deprived areas in the borough.*

Successfully implementing this scheme will require delivering a Strategic Outline Case and further feasibility studies, which can be used to support the Outline Business Case delivered for RBK approval. Timings are critical so not to miss the opportunity to connect into CRE and secure funding through the £320m Heat Networks Investment Project (HNIP) fund.

Benefits of district heat networks to Kingston

A DHN can contribute to The Royal Borough of Kingston upon Thames (RBK) drivers and targets in the current Core Strategy (2012). These include:

- **Reduce air pollution:** The proposed schemes reduce CO2e emissions by an average of 50% over DHN lifetime compared to a gas boiler alternative
- **Reduce carbon emissions:** The heat network is technology agnostic and provides the basis for further decarbonisation as future low carbon technology becomes commercially viable
- **Improve resilience and fuel security:** Through using waste heat from within the borough rather than relying on natural gas imports
- **Alleviate fuel poverty:** Ensure fair price for heat to all consumers and protect against rising energy costs and remove many of the disruptive impacts of boiler servicing and maintenance
- **Support growth within borough:** DHNs can provide an ongoing revenue stream to the Council and enable new development by simplifying the planning compliance for new developments. Also provides potential to attract 3rd party funding into RBK
- **Local job creation:** DHN can provide local jobs during procurement, construction and ongoing operation and maintenance
- **Funding and investment:** Including HNIP (£320m) and MEEF (£500m) funding can provide capital investment to support with the associated costs of construction, operation and maintenance of a DHN. The GLA's DEEP, to fund further early stage studies of energy master planning, through to feasibility, business case, procurement and commercialisation
- **Reduce risk:** Potential to share infrastructure costs with 3rd party partners such as ESCos and joint venture companies.

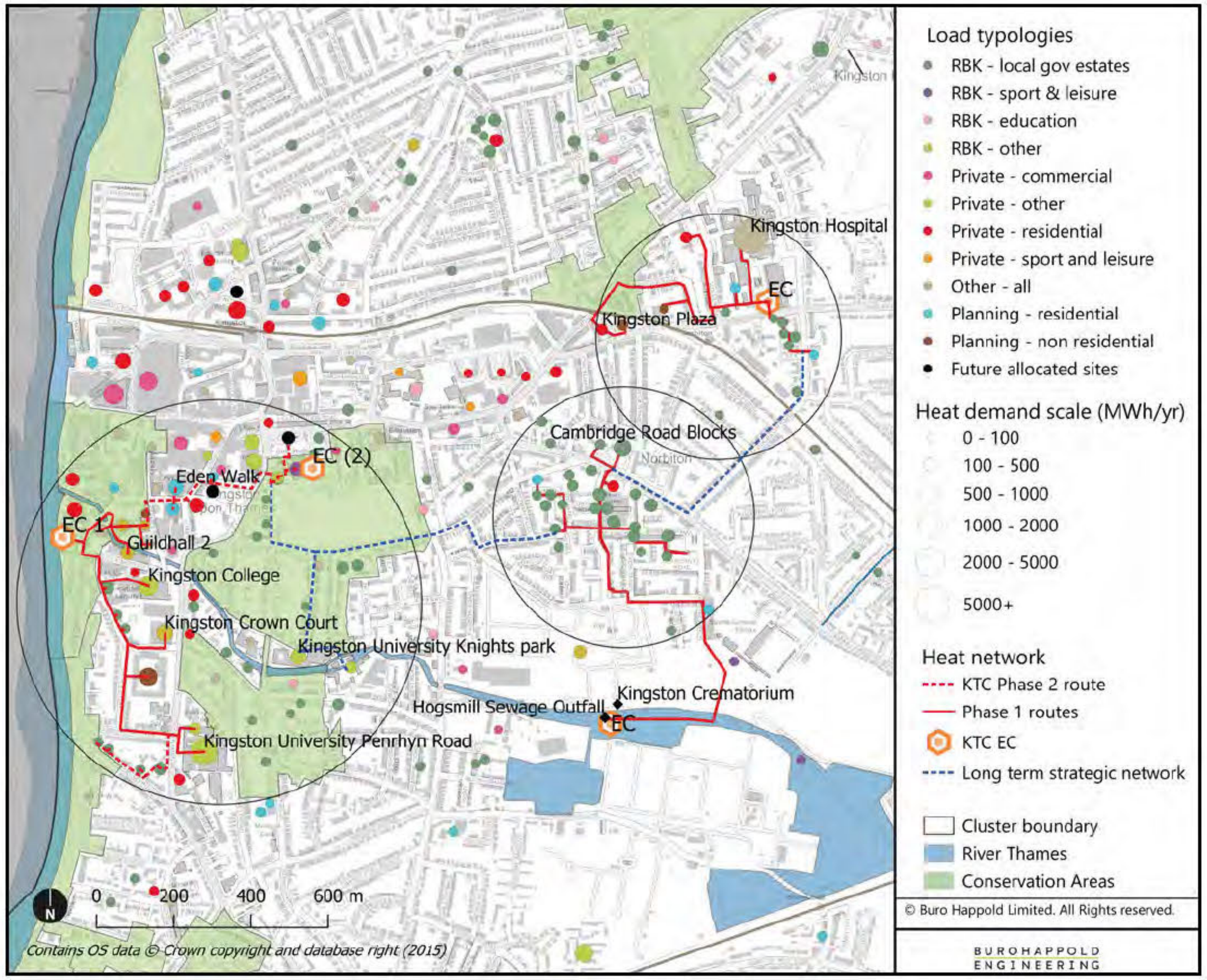


Figure 1.1: Long term strategic network

Methodology

BuroHappold were tasked with updating the borough-wide heat mapping from 2013, including new developments and sites earmarked for future expansion, to identify areas suitable for DHN.

From this mapping process, eight potential clusters were identified. Technical solutions were produced for each cluster based on site specific information and constraints. Techno-economic modelling was carried out over a period of 30 years considering projected capital costs, revenues and operational costs to test the scheme performance.

Heat tariffs to consumers have been derived to match the 'business as usual' technology to ensure that users who are obliged to connect to the network are at the very least no worse off. The basecase was modelled assuming no income from Renewable Heat Incentive (RHI) and no capital funding, assuming a discount rate of 3.5%. Sensitivity analysis was carried out to assess the scheme's performances with the addition of capital funding and RHI, as well as with a reduction in heat sales price. The results are presented in Table 1.1.

From this process, the three highest ranked clusters are Kingston Town Centre, Cambridge Road Estate (CRE) and Tolworth 2. A summary of their key opportunities are shown in Figure 1.2

Kingston Town Centre

- Access to secondary heat source - River Thames
- 24.7 GWh annual heat demand served
- Outline capital cost of [redacted]
- IRR o[redacted]ith no funding
- 51% CO_2 saving at year 10
- Opportunity to expand network to CRE in future

Cambridge Road Estate (CRE)

- Large waste heat source at Hogsmill Sewage Treatment Works outfall
- Opportunity to reduce fuel poverty in Kingston's most deprived area
- 2000 [redacted] planned
- [redacted] capital cost
- IRR of [redacted] with RHI funding

Tolworth 2

- Tolworth Hospital energy centre upgrade provides opportune timing to reduce CO_2 emissions to surrounding community
- Nearby social housing to be retrofitted to act as a model scheme for future RBK housing stock retrofit
- [redacted] capital cost and IRR of [redacted] with no funding

Figure 1.2: Key cluster opportunities

Table 1.1: Cluster results

	Cambridge Road Estate (CRE)	Tolworth 2	New Malden	Kingston Town Centre - Phase 1	Kingston Town Centre - Phase 1 & 2	Kingston Hospital	Surbiton	Chessington
Network:								
LZC technology	WSHP - Hogsmill	ASHP	GSHP	WSHP– River Thames	WSHP – River Thames	ASHP	ASHP	GSHP
Annual heat demand (MWh/yr)	8,790	5,140	4,310	17,440	24,670	25,340	5,360	990
Heat line density (MWh/m)	6.3	8	3.8	10.4	8.5	15.9	3.6	3.1
No residential units on network	2,632	135	325	0	1,248	441	385	71
Percentage tier 1 heat (%)	90%	95%	47%	94%	92%	91%	29%	0%
Commercial performance:								
CAPEX (£m)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
IRR @ 30 yrs (%) – no funding or RHI	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
IRR @ 30 years (%) – with 20% capital funding & no RHI	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
IRR @ 30 yrs (%) – with RHI & no funding	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Environmental performance:								
DH emissions saving @ yr 10 (% tCO_{2e})	51%	49%	55%	51%	51%	49%	49%	55%
Lifetime DH emissions savings vs counterfactual	29,895	16,776	15,397	57,619	82,184	8,396	17,485	3,533
Final ranking (1=best)	2	3	7	8	1	4	5	6

Using the threshold internal rate of return (IRR) recommended by RBK's financial team of [redacted], the best performing schemes are Tolworth 2 and KTC phase 1 & 2. Due to the adoption of electrified heat pumps within the energy centres, all the clusters achieve significant CO_2 savings against the 'business as usual' case of individual gas boilers, of an average of 51% at year 10. The clusters were ranked based on a mixture of key quantitative and qualitative outputs, including potential to elevate fuel poverty with KTC, CRE and Tolworth clusters coming out strongest.

Sensitivity analysis on scheme performance with 20% capital funding secured through HNIP or MEEF shows that financial performance increases significantly; with Tolworth 2 and KTC Phase 1 & 2 achieving IRRs above [redacted]. Acquiring a 40% capital funding level sees all the schemes exceeding the [redacted]% threshold IRR.

Accessing funding through the RHI, or its replacement funding stream post 2021, will have a positive impact of the financial performance of all schemes. The sensitivity results suggest that in this case all the schemes would meet the IRR threshold except for the Kingston Hospital cluster. It may be possible to obtain both RHI payments and capital funding, in which case these IRR improvements can be combined. The sensitivity analysis results are illustrated in Figure 1.3.

[redacted]

Conclusions and next steps

This study suggests there could be multiple viable schemes within Kingston. The highest performing schemes of CRE, KTC and Tolworth 2 have been identified based on their high percentage of RBK owned heat load, as well as good financial performance. As well as this, the timing provides an opportunity to integrate a solution within the proposed developments. This study provides a strong starting point on which to develop more detailed technical and commercial business case for DHN in the borough. The timeframe for these schemes is crucial to their viability. The missed connection opportunities of large developments in the town centre (such as Eden Walk) already through Planning, illustrate the importance of adapting planning policy to kick-start the development DHNs. Immediate action on the key cluster of CRE is required to ensure the opportunity is not missed. The following next steps and key decisions are required before design, procurement and construction can commence:

1. Delivery planning and Strategic Outline Case
   - Recommendations from the masterplan should be incorporated into the Planning Policy updates underway for RBK. All major planned developments in the opportunity areas identified in this study should be ensured that they are made connection ready for any future heat networks
   - Engage with external stakeholders – present proposed schemes to the connections and target signing MoU. Soft market testing with heat network operators.
   - Internal stakeholder engagement – to develop an understanding with RBK of the arrangements required for delivery. Including, internal department to own the DHN development, funding streams within RBK, approvals process.
   - High level Strategic Outline Case to establish the need, review options for delivery and scope out detailed assessments required
   - A clear delivery roadmap to be produced and identification of champions / steering committee from within RBK to provide a route to how these schemes would be delivered and approvals and clearances processes.
   - Funding: apply for further support from GLA DEEP funding to support further studies identified
2. Detailed Project Development including Outline Business Case
   - Further explore the commercial and technical solutions at KTC and CRE through detailed feasibility
   - Secure heat offtake agreements with developers
3. Procurement and Full Business Case
   - Further scheme development to Business Case (required to make HNIP application)

The results of this study were presented to an audience compromising of both internal and external stakeholders on the 19th February 2019. A summary of the written feedback received in documented in Appendix I. In attendance was Councillor Hilary Gander, who was supportive of the findings and the potential benefits of a district heat network in Kingston. She also expressed interest in being a 'Champion' of the proposed scheme.

Ed Davey, the MP for Kingston and Surbiton and previous Secretary of State for Energy and Climate Change, is also aware of the urgent need to decarbonise the built environment and sees the important role local authorities have in implementing this transition. Quoted in the Surrey Comet (22nd March 2019) he says:

> *"We need locally, nationally and globally, to make climate change a top priority because it is so urgent… Councils have got to work hard on energy efficiency… with the new homes programme on the Cambridge Road Estate, sustainability is really a much bigger aspect than it was under the last council… we have to tackle it, we have to act far more quickly than some people think… Local authorities have an important role to play"*

Interdependencies

Cambridge Road Estate

- **Securing CRE redevelopment connection** – scheme is subject to residential ballot in November 2019 and subsequent accepted planning application, targeting Phase 1 operation by 2022. A meeting with the CRE design team is proposed as soon as possible to ensure future connection to the heat network is captured.
- **Memorandum of Understanding (MoU) with Thames Water** – Positive engagement has been held with Thames Water to date. Further engagement should be carried out to further the review the viability of heat offtake with a view to signing a MoU
- **Alignment of road works with Go Cycle programme –** early engagement with Go Cycle and other planned roadworks in the area to ensure pipework can go into the ground at the same time if required. One Go Cycle route runs along Cambridge Road, along the northern boundary of the CRE, where the proposed DHN pipework will cross to connect to Cambridge Gardens Blocks heat load
- **Existing plant replacement cycles –** Ensure no boilers are replaced where this can be avoided in existing identified connections (e.g. Cambridge Gardens) as this may affect likelihood to connect in the near term. Where works are needed, consideration of future connection arrangements should be made (e.g. valve arrangements) to allow for easy future connection.

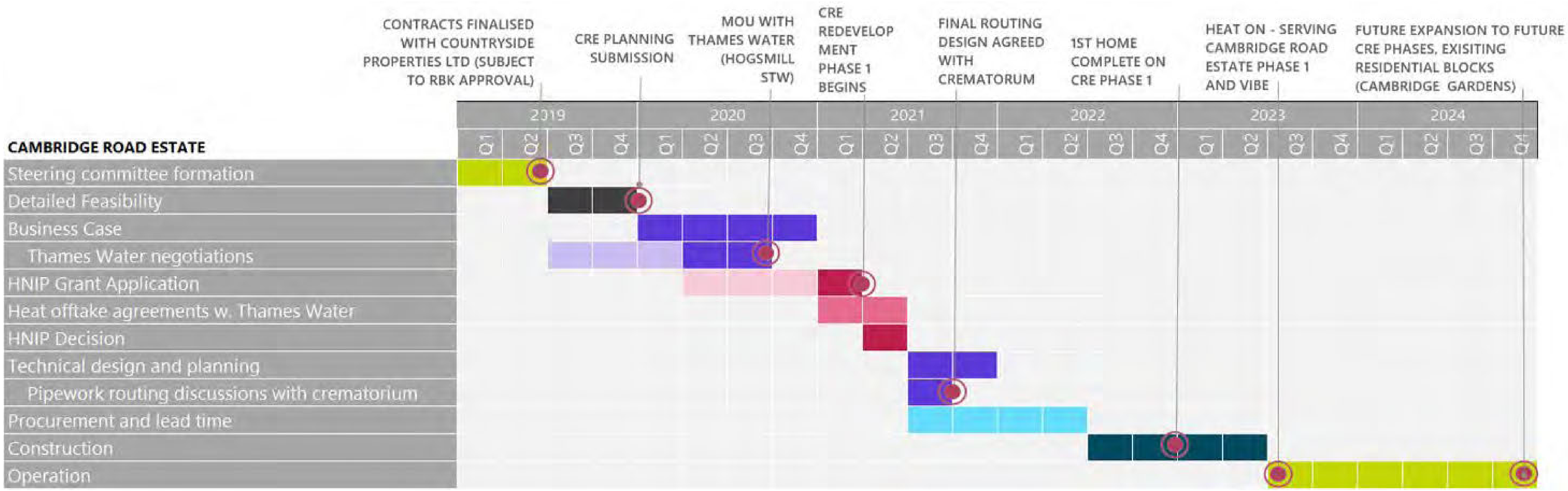


Figure 1.4: CRE outline delivery programme and key decisions

Kingston Town Centre

- **Surrey House –** a 320 residential unit development, currently awaiting planning permission. RBK to ensure development is connection ready to a future DHN. The GLA advised on June 5th 2018 that the application does not comply with the London Plan or Draft New London Plan[1]
- **Energy centre (EC) location** – Eagle Brewery Wharf is identified as a potential location, however a more detailed feasibility of this location is required or alternative locations suggested and reviewed with RBK
- **Reimagining Kingston Town Centre** – due for completion in April 2019, this project is likely to influence DHN routing. The outputs of the study, as well as the Go Cycle programme, should be aligned to the energy masterplannning in order to obtain the full benefit of both studies and negate unnecessary roadworks
- **K+20 Kingston Town Centre Area Action Plan** – identifies strategic development sites within the town centre, including the Cattle Market and Ashdown Road carparks, Guildhall refurbishment. The DHN proposal should align with these objectives and the proposed developments should be programmed for connection.
- **Phasing opportunities for future expansion** – design to allow for future expansion, such as the Strategic Network (Figure 6—23), expansion into large commercial loads of Bentalls and John Lewis in future or expansion to the north of the railway line.

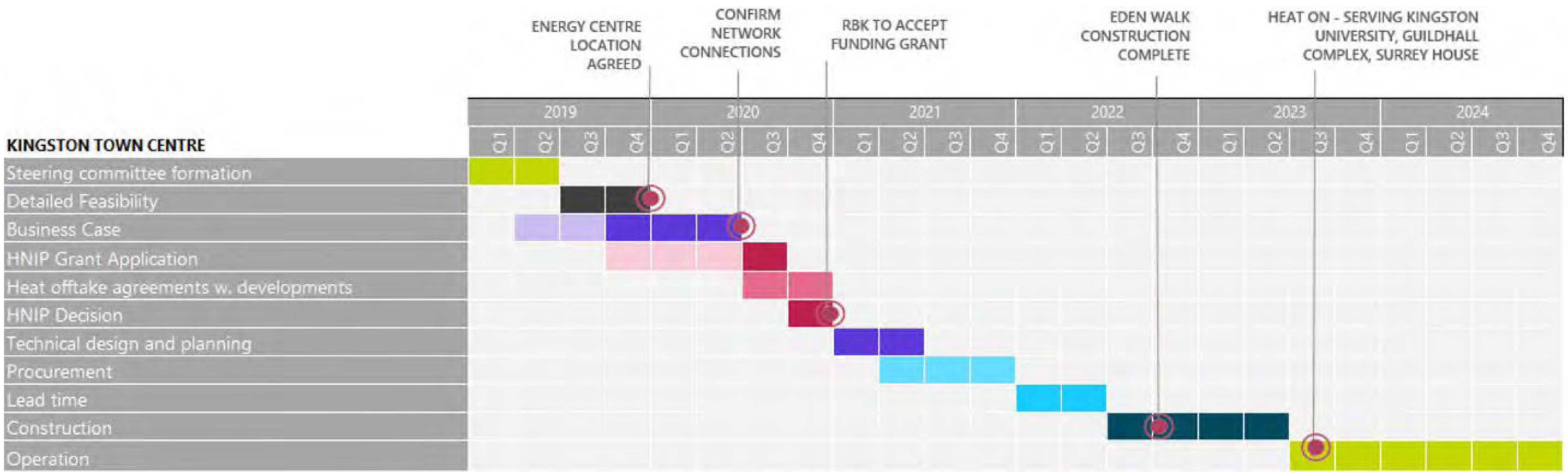


Figure 1.5: KTC outline delivery programme and key decision

1 GLA, 2018. Planning report FLA/4304/01 Surrey House, Eden Street. Planning application no. 18/12119/FUL. Available at: < https://www.london.gov.uk/sites/default/files/PAWS/media_id_411417/surrey_house_eden_street_report.pdf>

2 INTRODUCTION

2.1 CONTEXT

The Royal Borough of Kingston (RBK) secured Greater London Authority (GLA) Decentralised Energy Enabling Project (DEEP) funding to complete an energy masterplan of the borough with the aim of identifying opportunity areas for district heat network (DHN) development.

RBK are committed to reducing the impact of climate change and air pollution on its residents and the wider community. District heating provides heating and hot water via a below ground hot water pipe network from a single energy centre. This improves the efficiency of heat supply, typically providing lower carbon and lower cost heating and hot water, whilst removing the need for building based heating plant. With the Committee on Climate Change recommending no new build homes on the gas grid by 2025 at the latest[2], developing low carbon heating alternatives is an important way to ensure the borough meets its carbon emissions targets.

DHNs can contribute to the RBK drivers and targets set out in the 3 Thematic Policies in the current Core Strategy (2012):

- *A Sustainable Kingston*
  - **Low carbon** heat supply
  - **Flexibility** for further long-term decarbonisation
- *Prosperous and Inclusive*
  - Create a functioning business - **generate revenue**
  - Make development easy through **clear compliance** for planning
  - Alleviate **fuel poverty** - reduce costs of heat
  - Attract **funding** through innovation
- *Safe, Healthy and Strong*
  - **Improve air quality**
  - Community jobs and training opportunity.

2.2 SCOPE

This project targets three areas relating to decentralised energy network development across RBK:

1. Update of borough wide heat demand map: current and projected mapping of domestic and non-domestic heat demands to provide an update to the previous AECOM and Arup studies. Engage with RBK and relevant third parties to ensure all major new developments since 2015 are captured and heat loads of existing buildings are up to date.
2. Determination of potential locations for secondary heat supply sources: desktop Borough wide study of secondary heat sources in Kingston. Where secondary heat sources are found in areas identified under the heat mapping exercise as having potential for DHN growth, investigate the viability of each from a technical and economic perspective. Including a carbon emissions assessment.

   Identification of key opportunity areas: taking into account the above heat demand and supply mapping, identify, prioritise and recommend opportunity areas in the borough with potential for DHN development. Provide clear recommendations on how the opportunities should be taken forward.

This study is limited to the high level appraisal of DNH opportunities within RBK. Identified clusters should be subject to a subsequent detailed techno-economic analysis to validate assumptions on energy demands, physical and commercial constraints and project finances.

2 Committee on Climate Change, 2019. UK housing: Fit for the future? February 2019. Available at: <https://www.theccc.org.uk/wp-content/uploads/2019/02/UK-housing-Fit-for-the-future-CCC-2019.pdf> [Accessed 15 March 2019]

2.3 HEAT NETWORK IN KINGSTON

BuroHappold are aware that without sufficient support from within the council and a clear understanding of the approvals processes, opportunities such as these presented in this study can be easily missed. The two previous heat mapping studies commissioned by RBK in 2013 and 2015 (see Section 3.1) are an example of this.

To address this issue, the results of this study were presented to an audience compromising of both internal and external stakeholders on the 19th February 2019. A summary of the written feedback received in documented in Appendix I.

In attendance was Councillor Hilary Gander, who was in principle supportive of the findings and the development of a district heat network in Kingston. Ed Davey, the MP for Kingston and Surbiton and previous Secretary of State for Energy and Climate Change, is also aware of the urgent need to decarbonise the built environment and sees the important role local authorities have in implementing this transition. Quoted in the Surrey Comet

Ed Davey, the MP for Kingston and Surbiton and previous Secretary of State for Energy and Climate Change, is also aware of the urgent need to decarbonise the built environment and sees the important role local authorities have in implementing this transition. Quoted in the Surrey Comet (22nd March 2019)[3] in relation to the Cambridge Road Estate Redevelopment he says:

> *"We need locally, nationally and globally, to make climate change a top priority because it is so urgent… Councils have got to work hard on energy efficiency… with the new homes programme on the Cambridge Road Estate, sustainability is really a much bigger aspect than it was under the last council… we have to tackle it, we have to act far more quickly than some people think… Local authorities have an important role to play"*

3 https://www.surreycomet.co.uk/news/17521155.kingston-council-will-debate-joining-dozens-of-other-uk-councils-in-declaring-climate-emergency-in-challenge-to-leader-liz-green/

3 BACKGROUND

3.1 PREVIOUS HEAT MAPPING STUDIES

3.1.1 AECOM ENERGY MASTER PLAN (2013)

The Kingston Energy Masterplan study carried out by AECOM in 2013[4] identified several potential areas in RBK which could be suitable for a DHN. Kingston Town Centre (KTC) was highlighted as a particularly promising area for DHN development due to its high heat density and wide range of load typologies. The study proposed a first phase project in KTC, with potential future phasing connecting the Kingston Hospital and Kingston University Clay Hill Campus in the future. The study also identified the River Thames and Hogsmill Sewage Treatment Works (HSTW) as potential secondary heat sources. The proposed network route is shown in Figure 3.1.

The report suggests an energy centre at HSTW as it has a significant area of un-used land. Accessing secondary heat from the site is reported on, with the production of biogas from combustion of the dried sludge waste being exported to an energy centre. However, the sludge drying plant equipment is inefficient and expensive and the report concludes that there is minimal secondary heat resource. Converting the sewage water outfall into high-grade heat through a heat pump is briefly mentioned in AECOM report. Referencing the GLA's Secondary Heat Study, HSTW has an estimated 5,001+ MWh of heat available. AECOM state this is likely to be significantly higher; in the order of 10s or 100s of GWh. However, no consultation with Thames Water was carried out to confirm this figure.

The average IRR for all scenarios tested in this study was below 5% over 25 years and at the time none of the schemes were considered financially viable from the perspective of RBK. Since this study a number of new developments have come forward in RBK, this and the introduction of government funding for the capital outlay for heat networks means that there is a timely opportunity to reassess the opportunities within the borough.

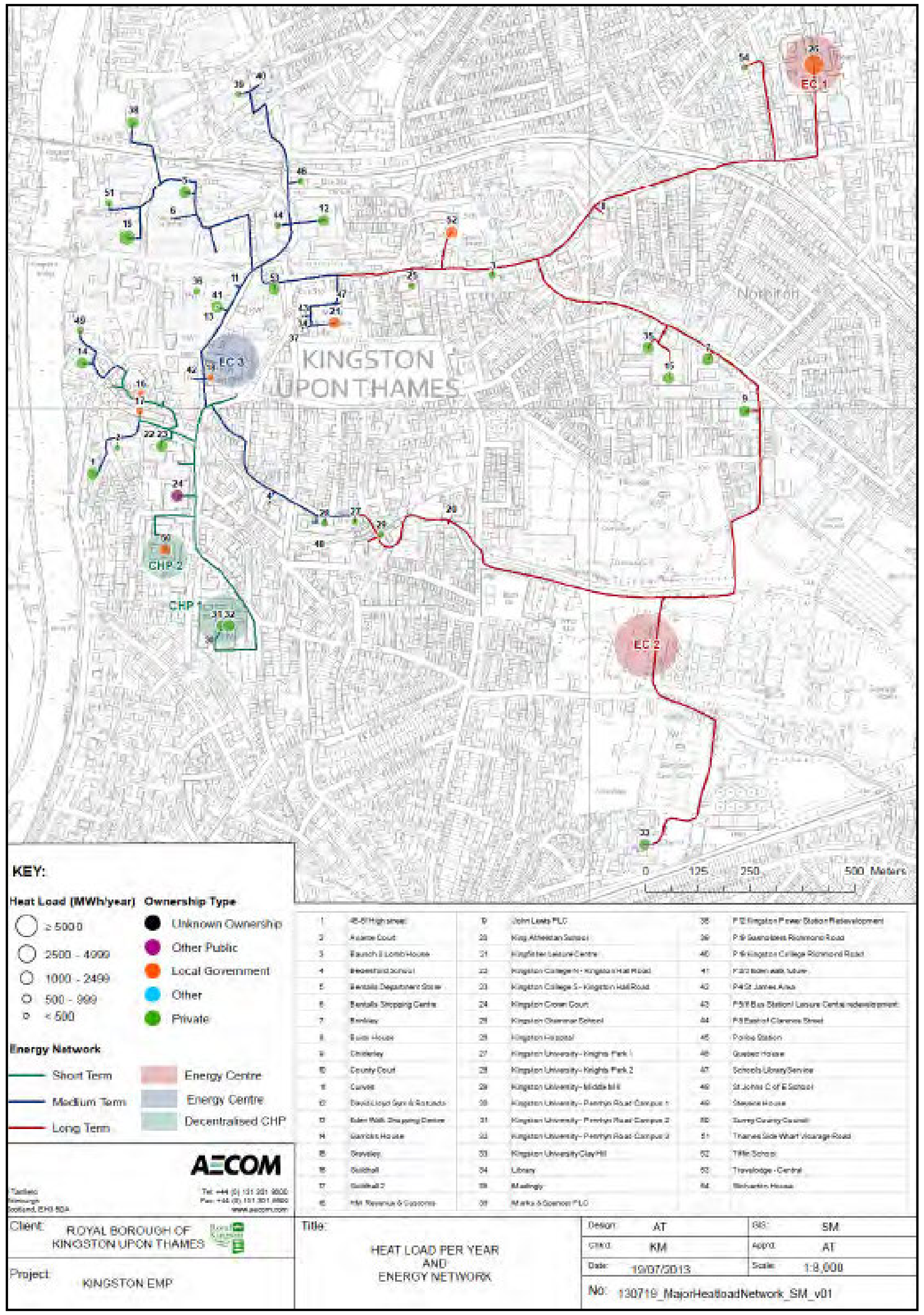


Figure 3.1: AECOM DHN route proposal[5]

4 https://www.london.gov.uk/sites/default/files/energy_masterplan_for_royal_borough_of_kingston_upon_thames.pdf

5 AECOM, 2015. Royal Borough of Kingston upon Thames: Energy Master Plan Final Report. Available at: <https://www.kingston.gov.uk/download/downloads/id/1920/kingston_decentralised_energy_network_-_feasibility_and_business_case_study_2015.pdf>

3.1.2 ARUP TOWN CENTRE FEASIBILITY STUDY (2015)

In 2015 Arup conducted a decentralised energy network feasibility and business case study for RBK[6]. This study built upon the AECOM 2013 study but focused on developing a DHN in the town centre. The core scheme focused on the retail and commercial heat loads within KTC. The main heat loads connected are Eden Walk, Old Post Office, John Lewis, Bentalls, Kingston College (Kingston Hall Road campus), David Lloyd Gym and the Guildhall. Two main DHN supply options were proposed (illustrated in Figure 3.2):

- CHP - A DHN in the town centre, with the energy centre located at Ashdown Road carpark. Heat is supplied by CHP, with gas boilers for peaking. The carbon savings were calculated at 1,460tCO_2 per year, a 34% reduction on BAU.
- WSHP - A DHN in the town centre, being served by a WSHP and gas boilers for peaking. The energy centre is located at Eagle Brewery Wharf. This scenario saw an annual carbon saving of 485tCO_2 per year at full build out, an 11% reduction on BAU. This is a lower carbon saving than the CHP scheme, however, this was reversed when the expected future grid carbon intensity was used.

The WSHP scheme was considered less favourable than the CHP option as the planning permission may not be granted for the river-side energy centre. It also concluded that the technical feasibility of WSHP is more uncertain, siting issues with water intake compliance and regulation.

Domestic and non-domestic heat sales unit price were modelled at £42/MWh and £38/MWh respectively. The total standing charge was set such that the total heat bill for the proposed scheme is a 10% discount on the price of heat from individual gas boilers.

The study concluded that the feasibility of both schemes is highly dependent on the developer connection charge. The IRR dropped below 12% in scenarios with lower, more realistic connection charges, making it unlikely that an ESCo financed scheme is feasible. To achieve the IRRs stated, the economic model included revenue from the non-domestic Renewable Heat Incentive (RHI) for 20 years. 31% of all revenue is derived from these payments at full network build out; totally £527k.

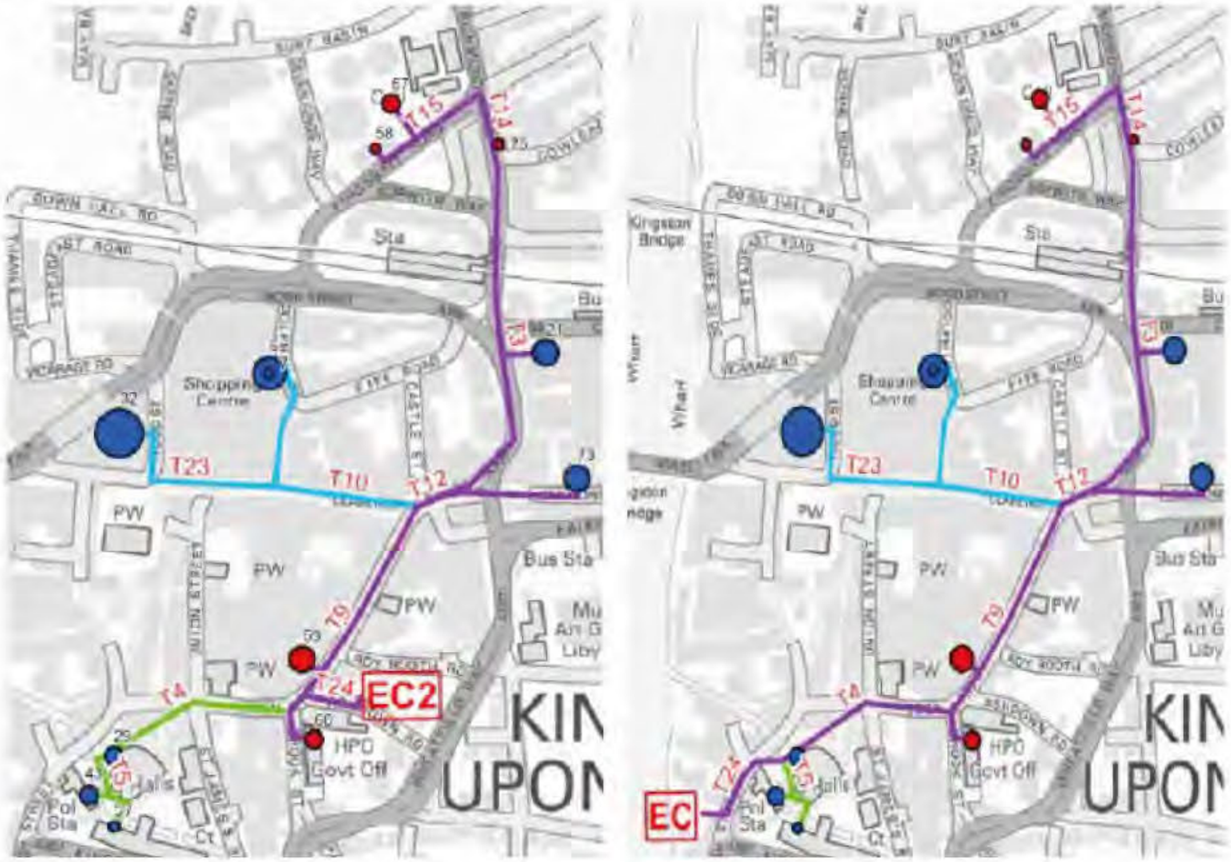


Figure 3.2: Proposed DHN routes from Arup's DEN study

6 https://www.kingston.gov.uk/download/downloads/id/1920/kingston_decentralised_energy_network_-_feasibility_and_business_case_study_2015.pdf

3.2 RELATED RBK STUDIES & DOCUMENTS

The K+20 Kingston Town Centre Area Action Plan[7] was adopted in July 2008. This report aimed to guide future improvements and developments in the town centre up to 2020. This report, along with the Eden Quarter supplementary planning document (SPD)[8], produced for RBK in 2015, outlines the key development aims for the area. Most notably:

- The British Land and USS' £400m redevelopment of Eden Walk Shopping Centre
- Eden street enhancement to become a primary retail street
- The Eden Quarter has an estimated 1,200 new dwelling capacity from 2015 to 2041. These will generally be delivered as apartment blocks above retail units. These housing targets have increase since the New London Plan, showing 3,834 new homes planned in the town centre by 2041
- Ashdown Road Car Park has been identified in the Eden Quarter SDP as a strategic site to extend the retail and commercial core of the town centre. It is located adjacent to The Old Post Office site. Although no developer is currently at the site, options include developing a mixed retail and residential development
- Cattle Market Car Park currently houses a weekly market on its surface car park. The SDP has identified this as a possible space for a new mixed leisure and commercial centre which retains the site's underground car parking facilities. There are currently no known developers interested in the site
- The K+20 Area Action Plan (AAP)[9] highlights RBK's desire to upgrade or replace the Kingfisher Leisure Centre and the nearby children's library
- The Guildhall complex refurbishment, consisting of three buildings: Guildhall, Guildhall 1 and Guildhall 2. Consultation with Tim Pritchard from RBK Property department confirmed a review of the estate operation is currently being commissioned. The main Guildhall building is Grade II listed with poor building performance.

The Reimagining Kingston Town Centre project is running alongside the energy masterplanning. It is due for completion in April and has the potential to influence DHN routing. The outputs from this piece of work should be aligned to the energy masterplannning in order to obtain the full benefit of both studies. For example, any roads assessed as needing resurfacing could install the DHN pipework at the same time to minimise disruption to pedestrians and business.

Consultation with Tim Thompson, the interim property consultant at RBK, has identified a project within RBK to synchronise major regeneration and develop an investment programme for a key corridor within the borough. The aim of the project is to produce a coordinated capital delivery programme for new homes, commercial space, and school space. The corridor encompasses the whole KTC area, along with the Hogsmilll valley, CRE, Kingston Hospital and New Malden clusters.

7 https://www.kingston.gov.uk/downloads/file/65/kingston_town_centre_area_action_plan
8 https://www.kingston.gov.uk/downloads/download/452/eden_quarter_spd_and_supporting_documents
9 Royal Borough of Kingston upon Thames Local Development Framework, 2008. *Kingston Town Area Action Plan (K+20).*

3.2.1 RBK POLICY

The RBK Energy Strategy (2009)[10] provides a framework to reduce the impact of climate change in the borough. It sets out strategies for energy management, behavioural change, energy efficiency measures and low-carbon energy generation. The priorities and projects are revised each year in an Implementation Plan and are adopted by the Place and Sustainability Committee. The Energy Strategy recognises the need for all sectors of the community to collaborate in this effort and in doing so, the council must work in partnership across these sectors.

RBK's Energy Strategy was produced to help meet the following targets:

- Climate Change Act (Nov 2008) target of reducing greenhouse gas emissions by 80% by 2050, and carbon dioxide emissions by at least 26% by 2020, against a 1990 baseline
- Renewable Energy Strategy target to achieve 15% of the borough's energy consumption from renewables by 2020
- In 2010, the Low Carbon Management Plan[11] was produced, setting a target for Kingston Council to reduce its CO_2 emissions by 24% from across its assets and service delivery by March 2015 from 2008/9 baseline.

The latest published Energy Strategy Implementation Plan (2013/14)[12] states one of the five key priorities is delivering District Heat Networks to reduce CO_2 emissions and provide cheaper energy, improved fuel security and income for investors.

RBK are currently preparing a new Local Plan to guide the future development of the borough. The Local Plan will provide long term vision and strategy to meet future needs for homes in the borough. As part of this, planning policies will be updated to align with the New London Plan targets and updates to RBK's Core Strategy. The results of this study are intended to feed into this policy update.

3.3 UPDATES TO SAP FACTORS AND REGIONAL POLICY

The Standard Assessment Procedure (SAP) is the methodology used by the Government to assess and compare the energy and environmental performance of dwellings. SAP 2012 guidance was followed by Building Regulations 2013. 'SAP 10' was released last year, and will be enacted with the next update to Building Regulations (date tbc). The fuel emission factors are compared in Figure 3.3

The reducing electric grid carbon emission factors (greater than half of SAP2012) will make CHP not technically feasible to provide the required carbon savings to meet planning targets, as the impact of the offset from the electricity generated by the CHP unit is significantly reduced. Other electrically led technologies will need to be considered in its place whilst also considering the cost of heat to consumers e.g. direct electric has a low capital cost but high operational cost. Use of heat pumps in communal heating systems is a way to reduce long term carbon and avoid high heat prices for customers.

The GLA have issued new **Energy Planning Guidance** which will be applicable from January 2019. In this update planning applicants are encouraged to use updated (SAP 10) carbon emission factors to assess the expected carbon performance of a new development. The implication of this will be, as above, that CHP will not be able to provide the required savings to achieve compliance. All major developments in RBK will be referable to the GLA.

Updates to the Draft New **London Plan** have been published as of July 2018 following public consultation. The new hierarchy continues to promote heat networks but, as with the above, the focus shifting to lower emission heat sources such as heat pumps (rather than CHP) if a building cannot connect to local existing or planned heat networks.

The **London Environment Strategy** 2018 (LES) is an integrated environmental strategy for London, commissioned by the Mayor of London. It states that although predominantly gas-based CHP engines have been used in new developments across London, the carbon savings from these systems is declining as a result of the national grid electricity decarbonisation. This increasing evidence of adverse air quality impacts from CHP systems has led the Mayor to recognise the need for alternative approaches.

Figure 3.3: Fuel carbon intensities as per SAP 2012 and SAP 10

10 Royal Borough of Kingston Upon Thames, 2009. An Energy Strategy for Kingston: Annex 1 to Appendix B. Available at: <https://www.kingston.gov.uk/info/200284/energy_climate_change_and_sustainability/799/our_energy_strategy>

11 Royal Borough of Kingston Upon Thames 2010, Low Carbon Management Plan. Available at: <https://www.kingston.gov.uk/info/200284/energy_climate_change_and_sustainability/799/our_energy_strategy/2>

12 Royal Borough of Kingston Upon Thames, 2013. RBK Energy Strategy Implementation Plan Year 5 2013/14. Available at: <file:///C:/Users/ihammond/Downloads/Energy_Strategy_5th_IP_v5_2013.09.04%20(1).pdf>

3.4 OVERVIEW OF DISTRICT HEATING

3.4.1 INTRODUCTION TO DISTRICT HEATING

In a district heating network, buildings of adequate heat load are served with hot water in a pipe network from a centralised energy centre generating heat (and often power).

Where the demand density of heating is low, for example in a small village, an individual building approach tends to be most suitable for heating (such as individual gas boilers running a conventional wet central heating system, or small electric point heaters). Where demand density is high, district heating can work better, reducing costs and enabling technologies with lower CO_2 emissions to be connected (such as gas CHP).

District heating infrastructure enables a wide spectrum of opportunity for low carbon heat, by facilitating the ability to change future heat sources without modifying building design. It allows the integration of larger heat sources that require a minimum number of heat customers to be cost effective. District heating can provide cost effective and technically feasible means of achieving significant CO_2 emissions savings for a large urban development. However, care is needed to optimise the commercial and technical aspects of the network to ensure a competitive and sustainable heat price, minimise losses and maximise efficiency.

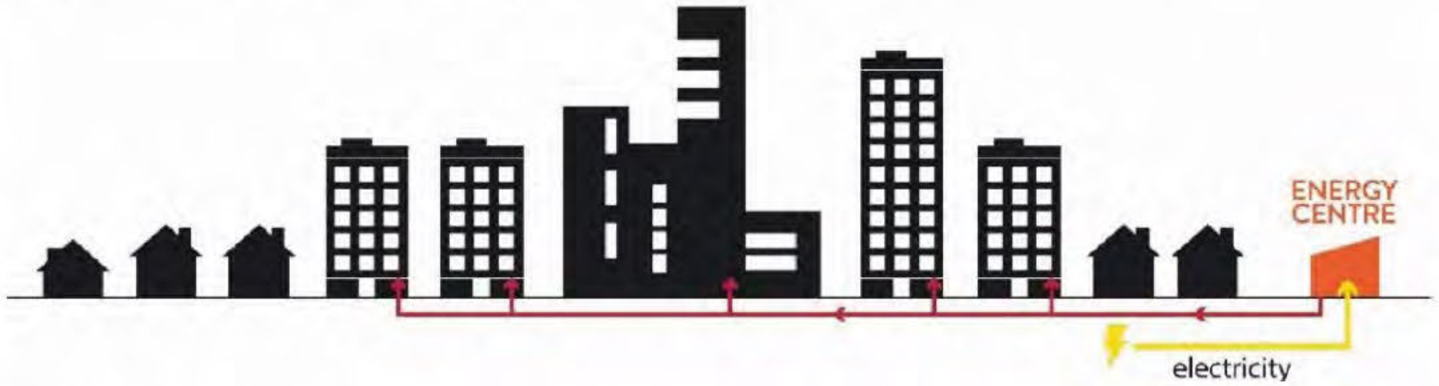


Figure 3.4: District Heating Network in principle

Figure 3.5: Left, example Gas Combined Heat and Power (CHP) engine commonly used in energy centres (Edina). Right, district heating flow and return pipe trench (Enviropipe)

Figure 3.6 overleaf shows a typical district heating trench cross-section with additional detail about the variation of trench width depending on diameter of pipe installed. The width of trench can be greater than 2m, with space needed for welding either side and therefore suitable consideration of existing constraints is required prior to installation (such as traffic management and utility congestion). Smaller pipe sizes may be able to use a twin pipe solution which encompasses the flow and return pipes within one insulated casing – reducing heat losses, trench width and cost of installation.

The deployment of DHN requires a heat network operator. Where networks are to be retrospectively developed (i.e. connecting to existing developments), the respective governing bodies can play a valuable role in de-risking a project and use publicly owned assets to form an initial cluster base.

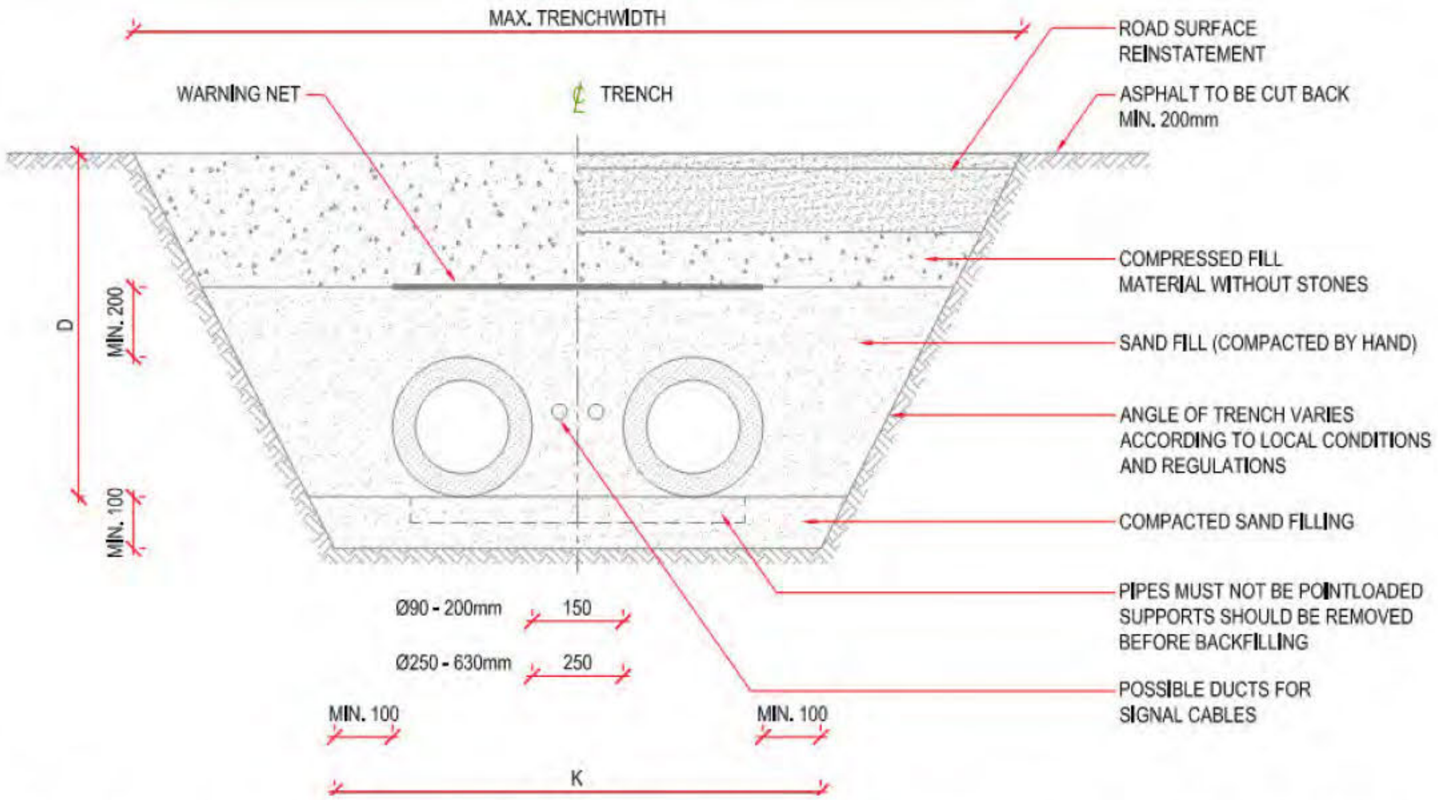


Figure 3.6: District heating buried pipework typical cross-section – the width "k" shown on the figure can vary between ~0.3 to 2m depending on diameter of pipe installed.

3.4.2 5TH GENERATION DISTRICT HEATING (5GDH)

District heat networks have evolved over time as the technology and practical experience has grown. Below is a summary of 3rd – 5th generation district heating (GDH) topologies:

- 3GDH – traditional DH topology with heat only being supplied from an energy centre at ~70/40°C. Any cooling is supplied through a separate system
- 4GDH – traditional DH topology with heat only being supplied from an energy centre at ~50/30°C. Any cooling is supplied through a separate system. Becoming the most well-established heat distribution system.
- 5GDH – 2 pipe warm and cool headers ~30/15°C heating only acting as a source/sink for distributed heat pumps to provide both heating & cooling and allowing an interchange between the two. Usually with balancing technology on the spine, including seasonal storage.

The aggregation and interconnection of heat loads can create an opportunity for low carbon technologies to be deployed at scale to share benefits and generate revenue.

A well-established heat distribution system, DHN is currently evolving to what is known as "4th Generation District Heating" (4GDH). This represents the development and integration of[13]:

- Low-energy space heating, cooling and hot water systems
- A supportive institutional framework for suitable planning, cost and motivation structures
- Waste heat recycling and integration of renewable heat
- Smart thermal grids for low temperature networks
- Integrated operation of smart energy systems including 4th Generation District Cooling systems.

Buildings using 5GDH require high levels of insulation or larger heat emitters (such as underfloor heating) to operate with heating temperatures of 45°C. This temperature allows water source active cooling to reject heat straight back into the network, thus improving efficiency. Due to the low network temperature, DHW boosters are required in the dwellings. Figure 3.7 shows the 5GDH network topology compared to the previous generations, where heat and coolth is shared between buildings on the network. 5GDH therefore typically works best where simultaneous heating and cooling occur e.g. retail spaces typically have year round cooling whilst residential have year round hot water demand. Figure 3.8 provides an illustration of the concept of 4GDH in comparison to the previous two generations.

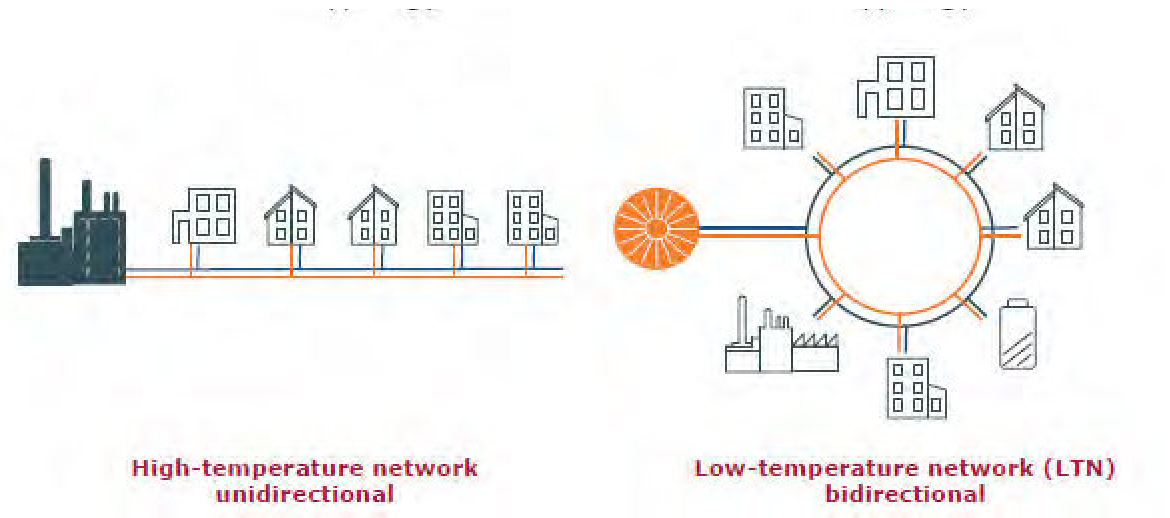
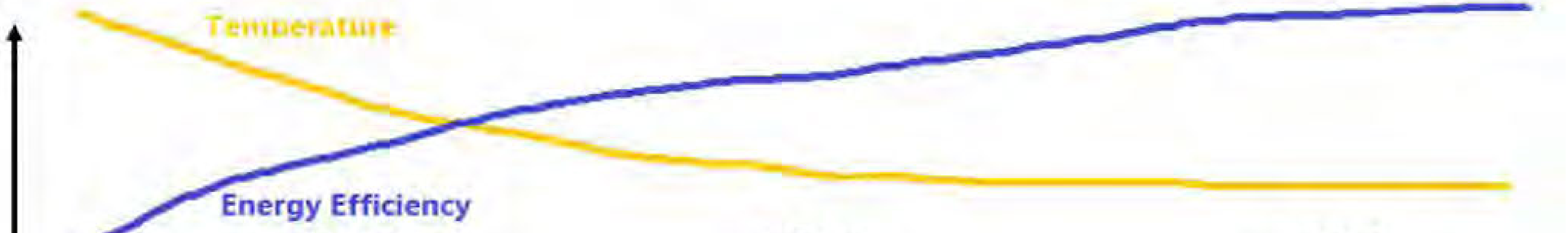


Figure 3.7: Example of different DHN architectures[14]

13 4th Generation District Heating (4GDH) – Integrating smart thermal grids into future sustainable energy systems. Lund et al, February 2014

14 Nadege Vetterli (2017). Insitute of Building Technology and Energy, Luncerne University of Applied Sciences and Arts.



	3GDH	4GDH	5GDH
Topology	Standard – single EC supply heat outwards	Standard – single EC supply heat outwards	New – decentralised plant supplying spine
Temps	Supply: 60-70˚C Return: 40-50˚C	Supply: 45-55˚C Return: 15-25˚C	Supply: <45˚C Return: 15-25˚C
Pipework	Well insulated pipework (steel)	Well insulated pipework (steel or plastic)	Little to no insulated required (plastic)
Storage	Significant thermal storage	Significant thermal storage	A small amount of short term thermal storage
DHW	Can supply DHW directly	May need booster	Will need booster for DHW
Cooling	Separate system	Separate system	Built in cooling in 2-pipe system
Heat exchange	No exchange of heat between buildings	No exchange of heat between buildings	Interchange of heat and coolth with balancing mechanism
+ve		Reduced operating costs and carbon emissions Lower heat losses Greater plant efficiencies More opportunity for waste/renewable heat	Even lower operating costs and carbon emissions Supplies both heating and cooling Heat recovery between buildings Easier to expand network in future Even lower heat losses in pipes
-ve		Larger pipework and pumping costs Requires DHW boost Less storage density No heat exchange between buildings	Larger pipework but somewhat offset by reduced insulation Larger pumping costs Requires DHW boost

Figure 3.8: Illustration of 5th generation district heating (5GDH) compared to previous two generations

4 METHODOLOGY

4.1 METHODOLOGY OVERVIEW

The methodology of this study follows the development stages summarised in Figure 4.1 below. Refer to Appendix F for full methodology details and data sources.

Figure 4.1: Methodology flow

4.2 DATA SOURCES

4.2.1 RBK SITES DATA

Major heat loads (defined as over 50 units or 5,000m² of GIA) were identified through a combination of data capture methods:

- Data from the previous URS, AECOM and Arup studies. A boiler efficiency of 80% is assumed for all existing buildings. A comparison and gap analysis was carried out with this data. In the event of discrepancies in heat demands between data sources, the most up to date information was used. This was then compared to BuroHappold benchmarks as a sense check
- Planning application trackers from 2015-2018 were provided by RBK and used to identify new developments since the previous Arup study (2015 onwards)
- Updated data was requested from major stakeholders such as Kingston Hospital
- The RBK planning portal was used to identify sites currently in planning process
- Energy Performance Certificates (EPCs) and Display Energy Certificates (DECs) were consulted to provide a sense check to the heat demands in the load schedule and to provide information on sites where unknown (including GIAs, current heat supply technologies, EPC ratings, ownership)

See Appendix F for details the data received to inform the energy master plan.

4.2.2 LOAD SCHEDULE DATA

- **Peak heat demands:** The peak loads per cluster are calculated using benchmarks, with a 0.9 diversity factor applied at the energy centre
- **Annual heat demands:** Data from energy strategies for new developments where available, measured site gas and electricity demand, and data from the previous heat mapping studies were used to estimate annual heat demands across the borough. The annual loads are benchmarked if no load information is known
- **Building heat supplies and fuel source:** Where the heat supply technology for buildings in Kingston was not known (through previous heat mapping studies or consultation with stakeholders), data from the Energy Performance of Buildings Data England and Wales[15] was used
- **GIA:** Gross Internal Floor Areas (GIA) from previous reports were used for existing buildings. Any new buildings and new developments floors areas were taken from a combination of planning applications and energy strategies. Where these were not obtained, the GIA was taken from EPC and DEC certificates
- **OS grid references:** the Latitude and Longitude of each site was converted from postcode data[16].

4.2.3 STAKEHOLDER ENGAGEMENT

A wider variety of stakeholders were contacted in inform this study, including those both internal and external to the council (see Appendix H).

15 https://epc.opendatacommunities.org/docs/guidance#glossary_display
16 Using the tool here: https://gridreferencefinder.com/postcodeBatchConverter/

4.3 LOAD SCHEDULE

A load schedule was developed for each identified heat load within the borough. The load schedule includes existing developments over 50 residential units or 5,000m² GIA. All developments identified in pre-planning are included in the map (i.e. loads smaller than 50 units) as RBK have more control over their energy strategy and therefore have a higher potential to connect into a DHN. This is also true for RBK social housing, where all blocks are mapped. The peak and annual cooling loads were estimated for Kingston Town Centre sites using benchmarks developed from previous BuroHappold projects and industry guidelines.

A description of the benchmarking process and key assumptions made are detailed in Appendix A.

4.4 CLUSTERING APPROACH

4.4.1 DEMAND TIERS

Each development mapped in the borough has been given a tier, based on the criteria set out in Figure 4 2 The tier assigned depends on the building's annual heat demand, typology, ownership and development status. New builds have been more favourably tiered due to RBKs ability to influence energy strategy and their higher probability of connection readiness to a DHN. RBK and other publicly owned buildings have an improved tier compared to privately owned to reflect RBK's influence over refurbishment and plant replacement strategies.

4.4.2 DATA QUALITY AND CONFIDENCE

43The heat load data quality was assessed based on the confidence level system shown in Figure 4.3, to give the reader a more accurate representation of data confidence. Different ranking has been applied based on if the building is a new development or not. There is a higher confidence applied to benchmarked data for new builds because they all have to comply with Part L (as a minimum). Whereas, older properties are more likely to deviate from the benchmarks if they were built before these standards came into effect.

4.4.3 PRIORITISATION CRITERIA

The following criteria was used to assess each identified heat load's priority to DHN connection.

Technical: heat load, typology, heat density, phasing

Financial: ownership, network length, potential for expansion, existing LZC technology

Deliverability: proposed refurbishments, new buildings, timescales for phasing, physical constraints (road and rail).

			Annual Heat Demand (MWh/a)						
New Development (as of 2018)	Building Ownership	Building Typology	Un-known	< 100	100-500	500-1000	1000-2000	2000-5000	5000+
No	Local Government	All typologies	Tier 2	Tier 3	Tier 2	Tier 1	Tier 1	Tier 1	Tier 1
No	Other Public	All typologies	Tier 2	Tier 3	Tier 2	Tier 1	Tier 1	Tier 1	Tier 1
No	Private	All typologies	Tier 3	Tier 3	Tier 3	Tier 2	Tier 1	Tier 1	Tier 1
No	Private	Multi-address buildings	Tier 3	Tier 3	Tier 3	Tier 2	Tier 2	Tier 2	Tier 2
No	Other	Churches	Tier 3	Tier 3	Tier 3	Tier 3	Tier 1	Tier 1	Tier 1
No	Other	Education Facilities	Tier 3	Tier 3	Tier 3	Tier 2	Tier 1	Tier 1	Tier 1
Yes	Private	All typologies	Tier 2	Tier 3	Tier 2	Tier 1	Tier 1	Tier 1	Tier 1
Yes	Private	Private Residential	Tier 2	Tier 3	Tier 2	Tier 2	Tier 1	Tier 1	Tier 1
Yes	Local Government	All typologies	Tier 1	Tier 2	Tier 1	Tier 1	Tier 1	Tier 1	Tier 1
Yes	Other Public	All typologies	Tier 1	Tier 2	Tier 1	Tier 1	Tier 1	Tier 1	Tier 1

Figure 4.2: Heat demand tiering criteria

		Year of Data Collection					
New Development (as of 2018)	Data Source	Unknown	< 2000	2000-2009	2010-2012	2013-2016	2017-2018
Yes	Unknown	CL 4	CL 4	CL 3	CL 3	CL 2	CL 2
Yes	Benchmark	CL 4	CL 4	CL 3	CL 2	CL 2	CL 2
Yes	Request	CL 3	CL 3	CL 2	CL 2	CL 1	CL 1
Yes	RBK	CL 3	CL 3	CL 2	CL 2	CL 1	CL 1
No	Unknown	CL 4	CL 4	CL 4	CL 4	CL 4	CL 4
No	Benchmark	CL 4	CL 4	CL 4	CL 3	CL 3	CL 3
No	Request	CL 4	CL 3	CL 3	CL 3	CL 2	CL 1
No	RBK	CL 4	CL 3	CL 2	CL 2	CL 1	CL 1

Figure 4.3: Data quality confidence levels

5 HEAT SUPPLY

5.1 LOW CARBON TECHNOLOGIES REVIEW

A range of low to zero carbon (LZC) heat supply technologies were reviewed for implementation within RBK. The results are summarised in Table 5.1 with further details provided in Appendix J.

Table 5.1: LZC technology qualitative summary

Technology	Capital costs	Operational costs	Revenue Potential	Maturity of technology	CO_2 abatement potential	District heating precedents	Opportunity appraisal
Gas boiler plant	Very low	Very low	Heat sales only	High	Low	High (for back-up and peak loads)	Yes – as peak or back-up boiler plant
Gas fired CHP	Medium	Low/ medium	Heat and power sales	High	Medium in the short term but reducing as the electricity grid decarbonises	High	No – no longer 'future-proofed' solution due to high relative carbon costs compared to future grid electricity
Biomass	Medium	Medium	Heat Sales and RHI	High	High	High – local fuel source important	No – fuel sources and storage present key issues
Biofuel CHP	High	High – due to O&M	Heat sales and RHI/ CfD	Low – unproven reliability & potential poor electrical efficiency	High	Low	No – high cost and lack of precedents
Air source heat pump (ASHP)	Medium	Medium	Heat Sales and RHI	Medium	Medium in the short term and improving as the grid decarbonises	Few – more suited for use on individual houses	Yes – potentially suited for ECs with limited space for GSHP ground arrays
Ground source heat pump (GSHP) – open loop	High	Medium	Heat Sales and RHI	Medium	Medium in the short term and improving as the grid decarbonises	Medium	Yes – Precedent examples in London but requires detailed ground survey
Ground source heat pump (GSHP) – closed loop	Very high –	Medium	Heat Sales and RHI	High	Medium in the short term and improving as the grid decarbonises	High	Yes – lower risk than open loop in achieving good thermal conductivity but requires large land area for borehole installation
Water source heat pump (WHSP)	Medium	Medium	Heat Sales and RHI	Medium	Medium in the short term and improving as the grid decarbonises	Few – where easily accessible body of water is available	Yes – River Thames runs through town centre, with large potential for heat recovery
Solar thermal systems	Low	Low	Heat sales and RHI	High	High	Few – but good option for individual houses	No – most suitable for smaller schemes
Sewerage heat recovery	High	Medium	Heat Sales and RHI	Low	Medium in the short term and improving as the grid decarbonises	Few –medium term potential with higher temp. heat pump technology	Yes - significant waste heat available from Hogsmill

Figure 5.1 shows carbon factor modelling until the year 2055; the counterfactual option represents individual gas boilers in each home/building. This modelling assumes that CHP electricity is used on-site. It demonstrates how CHP is expected to become a less attractive option in terms of CO_2 emissions than the counterfactual option in the year 2032.

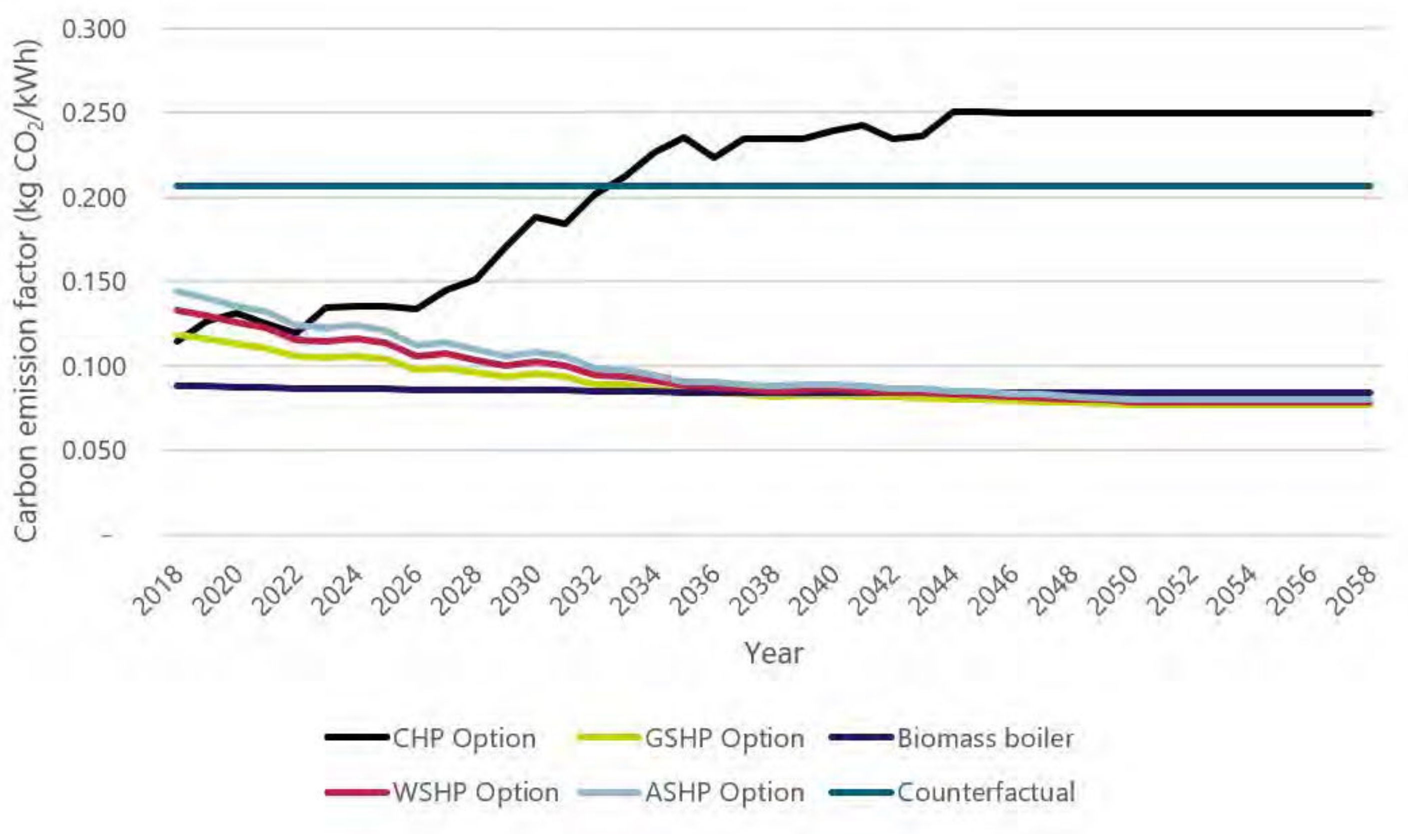


Figure 5.1: Carbon factor model to 2055 based on typical efficiencies and using BEIS projected carbon factors

Figure 5.2 shows the levelised cost of heat for a range of LZC technologies compared to the counterfactual case of individual gas boilers (assuming no RHI payments), showing that GSHPs, WSHP and gas CHP can have a lower lifetime levelised cost of heat compared to individual gas boilers. Gas CHP (with spill to grid electricity sales at indexed BEIS wholesale electricity prices) achieves the lowest LCOH. However, due to its higher carbon emission factors (Figure 5.1) and changes to SAP figures, DHN schemes powered by CHP are unlikely to meet the carbon targets set out in the New London Plan. This follows the recommendations in the London Environment Strategy which state that gas-fired CHP engines are having adverse air quality impacts, with the Mayor recognising the need for alternative approaches.

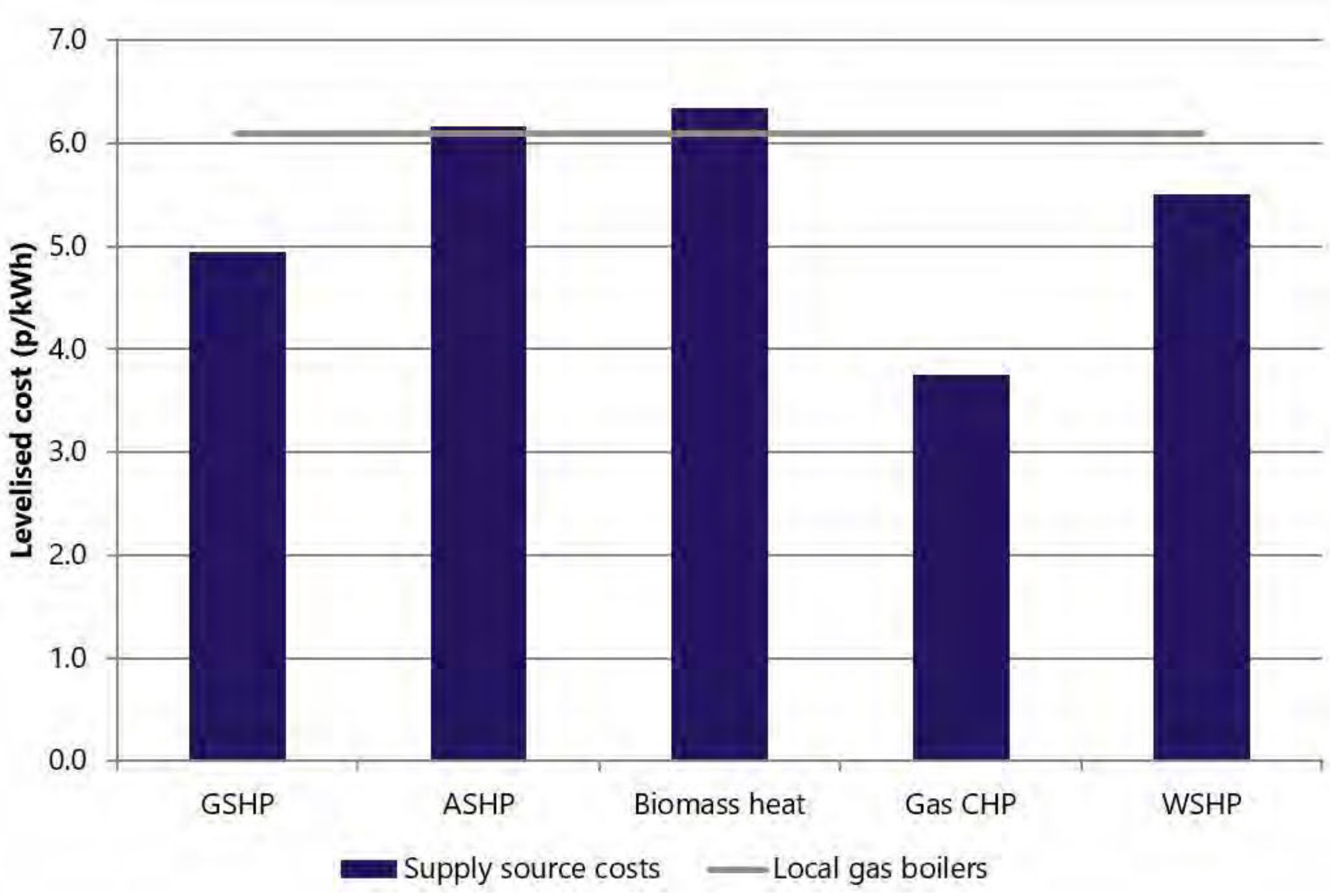


Figure 5.2: Levelised cost of heat

5.2 SECONDARY HEAT SUPPLY

5.2.1 RIVER THAMES

Figure 5.6 indicates that the River Thames has amongst the highest annual heat production density in England, of over 10,000GWh/yr. Kingston Town Centre is ideally located on the river to access this large source of secondary heat. Initial calculations suggest that 164MW of heat could be available from the river, assuming a volumetric flow rate of 65.4m^3/s [17] (with 10% of flow abstracted to the heat pump and a 5°C ΔT).

Previous work BuroHappold have completed on the DECC (now BEIS) Water Source Heat Map suggests that the maximum allowable heat pump size per site is 20MW, with a minimum space of 1,000m between each site to ensure COPs are not effected by upstream heat pumps. The WSHP at Kingston Heights is approximately 740m from Eagle Brewery Wharf however the heat pump size is only 2.3MW. Consultation with the Environment Agency and Kingston Heights is recommended at future project phase to ensure compliance with standards and best practice.

Using these as constraints, the maximum allowable heat available for delivery in the KTC area is 61GWh/yr (assuming only one 20MW WSHP within the 2000m stretch of river within KTC. A 35% heat pump annual availability for times of year when the ΔT is below 5°C, flow rate is above heat pump capacity and equipment is down for maintenance).

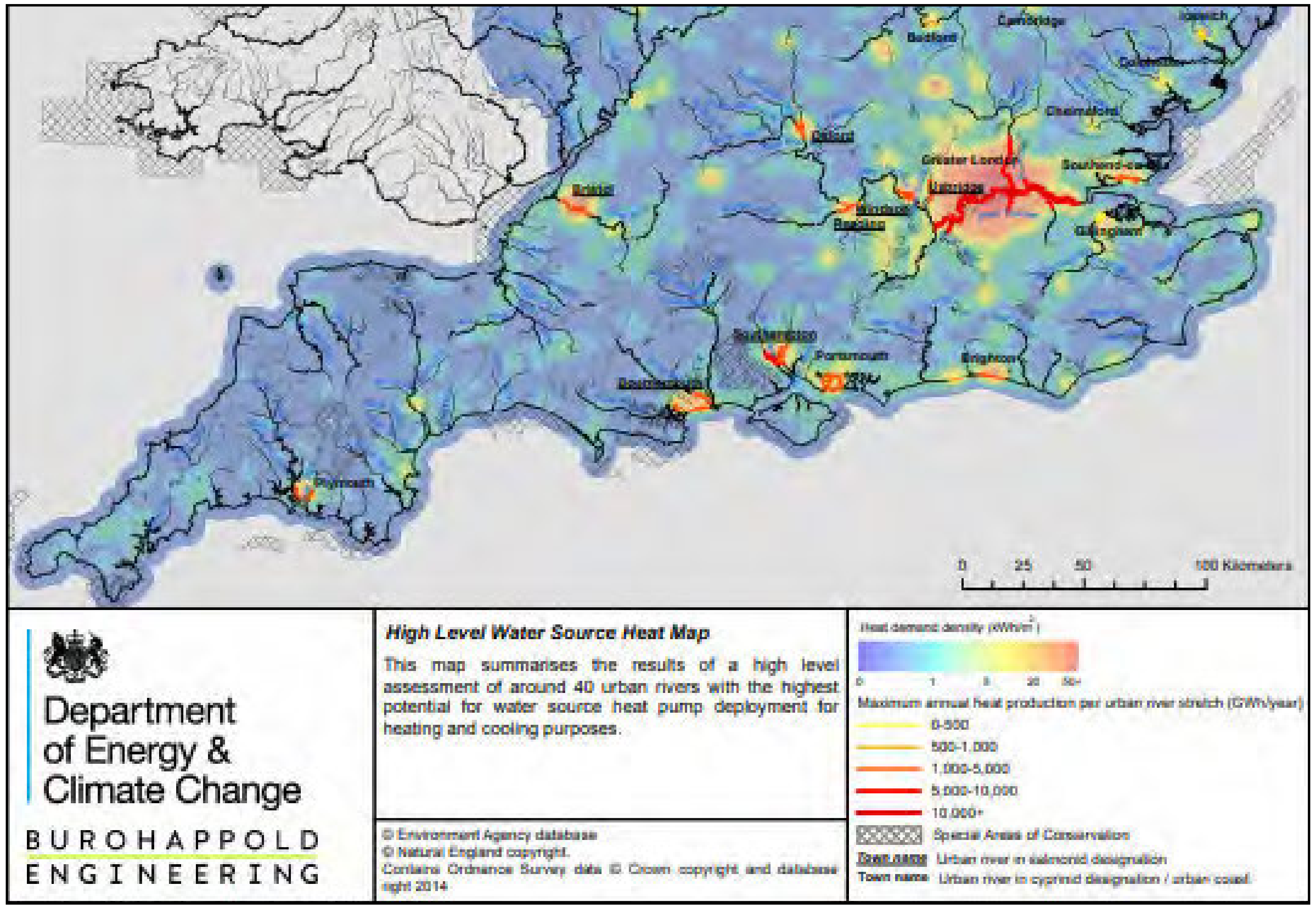


Figure 5.3: Water source heat map[18]

17 NFRA, 2018. Mean flow rate at Teddington weir from 1883 to 2017. Available at: <https://nrfa.ceh.ac.uk/data/station/meanflow/39001>
18 https://www.gov.uk/government/publications/water-source-heat-map

5.2.2 GROUND CONDITIONS

The performance and selection of an open or closed loop ground source heat pump (GSHP) system depends on the local geological conditions. The sub-surface temperatures down to 100-200m, thermal conductivity and diffusivities of the soil and rock layers, groundwater levels and aquifer properties are all important factors. Rock type is also a key factor in determining drilling costs.

A review of British Geology Survey (BGS) hydrogeology and borehole data shows that Kingston sits within The London Clay area[19] with access to the chalk aquifer, which is favourable for open loop GSHP if sufficient flow rates can be achieved. Several boreholes within KTC have been analysed, suggesting that the chalk aquifer is reached at approximately 100-200m below the surface[20]. Borehole data from 1911 Hodson's Brewery (at current Eagle Brewery Wharf site) suggests the chalk contains an active aquifer, as the water initially overflowed at an estimated 2.3l/s[21]. There are many examples of both open-loop GSHP schemes in London that utilise heat from the chalk aquifer and closed-loop systems within the London Clay. A full site investigation is recommended; however it is thought that both open and closed loop GSHP systems may be feasible in Kingston.

5.2.3 KINGSTON CREMATORIUM

BuroHappold have also consulted with stakeholders at Kingston Crematorium to estimate the potential of supplying the district heat network with waste heat. The crematorium currently carry out up to 1,100 cremations per year in two parallel cremators. Assuming an average heat output of 280kW per 75 minute cremation, an average cremation can deliver approximately 350kWh. At the crematoriums current rate, this equates to 385MWh/yr. Assuming the crematorium operates continuously 8 hours a day for 250 days of the year[22], this has an estimated average output of 193kW throughout the year.

The crematorium is currently planning an upgrade in order to meet legal requirements regarding mercury abatement (due to start in 2019). At the same time they are looking at cooling options so that they can store bodies to carry out cremations in one block to maximise efficiencies. This also provides an opportunity to change their Business Model to becoming more commercial e.g. more direct cremations, which could potentially lead to running 24/7 – this could significantly increase the available heat load. The addition of chillers also increases the recoverable waste heat potential of the site.

As part of the works they plan to recover heat to heat the building itself. BuroHappold have provided advice to include some wording to futureproof the development to potentially serve the wider area:

- Providing a hydraulic arrangement and space allowance to futureproof for heat recovery to be shared offsite, via a heat exchanger, to a future heat network
- Consider any further heat recovery opportunities (e.g. from chiller systems) and provision in future proofed arrangements
- Provide details of average heat recovery potential per cremation.

The crematorium is pictured in Figure 5.5; the proximity of the crematorium to the Cambridge Road Estate and timing of the proposed works both at CRE and the crematorium provides an opportunity to recover heat to serve the development.

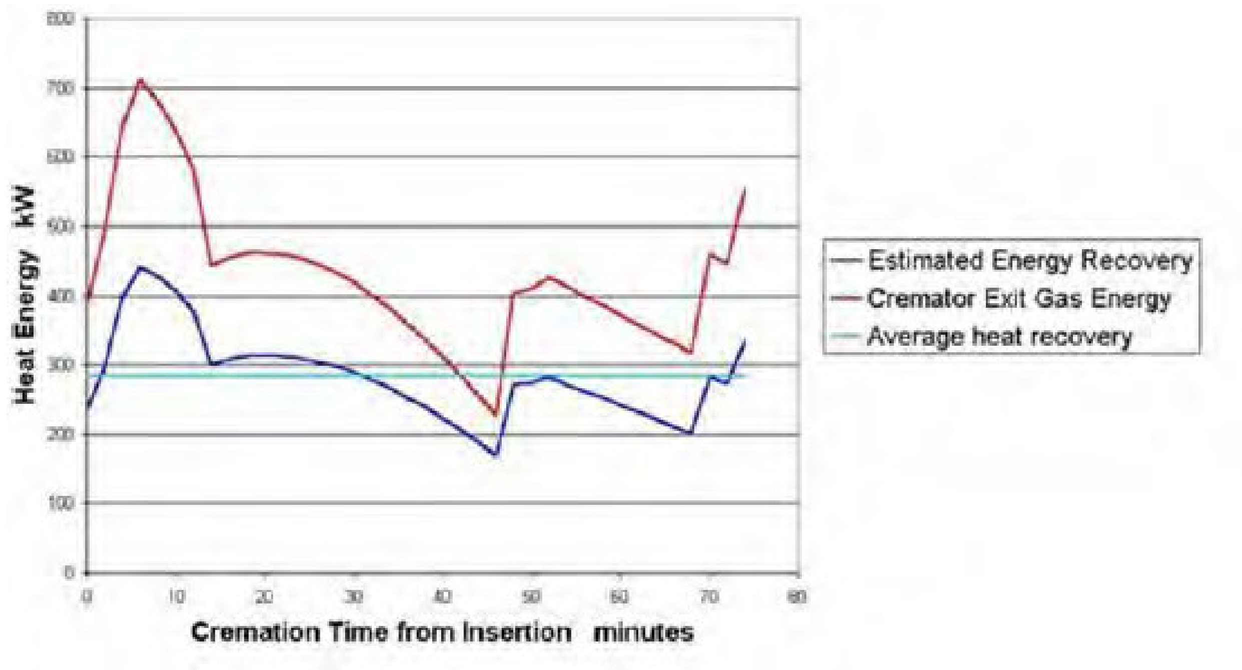


Figure 5.4: Crematorium heat output[23]

Figure 5.5: Kingston Crematorium

19 Bristish Geological Survey materials (201). Available at :<https://www.bgs.ac.uk/products/hydrogeology/maps.html> under the Open Government License
20 http://mapapps.bgs.ac.uk/geologyofbritain/home.html?
21 http://scans.bgs.ac.uk/sobi_scans/boreholes/579954/images/12199176.html
22 https://moderngovwebpublic.redditchbc.gov.uk/documents/g547/Public%20reports%20pack%2007th-Feb-2011%20Council.pdf?T=10

23 Facultatieve Technologies (2017)

5.2.4 HOGSMILL SEWAGE TREATMENT WORKS

The AECOM 2013 study assessed the potential energy supply from Hogsmill Sewage Treatment Works CHP unit. They concluded that the 0.94MWe CHP operating from the biogas produced at the treatment works is the only source of heat on the site. This small heat supply is used on site to power the plant and maintain the temperature in the digester units. Converting the sewage water outfall into high-grade heat through a heat pump is mentioned in AECOM report. Referencing the GLA's Secondary Heat Study, HSTW has an estimated 5,001+ MWh of heat available. AECOM state this is likely to be significantly higher; in the order of 10s or 100s of GWh.

The preference for Thames Water is to use final effluent from the treatment works and from their experience the incoming sewage water only experiences a small loss of temperature over the treatment process so is still likely to be more reliable/better temperatures than the ground or river. A schematic of the treatment process is shown in Figure 5.6. There are currently no restrictions on the minimum temperature of effluent to the river set by the Environment Agency, only a maximum, therefore a ΔT of 7K may be reasonable to assume. This could be a significant resource for any heat network.

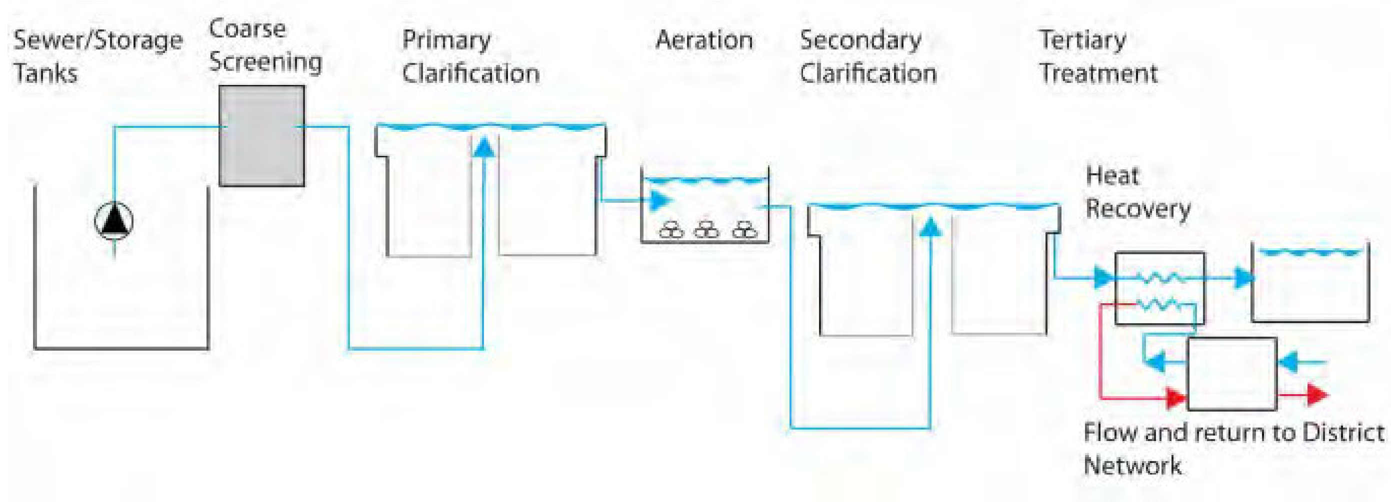


Figure 5.6: Water treatment works effluent treatment process (AECOM Energy Masterplan)

5.3 ENERGY CENTRE (EC) SIZING

5.3.1 EC CAPACITY SIZING

EC sizing was carried out to obtain the low or zero carbon (LZC) technology capacity per cluster. Analysis was based on the peak load per cluster and half-hourly load profiles per building typology. The assumptions are detailed in Appendix F.

Figure 5.7 shows the resulting annotated heat load duration curve for Cambridge Road Estate. Boilers are sized to meet the diversified peak load of the whole cluster in case of LZC technology failure. Under normal operation, the gas boilers will only run at the peak time slice. Excess heat generated by the LZC plant at low demand times can be stored in the thermal stores and used at peak times.

5.3.2 EC FLOOR AREA SIZING

The required floor area for each cluster EC was estimated based on the type and capacity of LZC installed. The footprint sizes are obtained from manufacture quotes and previous BuroHappold projects. The number of each unit required was estimated using the method described above. The total calculated area was multiplied by two to allow for maintenance access to equipment and future expansion. The resulting energy centre sizes are shown in Appendix F.

An example of the resulting EC floor plan for the Cambridge Road Estate (CRE) cluster identified later in this study is shown in Figure 5.8.

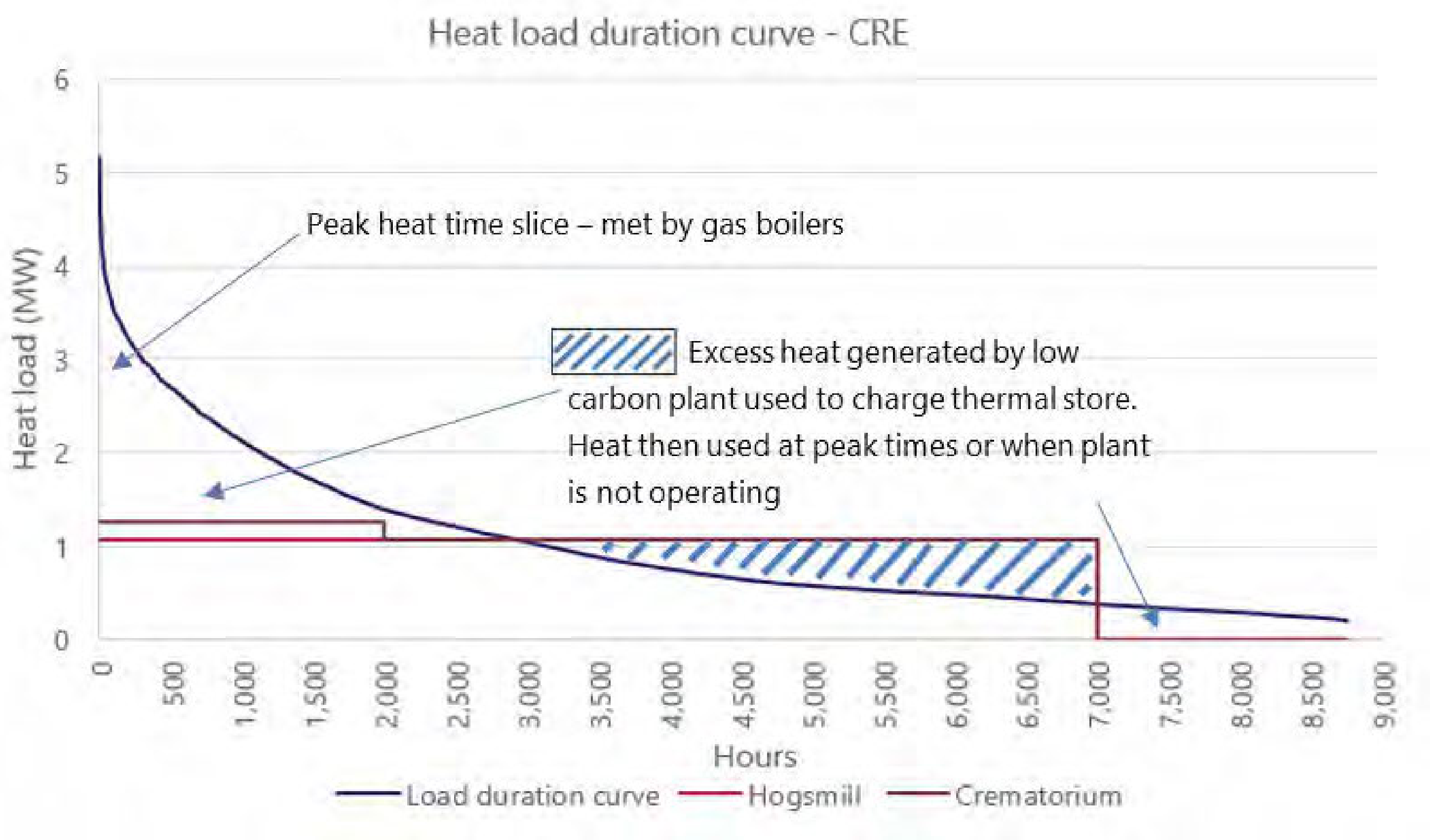


Figure 5.7: Annotated heat load duration curve

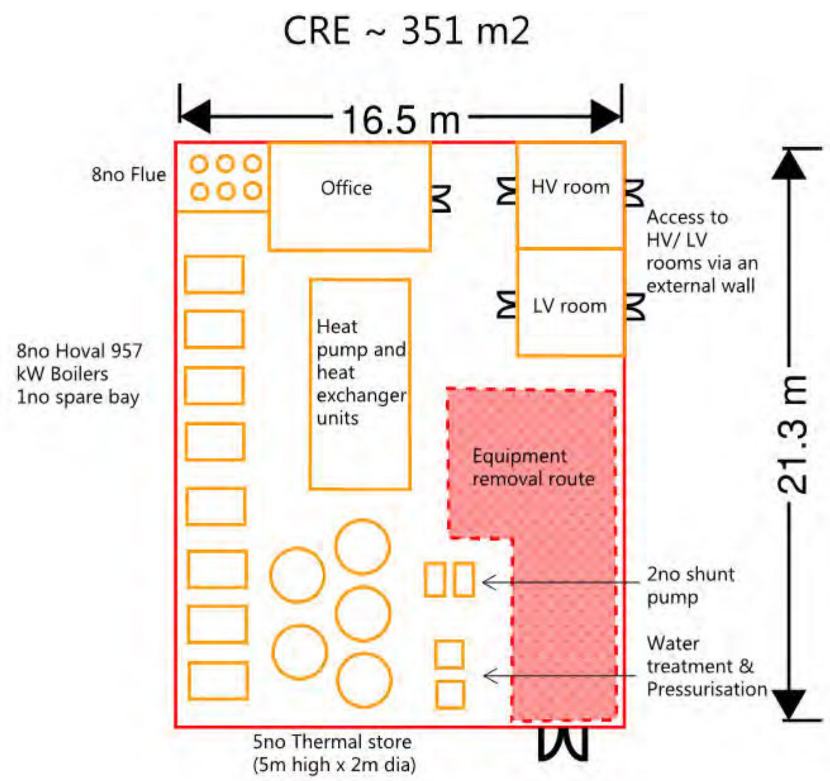


Figure 5.8: Cambridge Road Estate cluster indicative EC floorplan for heat network

Chessington individual GSHP sizing

- No energy centre is required for this cluster in the individual heat pump scenario.
- Instead, a small heat pump (560x606x565mm) based on the Kensa 6kW Shoebox range and a hot water cylinder (150 litre) are installed in each flat.
- These can typically be stored in an existing airing cupboard as illustrated here.

Figure 5.9: Kensa Shoebox individual GSHP installation[24]

24 https://www.kensaheatpumps.com/ground-source-review-flagship-group/

6 HEAT MAPPING AND CLUSTER SELECTION

6.1 HEAT MAPPING

The heat map of the overall borough is show in the figure below which was used to select clusters.

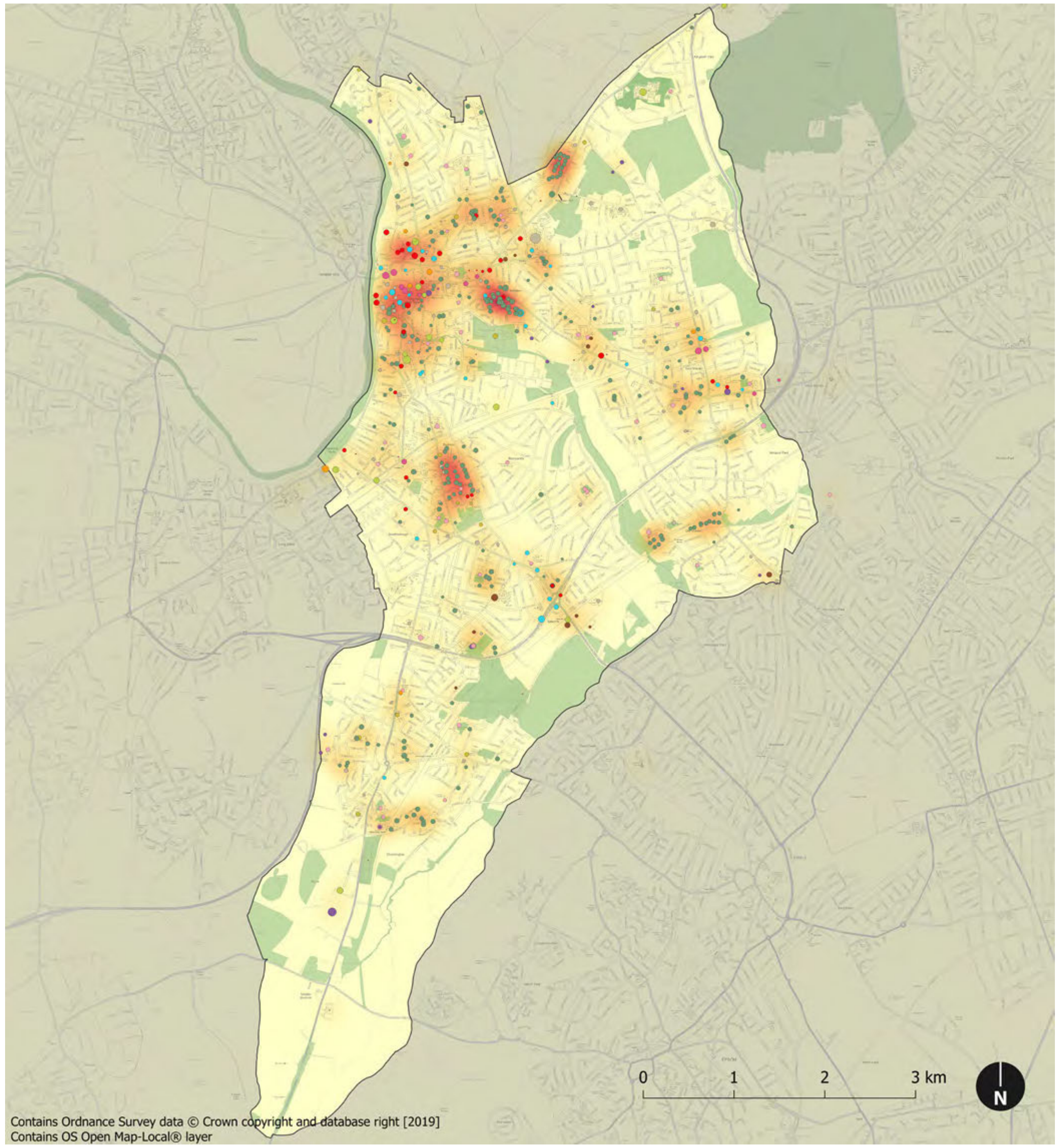


Figure 6.1: Heat map of the borough (all loads)

6.2 CLUSTERS SUMMARY

The heat mapping method identified eight potential areas for DHN development as shown in Figure 6.2. This includes Tier 1 and 2 loads only, with each cluster identified. The following section gives an overview of initial high level analysis of each of the seven identified cluster areas to provide a quantitative basis for selecting which of these have the highest potential for district heat network development in RBK.

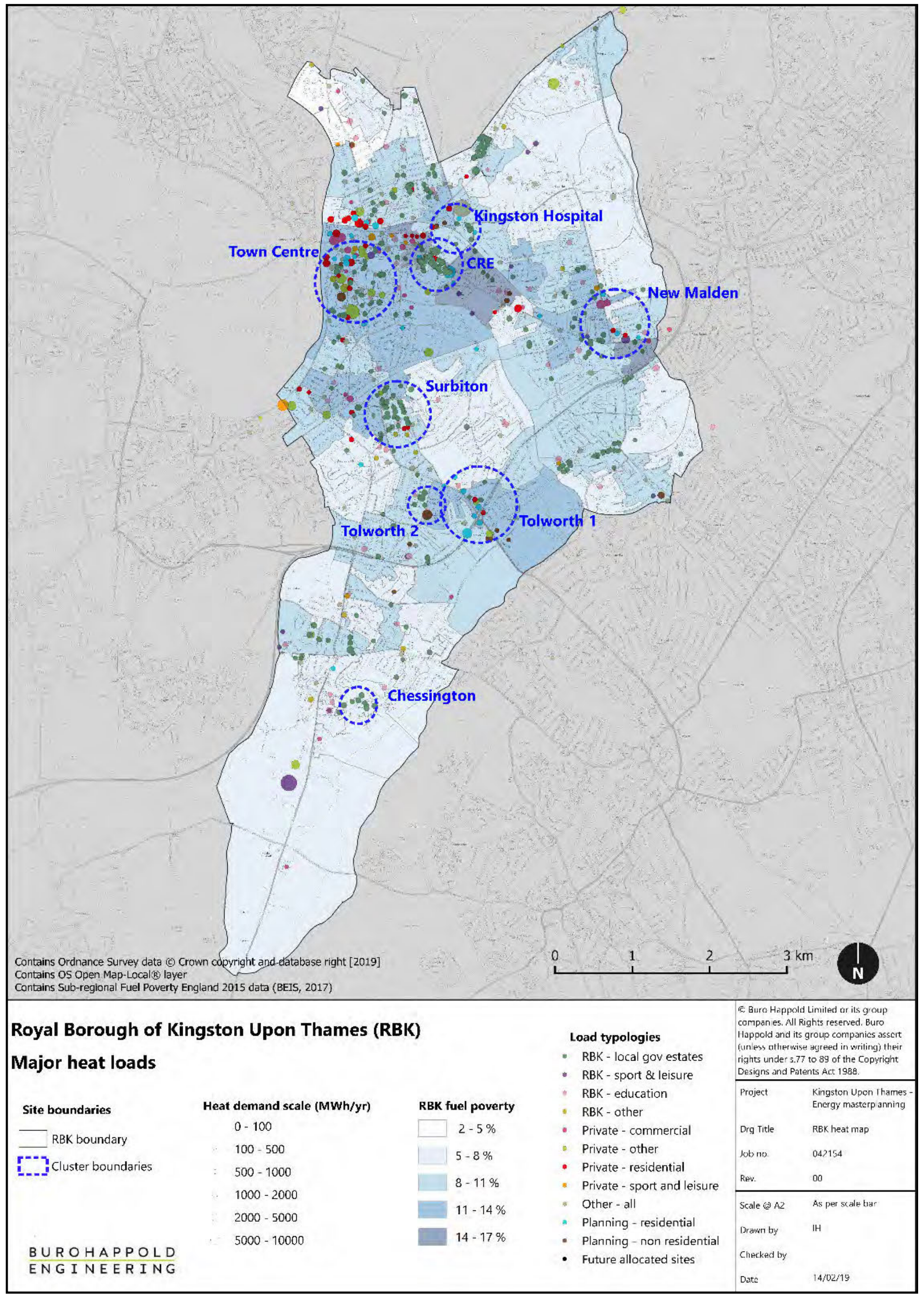


Figure 6.2: RBK heat map (tier 1 & 2 loads only)

Cluster Overview

Cambridge Road Estate (CRE)

- The CRE cluster has a modest line density of 6.3MWh/m, however the majority of the heat demand is RBK owned (89%), with 90% of this categorised as Tier 1
- The upcoming redevelopment of the CRE (~2000 units) provides a good opportunity to develop a DHN that can utilise waste heat from the nearby Hogsmill Sewage Treatment works and the crematorium and serve the wider area with low carbon heat

Kingston Hospital

- The Kingston Hospital cluster has a high DHN demand of 25.4GWh/yr. The cluster is likely to have a low cost per kWh delivered heat, as it has an estimated line density of 15.9MWh/m however Kingston Hospital provides 90% of this demand, therefore any DHN developed at the hospital would mostly be used onsite.
- The Hospital are proposing a new energy centre and are interested in serving the wider area with heat. The proximity of the CRE cluster and Town Centre mean it could support growth of a larger strategic network.

New Malden

- Both Phase 1 and 2 clusters have low line densities of 3.8 and 4.4 MWh/m, respectively. There is also a very low proportion of future heat in the area
- Cock's Crescent however has been identified as a key area for residential expansion to meet RBK population growth and there are a number of new developments planned in the area. The catalyst for the proposed DHN is likely to be the redevelopment and expansion of The Malden Centre, although timing is currently unknown.
- Phase 2 is not currently considered feasible due to the large disruption to the high street

Tolworth 1 East

- Tolworth 1 East has a high line density (8.5MWh/m) and percentage of tier 1 heat load (96%). However, the majority of this heat load is future demand (78%) which has either already obtained planning permission or is a future development
- Unlike the other clusters, Tolworth includes multiple large developments which are yet to attract any developers. As such, there is a high risk involved in developing a DHN in this area because the heat load is not guaranteed and the timeframes for development are unknown
- Meyer Homes and Lidl Headquarters, although granted planning approval, should be contacted to consider alternative technology and futureproofing of their energy centre for expansion in the future.

Tolworth 1 - West

- Tolworth 1 West has a lower line density (2.9MWh/yr) and a third of the annual heat demand compared to Tolworth 1 East. It also has no Tier 1 heat loads
- The introduction of Crossrail 2 (currently scheduled for completion on 2030s) could increase the heat demand of the Tolworth area in the future
- The Tolworth Tower redevelopment into residential blocks will increase the heat load to the area, however there are not currently any other large heat loads in the area to act as an anchor load. It is suggested that space is set aside in the Tolworth Tower energy centre so that a DHN can be development and housed there in the future, if more heat load reaches the area

Tolworth 2

- The Tolworth 2 cluster is a relatively small DHN scheme of 5,140MWh. However, it has a good line density (8.0MWh/m) and is 95% tier 1 loads
- The Tolworth Hospital refurbishment and installation of a site-wide heat network provides a good opportunity to expand the network to serve the wider community
- The RBK owned School Lane blocks provide a good heat density for this connection if they can be retrofitted to connect to a DHN

Surbiton and Chessington

- The Surbiton and Chessington clusters have relatively low heat line densities of 3.6MWh/m and 3.1MWh/m, respectively. The proposed routes would connect to only RBK owned housing assets, providing a low carbon heat scheme that could be replicated in other areas of the borough in the future
- The Chessington cluster is too small to qualify for HNIP funding. However, there are other revenue streams available such as ECO and MEEF
- The majority of housing in these clusters is socially rented by RBK, with a small proportion in each block privately owned/rented

KTC

- Kingston Town Centre (KTC) clusters were split into two phases. Both Phase 1 and 2 have good heat line densities of 10.4MWh/m and 8.5MWh/m respectively.
- Phase 1 connects the commercial loads within the town centre, over which RBK have high leverage than private residential developments.
- Phase 2 exents the network into the Eden Quarter new developments.
- A WSHP using secondary heat from the River Thames is suggested. However, this is highly dependent on procuring a suitable EC site near the river in the town centre.

Overall we propose to take the following clusters forward for economic assessment:

- CRE
- Kingston Hospital
- New Malden - phase 1
- Tolworth 2
- Surbiton
- Chessington
- KTC Phase 1
- KTC Phase 1 & 2.

Tolworth 1 and New Malden Phase 2 are proposed to be excluded. The Tolworth 1 West overall heat loads are low and are uncertain as they are mostly site allocation stage only, leaving little guarantee of sufficient heat load in the area. The Tolworth 1 East has a higher heat load however the majority of the load in this area has already been granted planning permission – engagement with Meyer Homes and Lidl is still recommended to establish interest in serving future properties in the area and future proofing within their energy centres.

New Malden Phase 2 would require ground works on the high street and in front of the train station. It is not thought the additional loads will warrant such extensive disruption to the local community.

Key metrics from the cluster analysis are presented in Table 6.1.

Table 6.1: Cluster summary table

Cluster name	Total heat demand (MWh)	Route line length (m)	Line density (MWh/m)	% RBK owned heat	% future to existing heat	% tier 1 heat demand	Peak heat load (kW)
CRE	8,790	1,400	6.3	89%	66%	90%	7,170
Kingston Hospital	25,340	1,590	15.9	4%	3%	91%	8,490
New Malden - phase 1	4,310	1,140	3.8	83%	7%	47%	2,385
New Malden - phase 2	8,440	1,930	4.4	43%	11%	73%	3,745
Tolworth 1 -east	6,500	760	8.5	0%	78%	96%	5,570
Tolworth 1 - west	2,480	850	2.9	7%	56%	0%	2,660
Tolworth 2	5,140	640	8.0	39%	61%	95%	1,980
Surbiton	5,360	1,500	3.6	100%	0%	29%	2,483
Chessington	990	324	3.1	100%	0%	0%	400
KTC Phase 1	17,440	1,670	10.4	22%	14%	94%	5,770
KTC Phase 1 & 2	24,670	2,890	8.5	27%	19%	92%	12,110

6.3 CLUSTER OVERVIEWS

6.3.1 CAMBRIDGE ROAD ESTATE

Summary

The Cambridge Road Estate (CRE) is a large RBK owned housing estate, located near the secondary heat supply sources of Hogsmill Sewage Treatment Works and Kingston Crematorium. With construction on the site's extensive redevelopment due to start in 2021, the CRE presents an exciting opportunity to implement a DNH that utilises waste heat in the borough. Future phasing could connect Kingston Hospital and the town centre into a single large network.

Overview

Figure 6.3 shows the possible connection route for the CRE cluster. As the detailed site layout is yet to be developed, the CRE has been condensed into 4 connection points; whose sum equates to the total estimated heat demand for the proposed site. The heat supply pipes from the crematorium and Hogsmill Sewage Treatment Works have been excluded from the line density calculations.

Table 6.2: CRE cluster performance metrics

Metric	Unit	Value
Heat demand	MWh/yr	8,790
Network length	m	1,400
Heat line density	MWh/m	6.3
Peak load	kW	7,170
Percentage of heat load RBK owned	%	89
Percentage of heat load future	%	66
Percentage of heat load Tier 1	%	90
Energy centre technology	-	Secondary heat (Crematorium and Hogsmill) with heat pumps and gas boiler backup

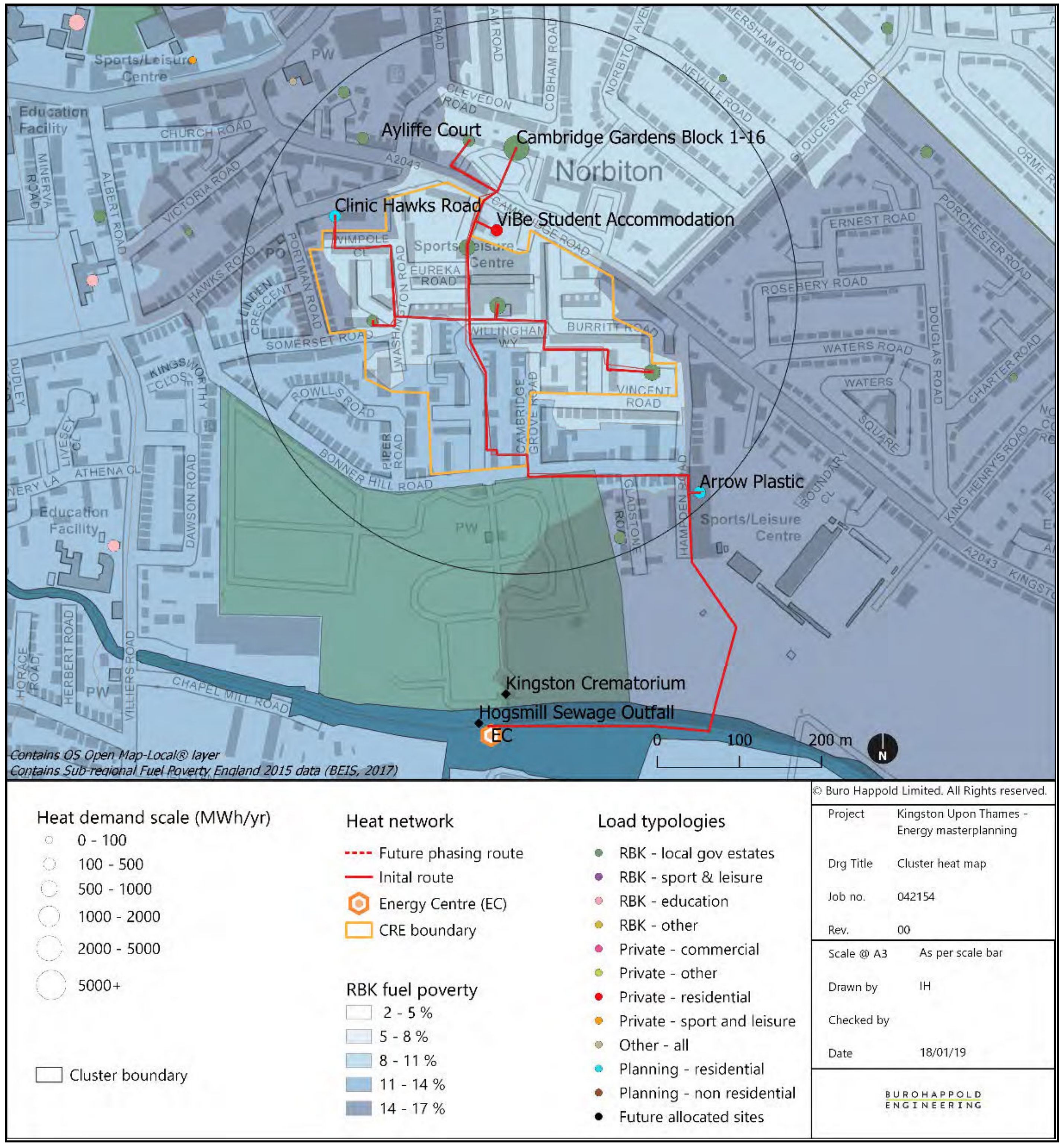


Figure 6.3: CRE cluster map

Description

Table 6.3: CRE cluster heat loads

Site	Description	Heat supply	Heat Load (MWh/yr)	Tier	Confidence Level	Ownership	Status	No. units/ GIA (m²)
CRE	Redevelopment of existing RBK housing estate	Not yet specified	5,340	1	2	RBK	Pre-Planning	2,000 units
Cambridge Gardens and Ayliffe Court	Existing RBK owned housing	Individual gas boilers	2,500	1	3	RBK	Existing	180 units
Arrow Plastic – Hampden road	Proposed new residential development	Individual gas boilers	220	2	2	Private	Pre-Planning	81 units
ViBe Student Accommodation	Existing student accommodation	CHP	480	3	3	Private	Existing	272 units
NHS Clinic on Hawks Road	Proposed redevelopment with residential units above clinic	Unknown	250	1	2	NHS	Pre-Planning	99 units & 800m² clinic

The individual sites are summarised in Table 6.3. The Cambridge Road Estate (CRE), is the largest concentration of RBK owned housing in the borough. In October 2018, Countryside Properties (UK) Ltd were selected by RBK as the preferred development partner for the CRE regeneration. Over the next 10-12 years, a total of ~2,000 homes will be built within the estate[25]. Submission of planning applications is expected in late 2019, with work starting on site in early 2021[26]. This timely redevelopment presents a good opportunity for RBK to introduce a wider district heat network into the borough, with CRE acting as a key anchor load, providing over half of the total annual heat load in the cluster.

There are several developments surrounding CRE connected to the heat network. This includes the proposed developments Hampden Road and Hawks Road as well as the recently completed (Sept 2017) ViBe student accommodation block to the north of CRE boundary, currently heated with a CHP system. On the opposite side of Cambridge Road there are RBK owned housing blocks, Cambridge Gardens and Ayliffe Court, both believed to be individually heated.

The site is situated to the North of Kingston Crematorium and the Thames Water owned Hogsmill Sewage Treatment works. Both sites have been identified as potential sources of secondary heat for the cluster.

Energy centre location and technology

Due to the availability of waste heat sources, a heat pump solution supplied by secondary heat for the Hogsmill Outfall is recommended. The energy centre is proposed to be located on the Thames Water site, near the Hogsmill outfall, as there is a large area of un-used land.

Locating the energy centre here means that high temperature flow pipe is required to transport heat to the CRE cluster over a direct distance of approximately 300m. However, as this would require significant disruption to the crematory, it is proposed that the route is extended to around the eastern edge of the crematory on the land bordering the RBK owned Kingsmeadow sports ground (as shown in Figure 6.3). For the crematorium heat to be integrated into the network, an additional pipe route over the river to the energy centre is required.

Opportunities and Constraints

Opportunities

Future heat load - CRE's proximity to other large residential loads (RBK and privately owned) means there is likely to be guaranteed heat load in the future.

Fuel poverty - The area surrounding CRE is amongst the highest fuel poverty dense in the borough (14-17%) and CRE is ranked as the most deprived in Kingston. Developing a DHN could bring significant savings to the local residents.

Waste Heat - Hogsmill Sewage Treatment Works outfall yield as much as 9,000kW of heat, assuming a 7ºC ΔT.

Plannned works on Kingston Crematorium in 2019 proivde an oportunity to utilise an estimated 193kW of high grade waste heat (assuming the crematorium operates continuously 8 hours a day for 250 days of the year).

Future network expansion - The sites proximity to Kingston Hosptial and the town centre means it may be possible to extend the network to these areas in the future.

Constraints

Existing plant replacement cycles - The CRE redevelopment is still in consultation phase. Any new developments in the area will have to invest in interim heat supply technology until the heat network connection becomes available.

DHN connection readiness - The Arrow Plastic development on Hampden Road (as well as any other proposed new builds) need to ensure they are connection ready at the early stage of planning to maximise the viability of the DHN. The current plan to install individual gas boilers will not allow for this and it is recommended that the heating system is reconsidered for communal heating.

River crossing - the Hogsmill outfall is located on the opposite side of the river to CRE. A river crossing ia required to transport the heat to the cluster. Relevant planning permission would be required.

Energy centre location - the energy centre and proposed heat source are on Thames Water land, and area subject to suitable commercial agreements.

25 https://www.kingston.gov.uk/downloads/download/562/cambridge_road_estate_-_shortlisted_options

26 https://www.kingston.gov.uk/info/200155/planning_applications_and_permissions/1325/about_the_cambridge_road_estate_regeneration/4

Initial plant sizing

Initial plant sizing was carried out using the method described in Section 5.3. The thermal store has been sized based on providing 2 hours of the peak low carbon heat supply of each cluster. The results are presented below.

Although the Hogsmill outfall has enough capacity to provide 100% of the CRE cluster's heat load, this would require a large investment in heat pumps that would only be operational for a small percentage of the year (see

Figure 6.4). Therefore, the WSHP has been sized to provide 70% of the clusters heat load. Combined with heat from the crematorium and utilising thermal stores for part of the year, it is estimated that 90% of the clusters heat load can be met from the low carbon supply; with the additional 10% provided by gas boilers.

In this scenario, only 9% of the Hogsmill outfall available heat capacity is being utilised. This shows the large potential to extend the network to the nearby clusters of KTC and Kingston Hospital.

Table 6.4: CRE initial plant sizing results

CRE (8.8GWh/yr, 7.1MW)	Unit	Value
Low carbon heat technology	-	WSHP and crematorium waste heat
Low carbon heat supply capacity	MW	1.07
Thermal store capacity	MWh / litres	2.14 / 67,960
Gas boiler capacity	MW	7.1
% yearly supply from low carbon heat	%	70%

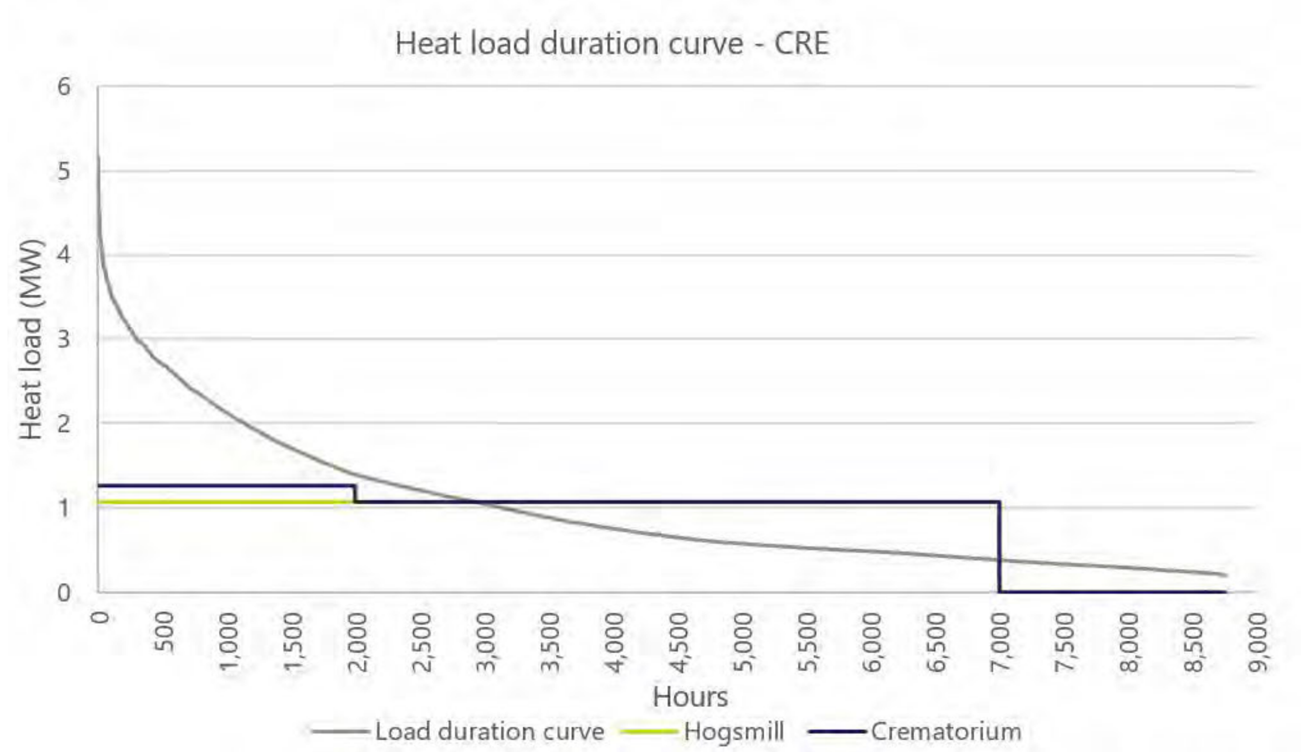


Figure 6.4: CRE heat duration curve

6.3.2 KINGSTON HOSPITAL

Summary

Kingston Hospital's large annual heat load and the plans for a new energy centre provides an opportunity to expand their network to the wider area, where there is significant residential heat load. Proximity to CRE provides opportunity to expand the network in future phasing.

Overview

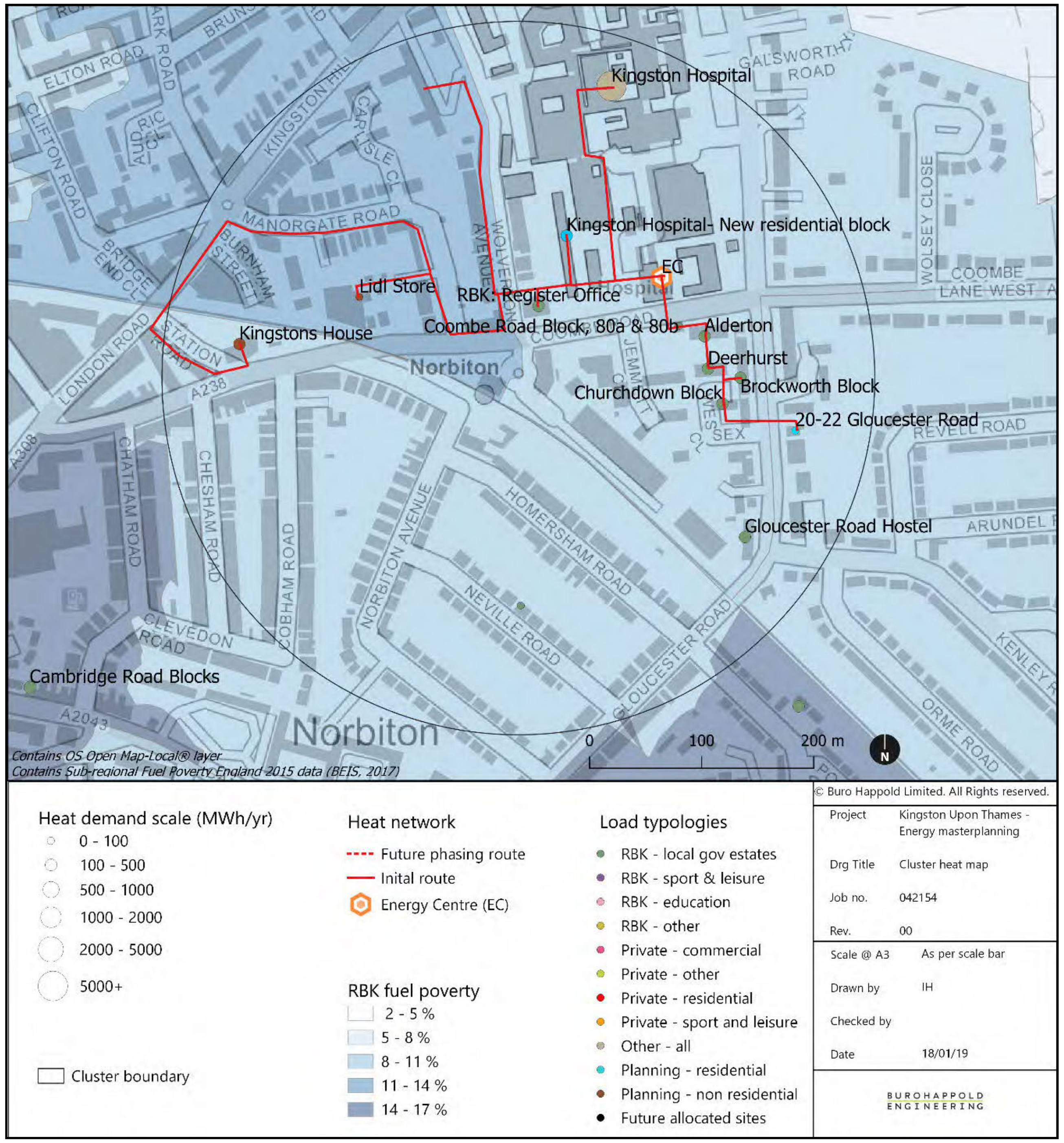


Figure 6.5: Kingston Hospital cluster map

Table 6.5: Kingston hospital cluster performance metrics

Metric	Unit	Value
Heat demand	MWh/yr	25,340
Network length	m	1,590
Heat line density	MWh/m	15.9
Peak load	kW	7,000
Percentage of heat load RBK owned	%	4
Percentage of heat load future	%	3
Percentage of heat load Tier 1	%	91
Energy centre technology	-	Hospital currently planning CHP, potential to combine with lower carbon heat sources

Description

The initial cluster is developed around Kingston Hospital providing the anchor heat load and low carbon heat supply to the wider area. Kingston Hospital has developed a comprehensive redevelopment strategy , due to start in 2019-20. The first phases include the construction of a new energy centre and a new 122 residential unit block. The long term phases include concentrating the hospital's footprint to free up space around the edge of the site boundary to be sold for residential housing redevelopments. The current energy load is estimated at 22.8GWh/yr and the energy centre comprises a 1415kWe/790kWth CHP system. The current CHP engine only has 4 years left on contract.

The GIA of the hospital remains constant by the end of the redevelopment plan. The proposed energy efficiency improvements to the existing buildings will decrease the heat demand per area, however the proposed new residential developments are likely to offset this reduction. Due to this, the future heat load for the site is assumed to remain at its current level and is not included in the percentage of future heat load calculated in Table 6.6.

The hospital is currently operating a 40 year old steam network. An internal study is planned to assess the feasibility of replacing this with a LTHW network. The hospital's redevelopment plans also include extending this network to all buildings on the site when their individual boilers need replacing. Kingston Hospital have expressed interest in supplying heat to the wider community.

BuroHappold's mapping has identified a cluster or RBK owned housing blocks to the south-east of the site which are well placed to connect to a wider DHN network. A number of proposed private developments have been considered for connection, including 20-22 Gloucester Road, Kingstons House and Lidl. Kingston Plaza, a newly built student accommodation block with a CHP unit could also be connected in the long term.

Table 6.6: Kingston Hospital cluster heat loads

Site	Description	Heat supply	Heat Load (MWh/yr)	Tier	Confidence Level	Ownership	Status	No. units/ GIA (m^2)
Kingston Hospital	Existing hospital	CHP (790kWth) and gas boilers	22,771	1	1	NHS	Existing	84,519m^2
Kingston Hospital – new residential	New residential building on Kingston Hospital site	Unknown	269	1	2	NHS	Pre-Planning	122 units
Lidl store	New 3 storey supermarket	Unknown	31	2	2	Private	Pre-Planning	2,200m^2
Kingstons House	New primary school and 19 residential units	CHP	308	2	2	Private	Approved	4,177m^2
Kingston Plaza	New student accommodation	CHP and ASHPs	362	3	3	Private	Existing	130 units
Brae Court	Existing residential	Community heating	464	2	3	Private	Existing	78 units
20-22 Gloucester Road	19 residential apartments and 5 house terrace	Unknown	64	3	2	Private	Awaiting Approval	24 units
RBK owned housing	Including Coombe Road, Alderton, Deerhurst, Brockworth and Churchdown Blocks	Individual gas boilers	947 (total combined)	2	3	RBK	Existing	85 units (total combined)

Energy centre location and technology

The site of the new energy centre is proposed in Kingston Hospital's Development Control Plan , on the southern end of the hospital site boundary – it is assumed that this would be expanded to serve the wider area. The hospital is currently planning for CHP however there may be opportunity to integrate other low carbon technologies – most likely ASHPs given the location of the site. Consultation with the hospital is recommended going forward to ensure that the new energy centre includes space for expansion to serve the wider DHN.

Kingston Hospital currently has 5265kW of chillers that could potentially be utilised for waste heat recovery onto the DHN. The new three-storey Lidl supermarket proposed on Manorgate Road could provide further secondary heat through capturing waste heat from their cooling equipment.

Opportunities and constraints

Opportunities

Kingston Hospital - has the largest heat load in the borough. A new energy centre is already proposed as part of their redevelopment plan. This will act as a key anchor load to a DHN serving the wider area.

The hospital's long term redevelopment plan includes selling off land for new residential blocks. This could increase future heat load in the area.

Kingston Hospital have expressed interest in supply heat to the wider area.

Waste heat from cooling - Consultation with Kingston Hospital has identified 5.27MWth of cooling units, which could be utilised for waste heat extraction.

The new Lidl supermarket could also supply waste heat from its chillers to the network.

Future DHN expansion - This area is located within 1km of the CRE cluster. This presents an opportunity to connect the CRE network with the hospital cluster into a strategic future network, shown in Figure 6—23. Combining these clusters could serve 34.1GWh/yr of demand with low carbon heat.

Constraints

Low percentage of RBK owned heat - only 3% of annual heat demand is RBK owned. This will make it challenging to implement a DHN as there are multiple private stakeholders. However, the majority of the heat demand is from the hospital, a public sector organisation. The timescale of this cluster is dependent on Kingston Hospital's cooperation and development plans.

Physical constraints - To avoid disruptive roadworks along Coombe Road, a busy road leading to the train station and hospital, the DHN pipe route is instead propsed along Manorgate road. This will reduce disruption to traffic during construction but does slightly increase network length.

The suggested route for future DHN expansion along Gloucester Road crosses the railway line over a small bridge. Blocking this road during construction is likely to lead to significant traffic delays.

Retrofitting existing housing stock - The RBK owned housing near the hospital will require retrofitting in order to connect to the proposed DHN. It is advised that plant replacement strategies are considered so as to support future connection to a DHN

Initial plant sizing

Initial plant sizing was carried out using the method described in Section 5.3. The results are presented below.

The ASHP and thermal store located at Kingston Hospital provide 75% of the networks heat demand, with gas boilers providing the additional heat at peak times (approximately 10% of the year). If the Hospital continue with their current plan of CHP then it is anticipated that this will be a similar size to the proposed ASHP.

Table 6.7: Kingston Hospital initial plant sizing results

Kingston Hospital (25.3GWh/yr, 7.0MW)	Unit	Value
Low carbon heat technology	-	ASHP
Low carbon heat supply capacity	MW	2.53
Thermal store capacity	MWh / litres	5.06 / 160,730
Gas boiler capacity	MW	7.0
% yearly supply from low carbon heat	%	70%

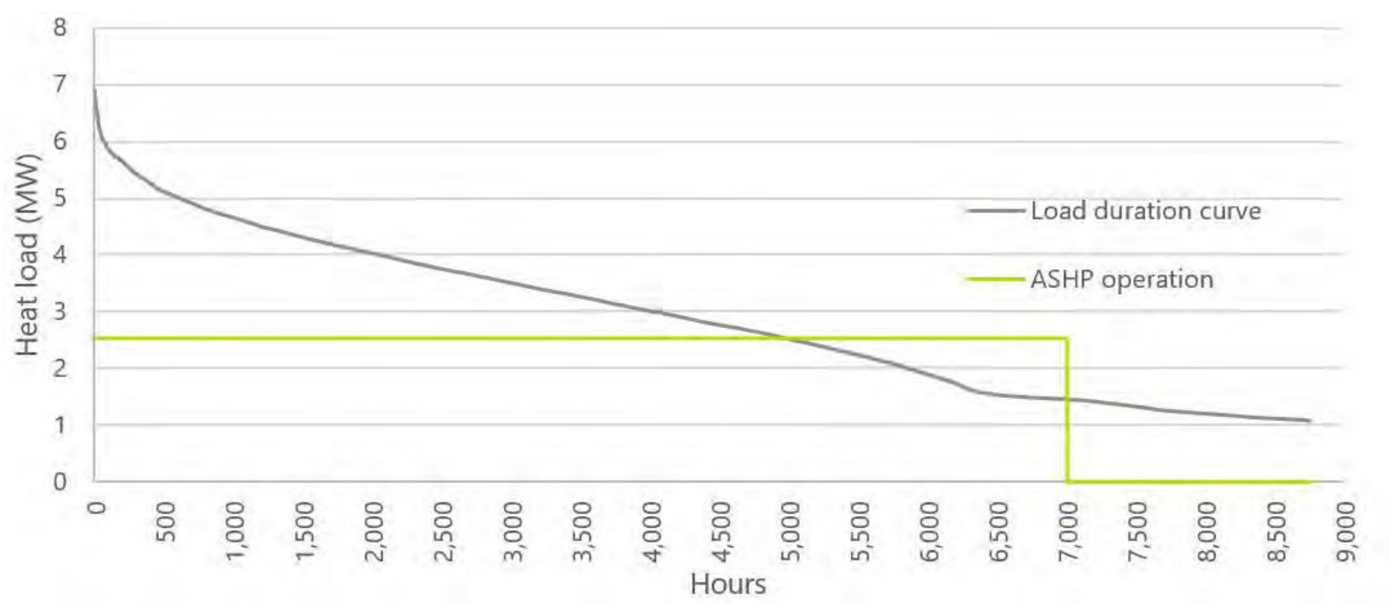


Figure 6.6: Kingston Hospital load duration curve

6.3.3 NEW MALDEN

Summary

The Cocks Crescent area in New Malden has been identified as a growth area in Kingston, with significant new residential heat load being added to the area. The forecast Malden Centre redevelopment is likely to act as the catalyst for DHN development, this could house an energy centre with GSHP to serve the surrounding new and existing buildings. Phase 2 long-term expansion of the network connects heat loads at the opposite end of the high street.

Overview

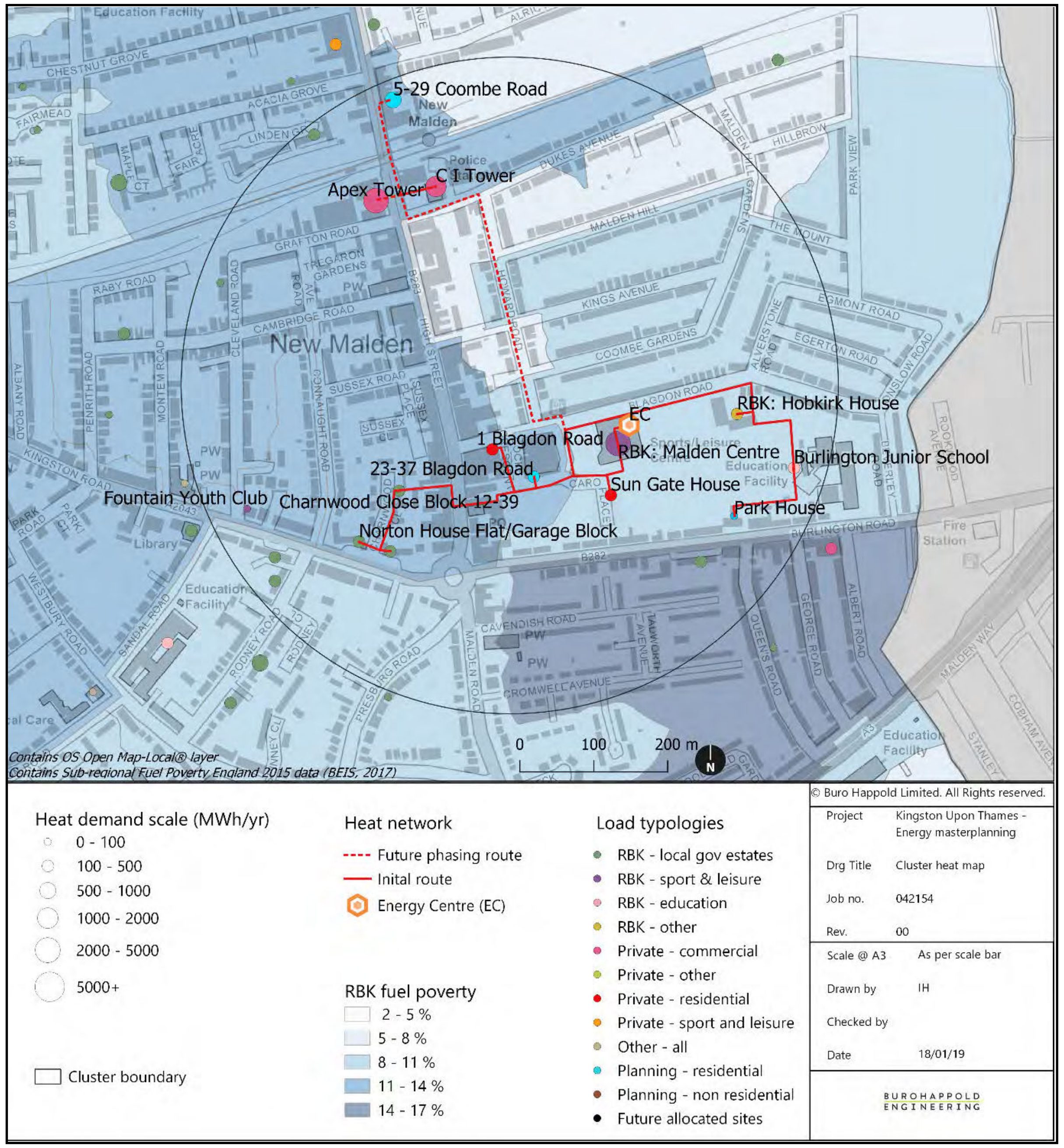


Figure 6.7: New Malden cluster map

Table 6.8: New Malden performance metrics

Metric	Unit	Phase 1	Phase 1 & 2 combined
Heat demand	MWh/yr	4,310	8,440
Network length	m	1,140	1,930
Heat line density	MWh/m	3.8	4.4
Peak load	kW	2,385	3,745
Percentage of heat load RBK owned	%	83	43
Percentage of heat load future	%	7	11
Percentage of heat load Tier 1	%	47	73
Energy centre technology	-	GSHP in the parkland area adjacent to The Malden Centre	

Description

Phase 1

The area south of Cocks Crescent has been cleared for the development of residential units. It is proposed that the first phase of DNH is developed in this area. This will supply heat at DHW to the Malden Centre, Burlington School, the New Malden House, Park House and Blagdon Road residential developments, as well as the existing residential loads of Sun Gate House and the RBK housing assets to the west of the site.

83% of the heat load in the area is RBK owned, with The Malden (Leisure) Centre providing a key anchor load to the area. Hobkirk House and the adjacent Nobel Centre are two RBK owned community buildings. These area currently being vacated and redevelopment plans are not currently known.

New Malden House (the development at 1 Blagdon Road) is near completion and will house its own CHP. The site at 23-37 Blagdon Road has been granted planning permission, with communal gas boilers providing heating and DHW.

Phase 2

Figure 6.7 shows Phase 2 extends to the Apex and CI towers (rentable office space), as well as the proposed new residential development on Coombe Road on the north end of New Malden high street, picking up a potential additional 4.1 GWh/yr.

The feasibility of such a scheme likely depends on the development at 5-29 Coombe Road, which is still awaiting planning permission. This proposes the demolition of existing buildings to provide a mixed residential and commercial space with 85 flats. A CHP scheme is currently proposed for heating and DHW.

As there are currently no plans to refurbish the tower blocks, the feasibility of phase 2 depends on the timeframe of the Coombe Road development. It is proposed that the DHN flow and return pipes are installed on Howard Road, parallel to the high street, to minimise disruption.

Table 6.9: New Malden cluster heat loads

Site	Description	Heat supply	Heat load (MWh/yr)	Tier	Confidence level	Ownership	Status	No. units/ GIA (m^2)
1 Blagdon Road	New Malden House: residential units	61kWe/ 35kWth CHP	269	3	3	Private	Under construction	93 units
Apex Tower	Office tower block	Gas boiler	2,434	1	3	Private	Existing	Unknown
23-37 Blagdon Road	New residential building	Communal boilers	243	2	2	Private	Approved	91 units
C I Tower	Office tower block	Gas boilers	1089	1	3	Private	Existing	Unknown
Burlington Junior School	RBK school	Gas boilers	220	2	1	RBK	Existing	1947m^2
Martin House Block	RBK housing block	Gas boilers	223	2	3	RBK	Existing	16 units
Charnwood Close Block 12-39	RBK housing block	Gas boilers	362	2	3	RBK	Existing	26 units
5-29 Coombe Road	New mixed use development	CHP	608	1	2	Private	Awaiting approval	85 units / 1077m^2 commercial
RBK: Hobkirk House	RBK community building	Unknown	435	2	1	RBK	Existing	5,050 m^2
Malden Centre	RBK leisure centre with pool	Unknown	2,044	1	2	RBK	Existing	4,055m^2
Norton House	RBK housing block	Gas boilers	306	2	3	RBK	Existing	22 units
Park House	Redevelopment of 4 storey office block to residential	Unknown	72	3	2	Private	Pre-Planning	27 units
Sun Gate House	Private residential units	Unknown	133	3	3	Private	Existing	50 units

Energy centre location and technology

The Malden Centre is currently under a management contract which runs until 2021[27]. Its redevelopment, as stated in RBK's 'Indoor Sports Facilities Strategy'[28] is most likely to act as a catalyst for the future area wide DHN. Therefore, the proposed energy centre is located within The Malden Centre site.

Blagdon Road Open Space, adjacent to the Malden Centre, provides a good location to install a GSHP borehole array to supply heat to the network. This would require temporary restricted access to the local open space during construction.

Another option is to locate the energy centre within the 23-37 Blagdon Road site, where it is proposed to be incorporated into the new residential development buildings. This central location will make any required phasing as efficient as possible. However, as the development has already been approved by planning it is unlikely that sufficient space is available in the plant room to accommodate additional lower carbon technologies.

Opportunities and constraints

Opportunities

The Malden Centre - the SPD for Cock's Crescent proposes redevelopment of the leisure centre which could incorporate a larger energy centre to serve the area. If the existing leisure centre is to stay, a review of the space within the energy centre for additional heating plant should be reviewed.

Housing growth targets - Cocks Crescent has been identified by RBK as an area which could support the borough's population growth plans. 1,212 new residential units are planned in New Malden by 2041, increasing the heat density and DHN feasibility in the future.

Fuel poverty - A DHN scheme could also help reduce the fuel poverty in the area, which currently stands at 8-11% of housing stock.

Housing stock - the majority of the housing stock connected to the DHN are new builds, with communal heating. This makes them easier to connect into the network than old buildings with individual boilers.

Constraints

New developments granted planning permission - Therefore, in the short term it is unlikely that these will be connected into a DHN, as each has its own communal heating systems proposed.

Physical constraints - The three RBK housing blocks: Norton House, Martin House and Charnwood Close are separated from Cocks Crescent by the high street. Connecting these sites will require temporary disruption to cross the high street.

Route access to the Coombe Road development (Phase 2) is restricted by the railway line, which runs over the high street. The only possible route is to place the pipes along the high street, past the Apex and CI towers. This could cause significant disruption to traffic and pedestrian access, particularly as New Malden train station entrance is located on the north side of the railway line.

After analysis, these physical constraints are currently considered too large to justify extending the network into Phase 2, where the heat loads are not yet guaranteed.

27 RBK, April 2017. Cocks Crescent SPD. Available at: https://www.kingston.gov.uk/downloads/download/697/cocks_crescent_supplementary_planning_document_spd

28 RBK, 2016. Indoor sport and leisure facility strategy report 2016. Available at: https://www.kingston.gov.uk/downloads/file/1737/indoor_sport_and_leisure_facility_strategy_report_2016

Initial plant sizing

Initial plant sizing was carried out for New Malden Phase 1, using the method described in Section 5.3. The results are presented below.

Figure 6.8 shows the New Malden Phase 1 load duration curve. The low carbon plant is sized to serve up to 77% of the cluster's heat load, with a capacity of 0.43MW. Gas boilers are used to provide the remaining heat at peak times.

Table 6.10: New Malden initial plant sizing results

New Malden (4.3GWh/yr, 2.4MW)	Unit	Value
Low carbon heat technology	-	GSHP
Low carbon heat supply capacity	MW	0.43
Thermal store capacity	MWh / litres	0.86 / 27,310
Gas boiler capacity	MW	2.4
% yearly supply from low carbon heat	%	70%

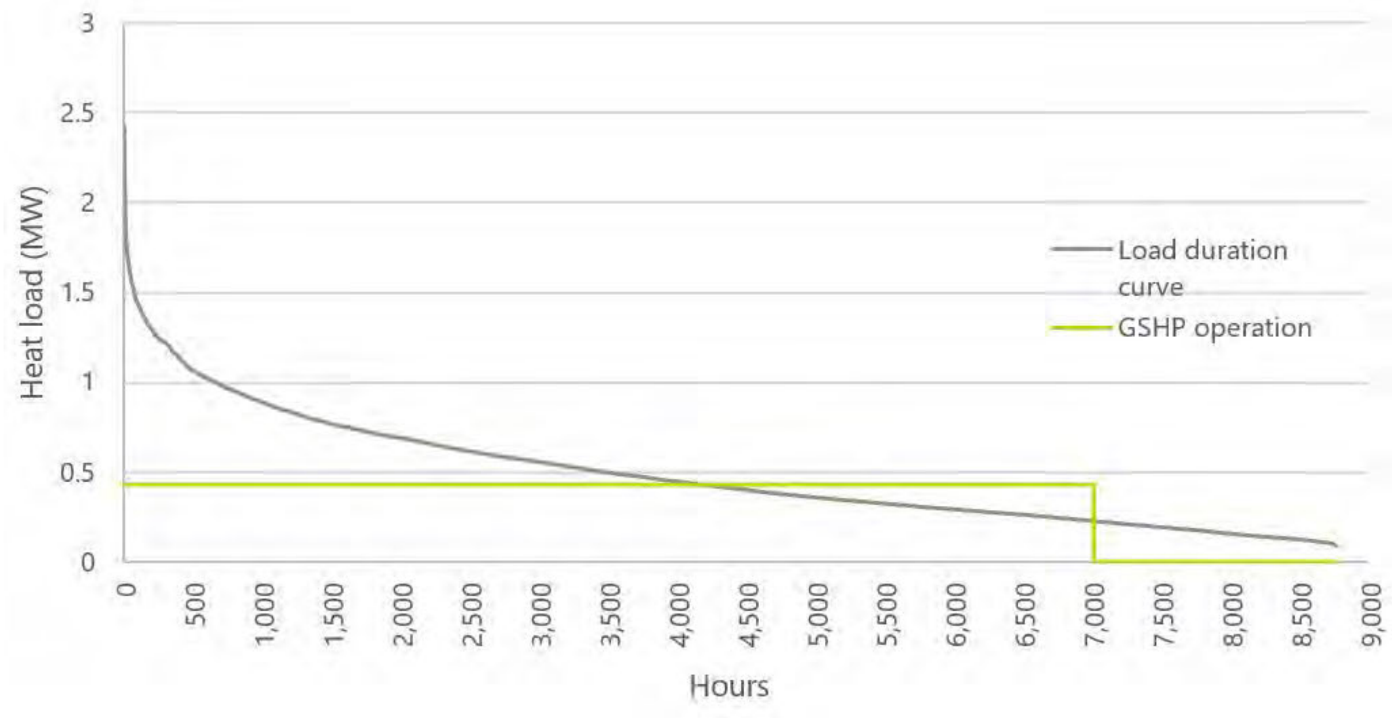


Figure 6.8: New Malden Phase 1 load duration curve

6.3.4 TOLWORTH 1

Summary

The proposed Tolworth 1 East DHN has a high line density (8.5MWh/m). However, the two large new developments, Meyer Homes and the Lidl Headquarters, have already been granted planning permission with site wide communal heating. It is therefore unlikely that a larger DHN will be developed until their plants are due for replacement in around 30 years – however it is recommended that they are contacted to consider providing sufficient space to futureproof the energy centres for a wider heat network.

The Tolworth 1 West network centres on Tolworth Tower, as it is currently the only large new development in the area. If the strategic development sites, identified in black in Figure 6.9, are developed in the future this network could become more feasible. However, there is not currently enough heat load on the west side of the A3 to warrant a DHN.

Overview

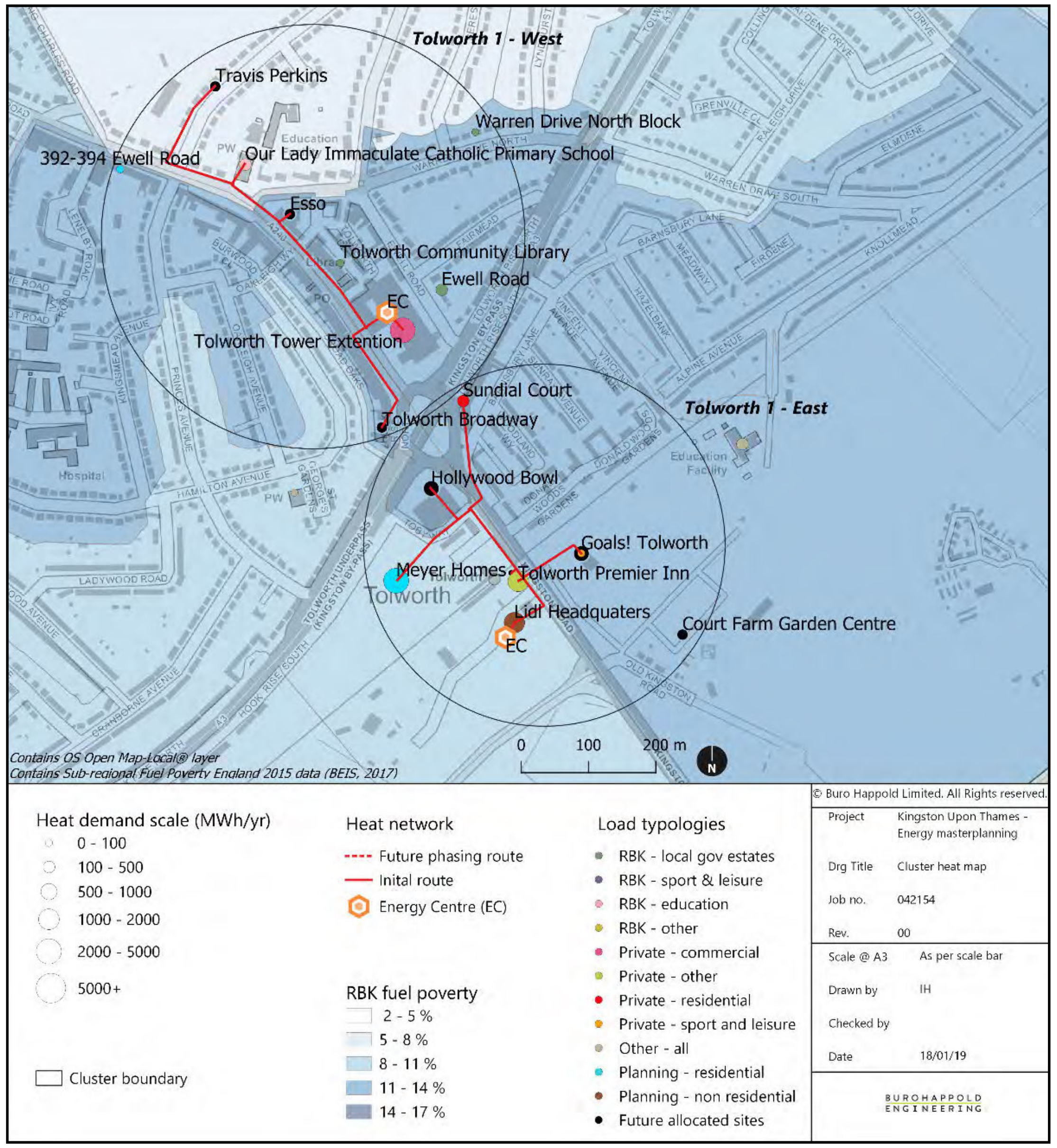


Figure 6.9: Tolworth 1 cluster map

Table 6.11: Tolworth 1 performance metrics

Metric	Unit	Tolworth 1 - West	Tolworth 1 - East
Heat demand	MWh/yr	2,484	6,500
Network length	m	852	764
Heat line density	MWh/m	2.9	8.5
Peak load	kW	2,660	5,570
Percentage of heat load RBK owned	%	7	0
Percentage of heat load future	%	56	78
Percentage of heat load Tier 1	%	0	96
Energy centre technology	-	ASHP at Tolworth Tower	GSHP at Lidl Headquarters and CHP at Meyer Homes (to be replaced in long term)

Description

Tolworth 1 has been separated into two clusters, East and West, as it centres on a large intersection which has been assessed as too busy to cross with DHN pipework. The Tolworth Area Plan recently commissioned by RBK[29] identifies sites for future development in the area. These are identified in black in Figure 6.9, as there are currently no developers interested in the sites.

Tolworth 1 West

Table 6.12: Tolworth 1 West cluster heat loads

Site	Description	Heat supply	Heat Load (MWh/yr)	Tier	Confidence Level	Ownership	Status	No. units/ GIA (m²)
Tolworth Tower Redevelopment	Planning application to redevelop tower to residential	ASHP and boilers	475	2	2	Private	Awaiting Approval	178 units
Tolworth Tower – Travelodge & residential block	Existing 132 bed hotel and 78 unit residential block	Unknown	923	2	3	Private	Existing	210 units (total)
Travis Perkins Site	Currently a warehouse, marked for a possible new care home	Not yet specified	341	2	2	Private	Proposed development opportunity	5,300 GIA
Esso Site	Currently a garage, could house a mixed development including residential and retail units	Not yet specified	312	2	2	Private	Proposed development opportunity	5,200 GIA
Tolworth Broadway	Proposed to densify existing terrace of commercial buildings to include residential units above	Not yet specified	255	2	2	Private	Proposed development opportunity	4,800 GIA
Our Lady Immaculate Catholic Primary School	RBK owned educational facility	Gas boilers	179	2	1	RBK	Existing	2,370 GIA

29 RBK, 2018. Tolworth Area Plan. Available at: https://www.kingston.gov.uk/homepage/245/tolworth_area_plan

The Tolworth Tower extension has been in planning since 2015 due to issues with excess solar gains from the all glass façade. The current planning application is to transform the office block into 178 residential flats, with commercial space on the ground floor. The tower sits alongside an existing Travelodge hotel and a 78 residential unit block, with an M&S supermarket on the ground floor, which could supply waste heat.

Very few other existing heat loads have been identified in this cluster during the mapping. However, the Tolworth Area Plan has identified the Travis Perkins, Esso and Tolworth Broadway sites as potential future developments.

The development of a heat network within the Tolworth 1 West heat cluster relies upon the Tolworth Tower refurbishment, as it is currently the only site in planning and therefore RBK can still influence its heating system design.

Tolworth 1 East

Table 6.13: Tolworth 1 East cluster heat loads

Site	Description	Heat supply	Heat Load (MWh/yr)	Tier	Confidence Level	Ownership	Status	No. units/ GIA (m^2)
Meyer Homes	950 new residential units with nursery and café	CHP 378kWe / 400kWth	3,056	1	2	Private	Approved	950 units
Sundial Court	Change of use from offices to 56 residential flats	Individual boilers	149	3	3	Private	Existing	56 units
Lidl Headquarters	New Lidl office headquarters	GSHP 600kWth & 500m^2 solar thermal	1,351	1	2	Private	Approved	22,950 GIA
Premier Inn	Hotel	Unknown	1,281	1	3	Private	Existing	137 units
Hollywood Bowl Site	Proposed renovation to include residential accommodation	Not yet specified	556	1	2	Private	Proposed development opportunity	14,600 GIA
Goals! Site	Proposed extension of sports facility to include a leisure centre	Not yet specified	88	3	2	Private	Proposed development opportunity	3,500 GIA
Rail Freight Site	Proposed pop-up office space in old rail freight site	Not yet specified	18	3	2	Private	Proposed development opportunity	1,300 GIA

Both the 950 residential unit Meyer Homes site and the new Lidl Headquarters provide new heat load to the area. The Lidl Headquarters has been approved and is proposing a 600kWth GSHP system to supply heat to the site. Meyer Homes has also been approved by planning and is installing a 378kWe/400kWth CHP unit.

The Hollywood Bowl could be redeveloped to provide 11,858m^2 residential floor area and 2,768m2 of residential space. It is estimated that this site could contribute 560MWh to the heat density of the area.

It is recommended that this cluster is reassessed in 15-20 years, when the existing low carbon plants in Meyer Homes and Lidl Headquarters have come to end of life and Crossrail 2 may have attracted more heat load to the area.

Energy centre location and technology

Tolworth 1 East: The energy centre is located on the Lidl Headquarters site, where there is already a GSHP planned to serve heat to the site. It proposed that this be extended in the future to provide heat to the surrounding area. Alternatively, the Meyer Homes site could serve the wider area, with the current CHP replaced with a larger, lower carbon technology at end of life.

Tolworth 1 West: The proposed energy centre is located within the Tolworth Tower site as it is thought that is development will provide the key anchor load that would make a DHN most feasible in the area. It is proposed that ASHPs are used to supply heat as space is at a premium – this could potentially be housed on the car park site if this were to remain.

Opportunities and constraints

Opportunities

High heat line density - Due to the large amount of new developments identified in the Tolworth Area Plan, the heat line density in Tolworth East is high (8.5MWh/m).

High percentage of new builds - As most of the large heat loads are new builds, the buildings will be easier to retrofit for connection to a DHN in the future, when the sites current heat systems will need replacing (10-15 years). This may coincide with the sites identified in the Tolworth Area Plan being commissioned.

Crossrail 2 - The introduction of Crossrail 2 to the area could transform Tolworth Train Station and provide a high-speed route into the city in the 2030s. This is likely to bring more investment and residents to the area, making a future heat network more feasible.

Constraints

Physical constraints - The Tolworth railway line intersects the Lidl headquarters and Meyer Homes site.

All major heat loads privately owned - None of the major heat loads in the area are under RBK control. The development of any DHN would require cooperation with multiple stakeholders.

Timing - The major heat loads in Tolworth 1 East have already been accepted for planning permission (excluding those identified in the Tolworth Area Plan), making a DHN unlikely at this time.

Heat load uncertainty - Due to the uncertainty of the loads identified in the Tolworth Area Plan, that make up the majority of heat demand in Tolworth 1 West, a DHN is not currently considered feasible at this time

6.3.5 TOLWORTH 2

Summary

The heat load at Tolworth 2 is split between just two main stakeholders, RBK and Tolworth Hospital NHS Trust. The timely redevelopment of the hospital means the local RBK owned housing blocks on School Lane are well placed to connect into a future DHN that serves the wider area.

Overview

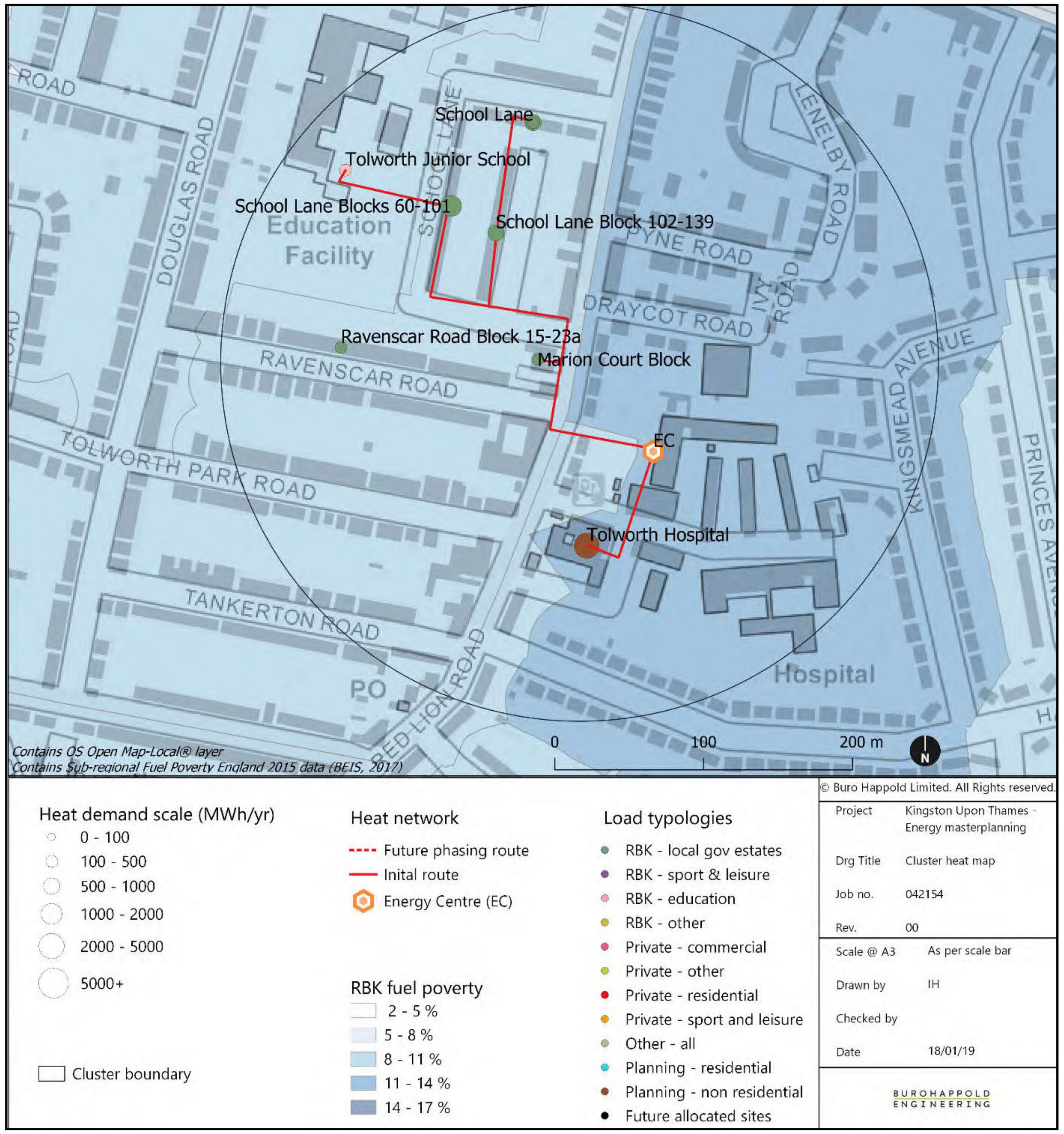


Figure 6.10: Tolworth 2 cluster map

Table 6.14: Tolworth 2 cluster performance metrics

Metric	Unit	Value
Heat demand	MWh/yr	5,140
Network length	m	642
Heat line density	MWh/m	8.0
Peak load	kW	1,976
Percentage of heat load RBK owned	%	39
Percentage of heat load future	%	61
Percentage of heat load Tier 1	%	95
Energy centre technology	-	ASHP

Description

Table 6.15: Tolworth 2 cluster heat loads

Site	Description	Heat supply	Heat Load (MWh/yr)	Tier	Confidence Level	Ownership	Status	No. units/ GIA (m²)
Marion Court Block	RBK owned block housing	Individual gas boilers	125	2	3	RBK	Existing	9 units
School Lane Blocks	RBK owned block housing	2 blocks with individual gas boilers, 1 with communal heating	1,754	1	3	RBK	Existing	126 units
Tolworth Hospital	Refurbishment and extension of existing hospital buildings	Site-wide CHP network	3,154	1	2	NHS	Approved	15,308 GIA
Tolworth Infant School	RBK owned education facility	Unknown	109	2	1	RBK	Existing	1,710 GIA

Tolworth Hospital has received planning permission for refurbishment of its existing buildings and the construction of a new mental health facility and energy centre. This energy centre is planned to be located on the west side of the site, near Red Lion Road, shown in Figure 6.10. The hospitals energy strategy states that the energy centre will house a new CHP unit and gas-fired boilers for peaking that will serve the whole site. The CHP unit is rated at 90kWe/163kWth.

Assessment of the heat loads in the area show there is a concentration of RBK owned housing blocks on School Lane, with a total heat load benchmarked at 1,880MWh/yr. Two of these blocks, shown in Figure 6.11, are currently heated with individual boilers. The third has been retrofitted with a communal CHP boiler. The Tolworth Junior School is also well placed to connect into the DHN.

It is proposed that the energy centre for the proposed DHN is built alongside the Tolworth Hospital refurbishment to minimise disruption. When the residential blocks, currently heated by individual boilers, are ready to be refurbished the DHN can be extended down Red Lion Road. The School Lane block already retrofitted with communal heating can connect to the network at the end of its CHP plant life.

Energy centre location and technology

The energy centre will be located within the Tolworth Hospital site boundary, in the location proposed in the Energy Statement. It is proposed that the new hospital energy centre size is increased to incorporate the additional loads.

As the hospital is located in a dense residential area, an ASHP is recommended to supply low carbon heat to the network. The current Tolworth Hospital strategy proposes a CHP and a hybrid CHP/HP scheme could be considered.

Figure 6.11: School Lane Housing Blocks

Opportunities and constraints

Opportunities

Tier 1 loads - Although the proposed scheme is small (5,140MWh/yr) it consists of 95% tier 1 loads.

Housing blocks are RBK owned - giving more control over implementing the network.

Retrofitting proven - The existing communally heated housing block illustrates the feasibility of performing a similar retrofit to the other blocks, with external heat pipes running along the outside of the building to each flat. Their flat roofs provide a good opportunity to install solar PV to provide electricity to power the ASHPs through a private wire connection.

Timing - The redevelopment of Tolworth Hospital is well timed to implement such a scheme and includes a new energy centre.

Location - Tolworth Hospital is located approximately 500m from the Tolworth 1- West cluster, presenting an opportunity to connect the two sites in the future. The route suggested is through the residential area on Kingsmead and Oakleigh Avenues (shown in Figure 7—11).

Constraints

Boiler replacement strategy - The School Lane estate is heated predominantly by individual gas boilers of varying ages. RBK's current replacement schedule is incremental, depending on the age of the boiler. This is likely to lead to a new boiler being discarded during the heat network retrofit. It is suggested that no boiler replacements are carried out in the flats within 5 years of the expected DHN connection date, unless necessary.

3rd party stakeholder - The feasibility of the scheme depends on the full engagement of Tolworth Hospital.

Energy centre (EC) - The footprint of the proposed EC at Kingston Hospital will likely need to be increased to incorporate the additional low carbon plant required.

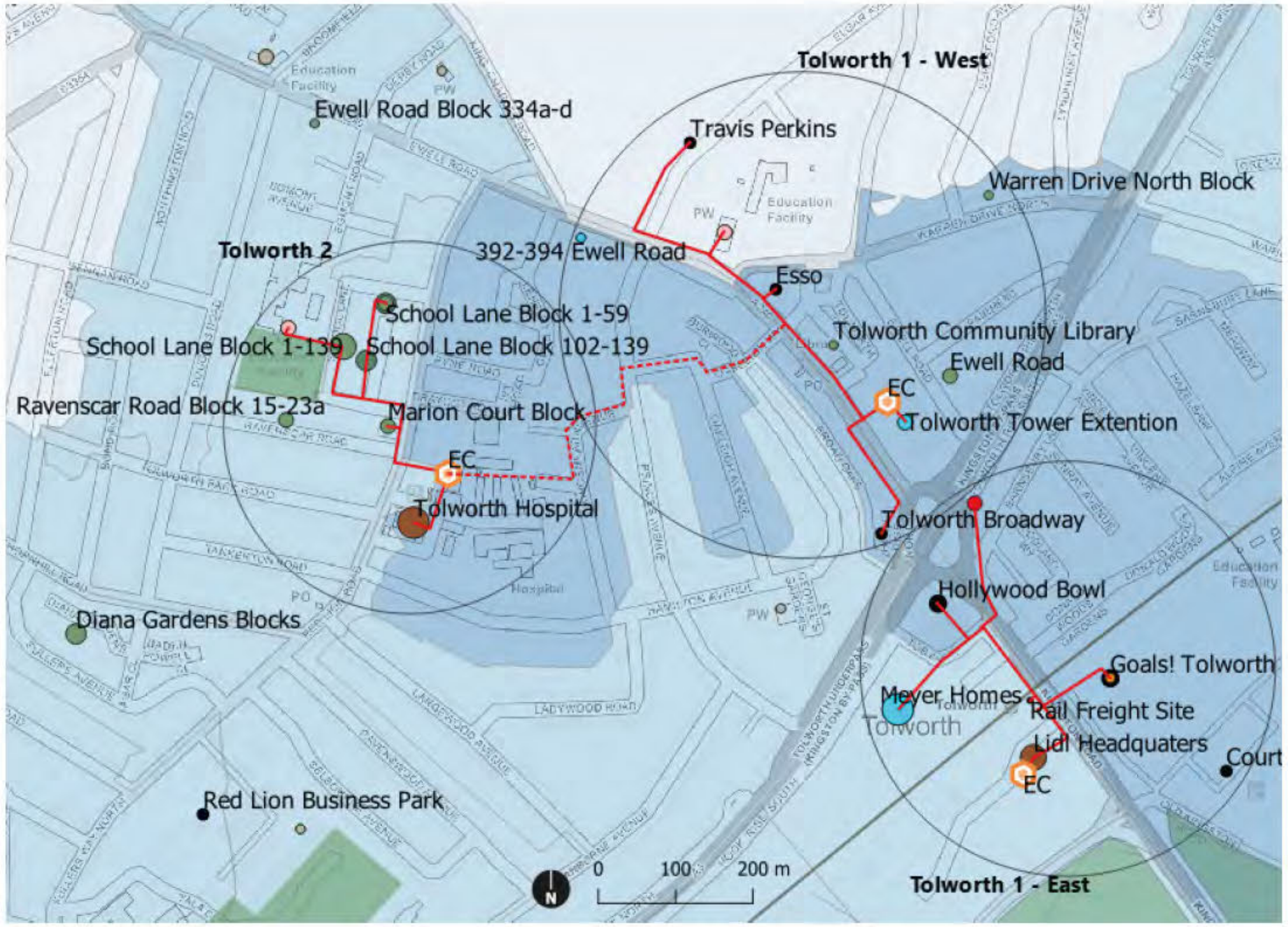


Figure 6.12: Tolworth 1 and 2 future connection route

Initial plant sizing

Initial plant sizing was carried out using the method described in Section 5.3.

Utilising an ASHP capacity of 0.51MW and 32,610 litres of thermal store, 75% of the cluster's heat load can be met. Additional gas boiler capacity of 2.0MW is recommended to provide heat during peak demand and act as backup heat generation should the ASHPs fail.

In the short term, if Tolworth Hospital installed their proposed 163kWth CHP, the remaining 374kWth of heat load can be met by an ASHP within the energy centre. When the CHP comes to the end of life, it can be replaced with a lower carbon technology.

Table 6.16: Tolworth 2 initial plant sizing results

Tolworth 2 (5.1GWh/yr, 2.0MW)	Unit	Value
Low carbon heat technology	-	ASHP
Low carbon heat supply capacity	MW	0.51
Thermal store capacity	MWh / litres	1.03 / 32,610
Gas boiler capacity	MW	2.0
% yearly supply from low carbon heat	%	70%

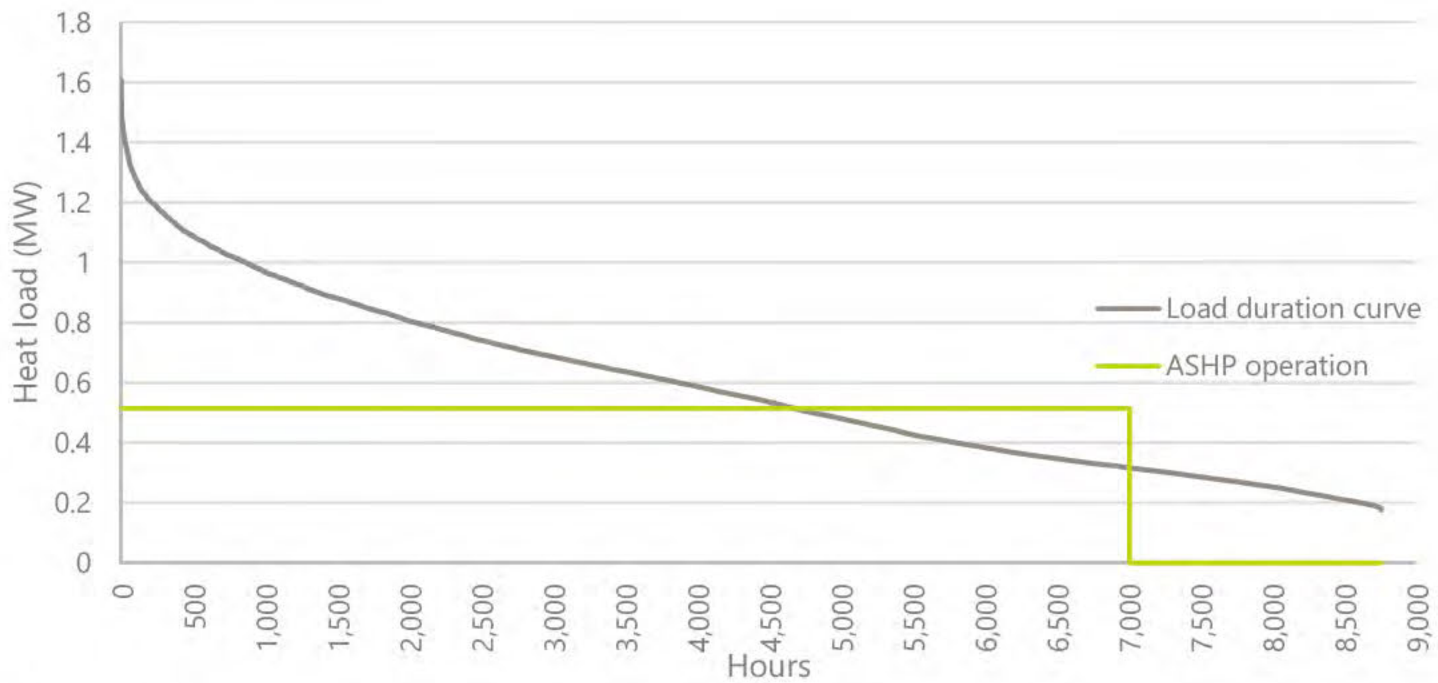


Figure 6 13: Tolworth 2 load duration curve

6.3.6 SURBITON

Summary

Surbiton could act as a pilot scheme to decarbonise RBK assets, as the proposed scheme consist of 100% RBK owned housing blocks. However, the cluster has a low heat line density of 3.6MWh/m and the blocks are likely to require expensive retrofits to make them suitable for DHN connection.

Overview

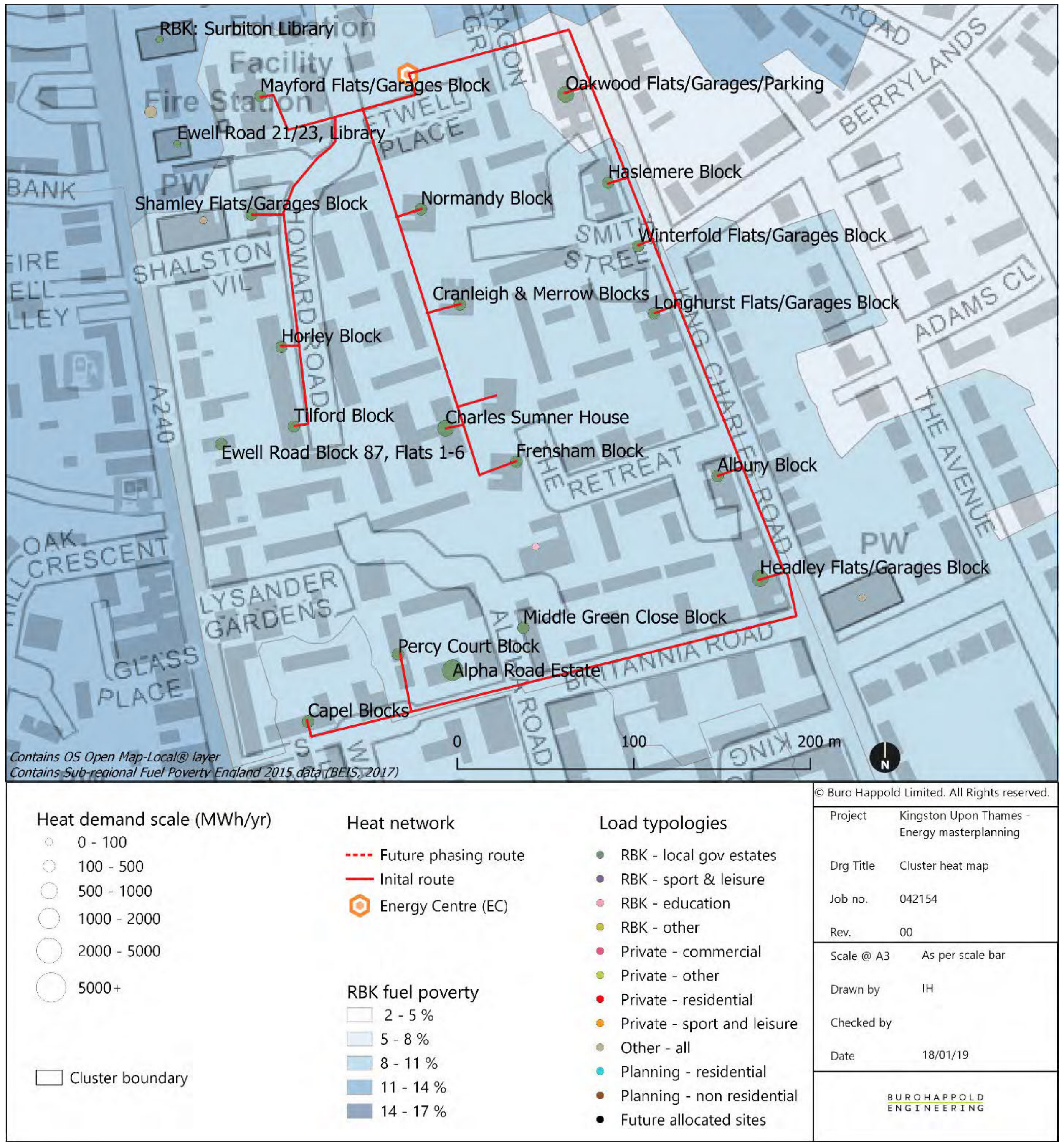


Figure 6.14: Surbiton cluster map

Table 6.17: Surbiton cluster performance metrics

Metric	Unit	Value
Heat demand	MWh/yr	5,360
Network length	m	1,500
Heat line density	MWh/m	3.6
Peak load	kW	2,480
Percentage of heat load RBK owned	%	100%
Percentage of heat load future	%	0%
Percentage of heat load Tier 1	%	29%
Energy centre technology	-	ASHP

Description

The Surbiton cluster DHN centres around the Alpha Road Estate; a dense area of RBK owned residential housing blocks with a total heat demand of 5.4GWh/yr. The proposed network connects 17 housing blocks ranging from 12-38 residential units.

Table 6.18: Surbiton cluster heat loads

Site	Description	Heat supply	Heat Load (MWh/yr)	Tier	Confidence Level	Ownership	Status	No. units
Cranleigh & Merrow Blocks	RBK owned housing	Individual gas boilers	390	Tier 2	3	RBK	Existing	28
Frensham Block	RBK owned housing	Individual gas boilers	195	Tier 2	3	RBK	Existing	14
Oakwood Flats/Garages/ Parking	RBK owned housing	Electric storage heaters/gas boilers	501	Tier 1	3	RBK	Existing	36
Haslemere Block	RBK owned housing	Electric storage heaters/gas boilers	334	Tier 2	3	RBK	Existing	24
Longhurst Flats/Garages Block	RBK owned housing	Electric storage heaters/gas boilers	334	Tier 2	3	RBK	Existing	24
Tilford Block	RBK owned housing	Individual gas boilers	251	Tier 2	3	RBK	Existing	18
Horley Block	RBK owned housing	Gas boilers	334	Tier 2	3	RBK	Existing	24
Shamley Flats/Garages Block	RBK owned housing	Electric storage heaters/gas boilers	334	Tier 2	3	RBK	Existing	24
Normandy Block	RBK owned housing	Individual gas boilers	195	Tier 2	3	RBK	Existing	14
Winterfold Flats/Garages Block	RBK owned housing	Electric storage heaters/gas boilers	167	Tier 2	3	RBK	Existing	12
Charles Sumner House	RBK owned housing	Central gas boilers	529	Tier 1	3	RBK	Existing	38
Mayford Flats/Garages Block	RBK owned housing	Individual gas boilers	487	Tier 2	3	RBK	Existing	35

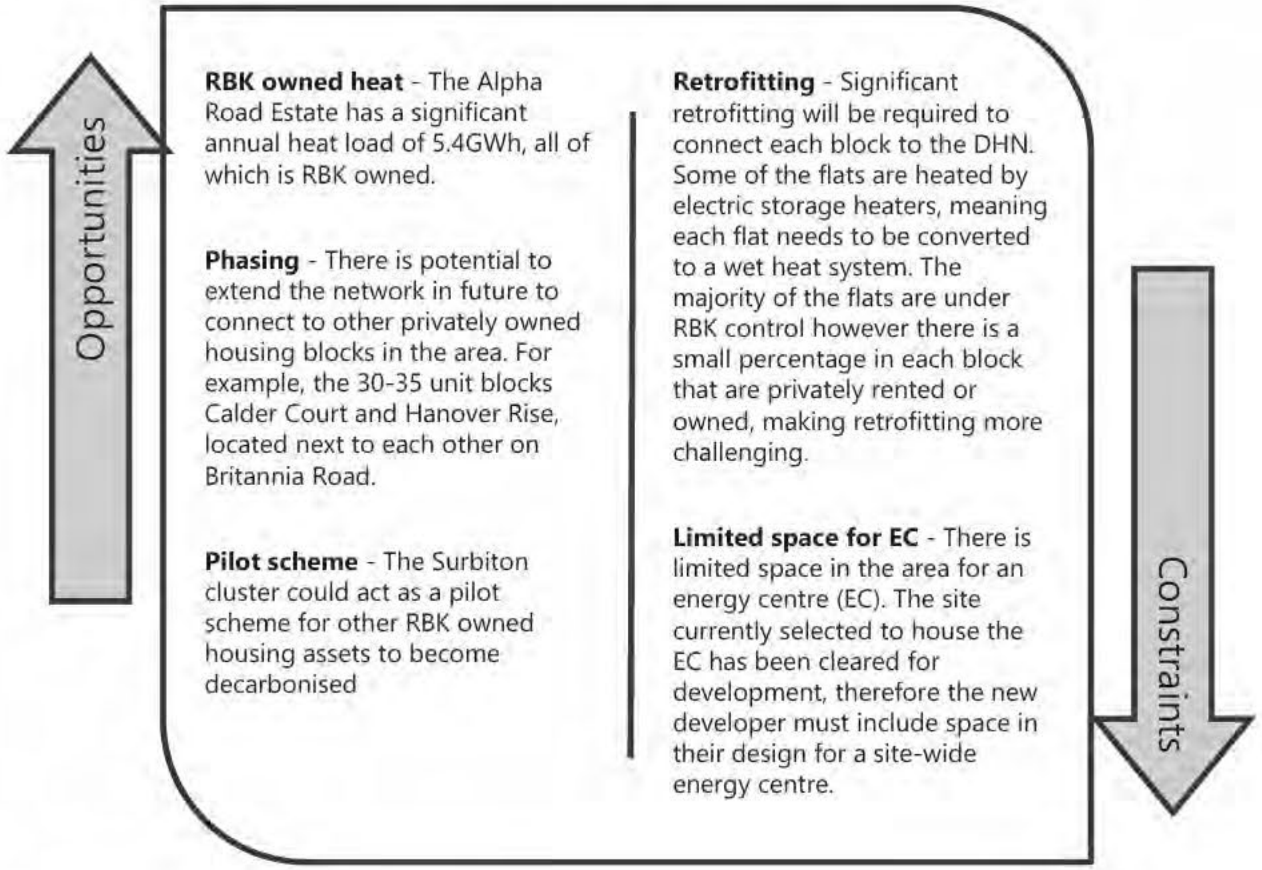
Site	Description	Heat supply	Heat Load (MWh/yr)	Tier	Confidence Level	Ownership	Status	No. units
Percy Court Block	RBK owned housing	Individual gas boilers	167	Tier 2	3	RBK	Existing	12
Headley Flats/Garages Block	RBK owned housing	Individual gas boilers	501	Tier 1	3	RBK	Existing	36
Capel Blocks	RBK owned housing	Individual gas boilers	306	Tier 2	3	RBK	Existing	22
Albury Block	RBK owned housing	Electric storage heaters/gas boilers	334	Tier 2	3	RBK	Existing	24

Energy centre location and technology

The Surbiton area is densely populated, with very little available land for a GSHP borehole array. There is a large park (Fishponds) 200m to the south of the site, however given its distance, the relatively small cluster load and that it is bordered by trees, ASHPs are likely to be favourable to supply low carbon heat to the cluster.

The currently vacant 1,790m² plot of land on Etwell Place has been selected as a suitable location to house the energy centre. The land has been cleared for development, however at time of writing there is currently no planning application submitted for the site. It is recommended that any future development accommodates the potential to install an energy centre at the site.

Opportunities and constraints



Initial plant sizing

Initial plant sizing was carried out using the method described in Section 5.3.

The ASHP configuration sized for Surbiton is estimated to meet 76% of the cluster's annual heat load, with the addition of 34,000 litres of thermal storage. Gas boilers are installed to meet the remaining demand.

Table 6.19: Surbiton initial plant sizing results

Surbiton (5.4GWh/yr, 2.5MW)	Unit	Value
Low carbon heat technology	-	ASHP
Low carbon heat supply capacity	MW	0.54
Thermal store capacity	MWh/ litres	1.07 / 34,000
Gas boiler capacity	MW	2.5
% yearly supply from low carbon heat	%	70%

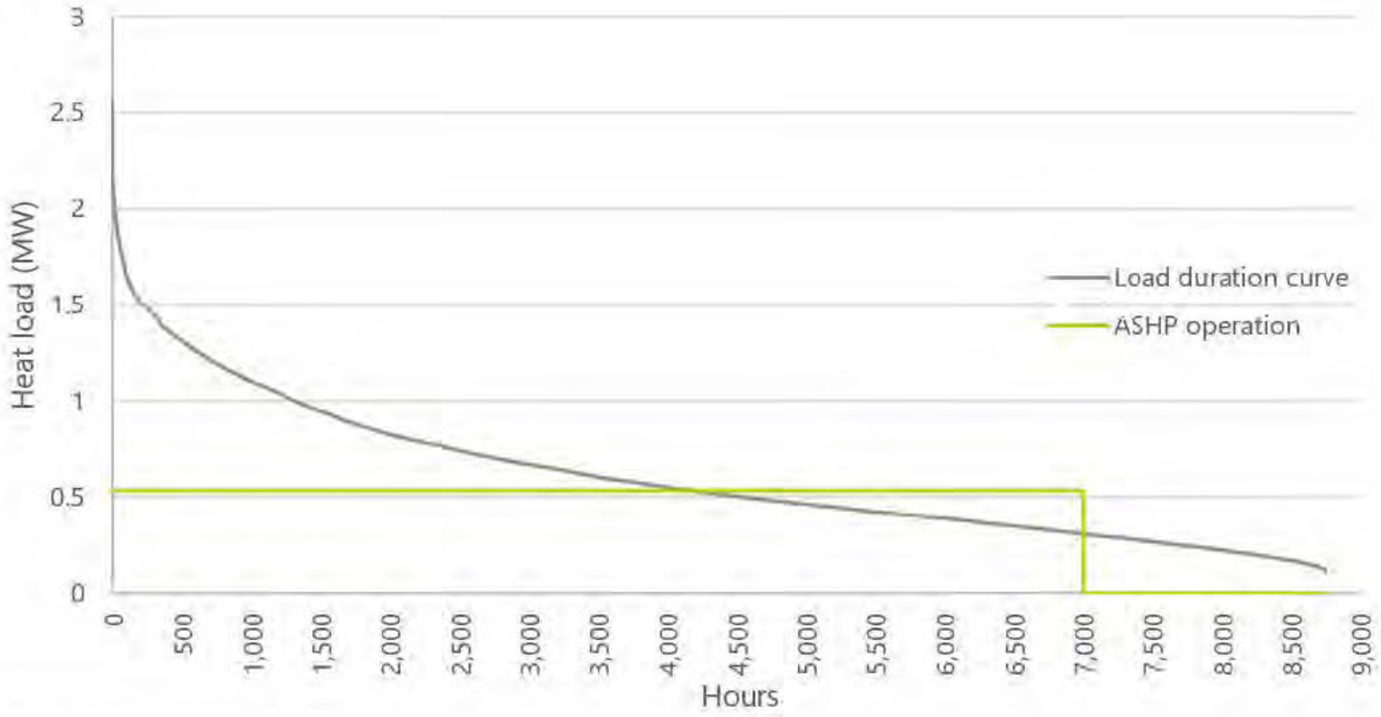


Figure 6.15: Surbiton load duration curve

6.3.7 CHESSINGTON

Summary

As with Surbiton, the small cluster developed around Chessington South provides a good opportunity for a pilot scheme to decarbonise RBK housing assets. The scheme is too small (990MWh/yr) to qualify for HNIP funding, however there are other funding streams available that could make this an interesting site to test a pilot scheme for similar areas in the borough.

Overview

Figure 6.16 shows the South Chessington area, which has been selected as a potential cluster due to its high density of RBK owned housing assets.

The site boarders a railway line. On the other side is a series of three schools, with low estimated heat loads of 100-200MWh/yr. The railway line acts as a significant barrier to DHN routing as they can only be accessed by the bridge on Garrison Lane. Therefore, these are not considered for connection to a network.

The heat density of the RBK owned blocks is low, as the majority of housing on the east side of the cluster are 1-2 storey dwellings. The blocks on the west side of the site, York Way and Garrison Lane, are 3-4 storeys and are therefore assessed further for DHN potential as possible demonstrator schemes for the council.

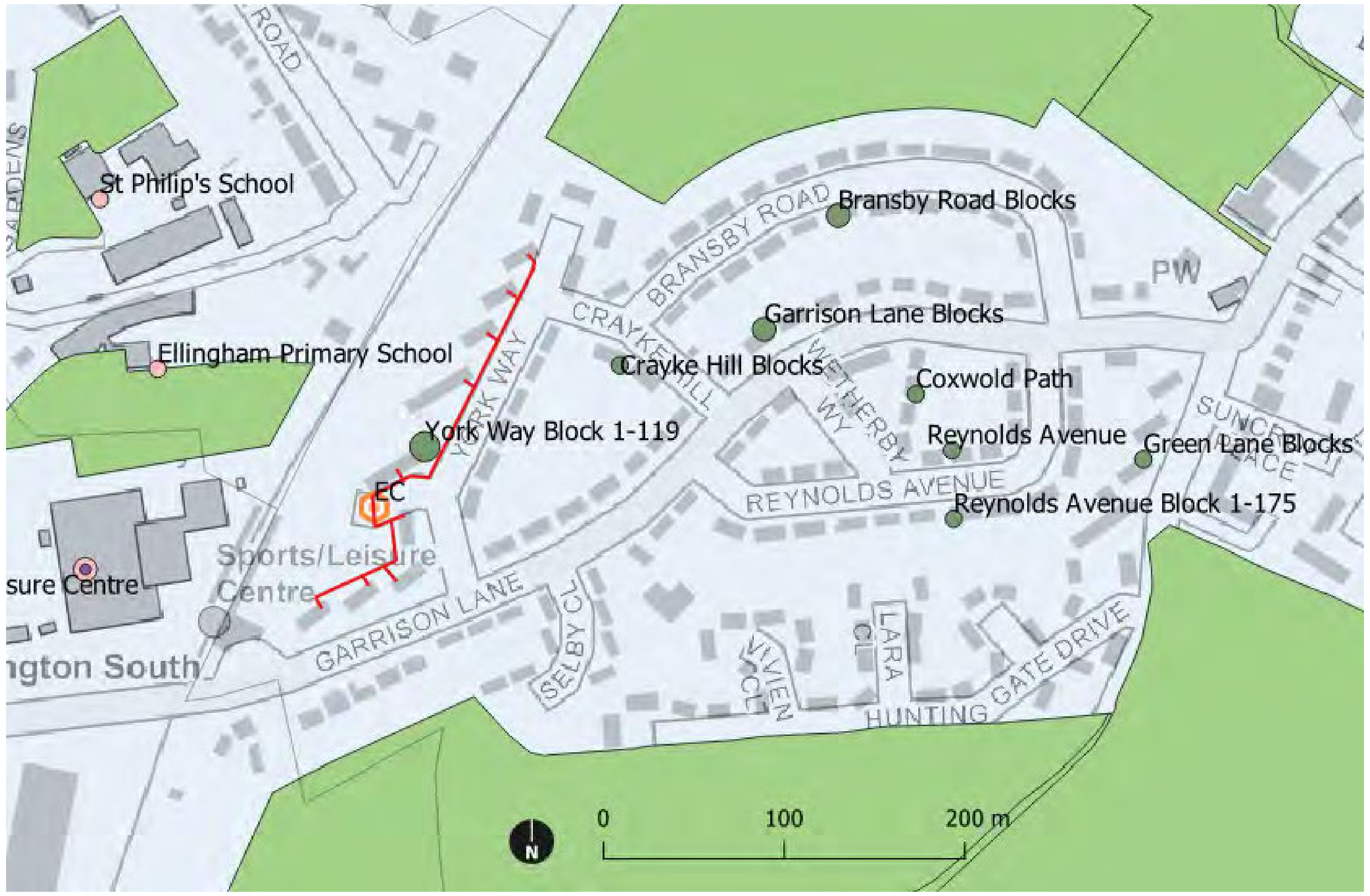


Figure 6.16: Chessington South area

Table 6.20: Chessington cluster performance metrics

Metric	Unit	Value
Heat demand	MWh/yr	990
Network length	m	325
Heat line density	MWh/m	3.1
Peak load	kW	400
Percentage of heat load RBK owned	%	100%
Percentage of heat load future	%	0%
Percentage of heat load Tier 1	%	0%
Energy centre technology	-	GSHP

Description

This area in Chessington South has a high density of RBK owned housing blocks which could be retrofitted to provide low carbon heating in a pilot scheme that can then be rolled out to other RBK housing assets in the borough.

The blocks on York Way and Garrison Lane have been identified as a good area for such a scheme. The 4 Garrison Lane Blocks are all three storey RBK owned housing assets built in 1935 and currently fitted with individual gas boilers. The 5 York Way blocks are also RBK owned with individual gas boilers and built in 1950. These block range in height from 3-4 storeys.

Table 6.21: Chessington cluster heat loads

Site	Description	Heat supply	Heat Load (MWh/yr)	Tier	Confidence Level	Ownership	Status	No. units
Garrison Lane Block 110-120	RBK owned housing	Individual gas boilers	83.5	3	3	RBK	Existing	6
Garrison Lane Block 122-132	RBK owned housing	Individual gas boilers	83.5	3	3	RBK	Existing	6
Garrison Lane Block 134-144	RBK owned housing	Individual gas boilers	83.5	3	3	RBK	Existing	6
Garrison Lane Block	RBK owned housing	Individual gas boilers	83.5	3	3	RBK	Existing	6
York Way Block 1-11	RBK owned housing	Individual gas boilers	84	3	3	RBK	Existing	6
York Way Block 13-41	RBK owned housing	Individual gas boilers	195	2	3	RBK	Existing	14
York Way Block 43-71	RBK owned housing	Individual gas boilers	209	2	3	RBK	Existing	15
York Way Block 73-83	RBK owned housing	Individual gas boilers	84	3	3	RBK	Existing	6
York Way Block 10-16	RBK owned housing	Individual gas boilers	84	3	3	RBK	Existing	6

Energy centre location and technology

A GSHP array is recommended to supply low carbon heat to this network. It is suggested that both the energy centre and GSHP array are installed in the car park at the south end of York Way (shown in Figure 6.17)

Initial borehole array calculations for a closed-loop GSHP suggest ~28no 150m deep boreholes will be required to meet the 247kW low carbon heat supply capacity, requiring an area of ~625m². As the car park has an area of 1,300m², the GSHP array is likely to fit into the area. However, it leaves little room for network expansion or for the energy centre.

The other option considered is a shared ground array system (fully described in Section 0) where low grade heat from the ground is circulated through the building to individual flats. A small heat pump (3-5kW) in each flat then upgrades the heat to provide independently controllable heat and DHW to the property. The benefits of such a scheme are reduced distribution heat losses, independent billing and no large energy centre. As the low grade heat extends into each flat, it can also provide free cooling in the summer. This presents a good solution for socially rented housing, where the building is centrally controlled. The main disadvantage of individual heat pumps is that it locks consumers into using the GSHP borehole array and does not allow for an easy switch to future alternative lower carbon technology in the future – it also requires sufficient space within the flats to house the heat pumps.

The Churchfields Recreation Ground, the area of land to the north of York Way, is designated a Local Open Space. This space has been identified as a possible alternative location for a GSHP borehole array due to its proximity to the high heat density area. The construction of which would only temporarily restrict the use of the recreation ground, however Local Authorities are required to consult Sport England in cases where a development would affect the use of an existing open space[30]. Locating a centralised energy centre and borehole array here could be useful in the long term if the network were to be extended to serve the lower heat density housing in the surrounding area.

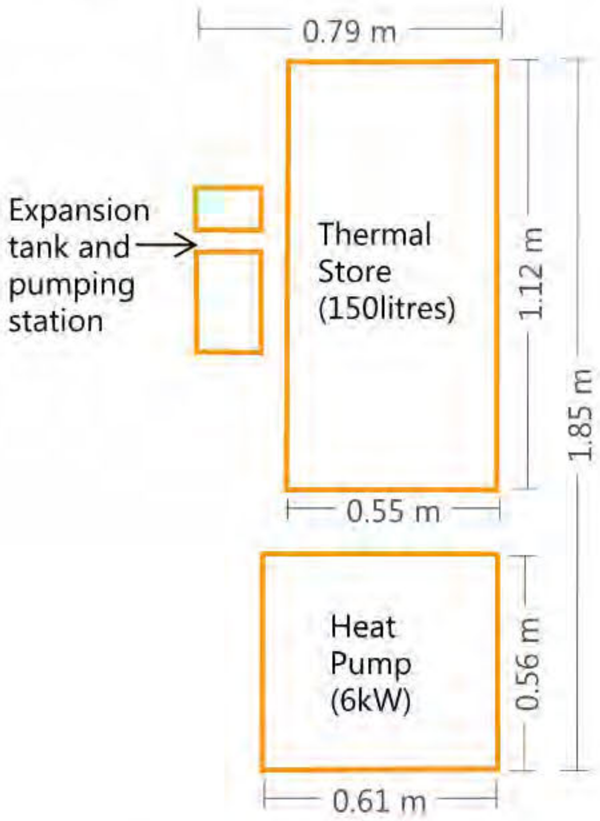
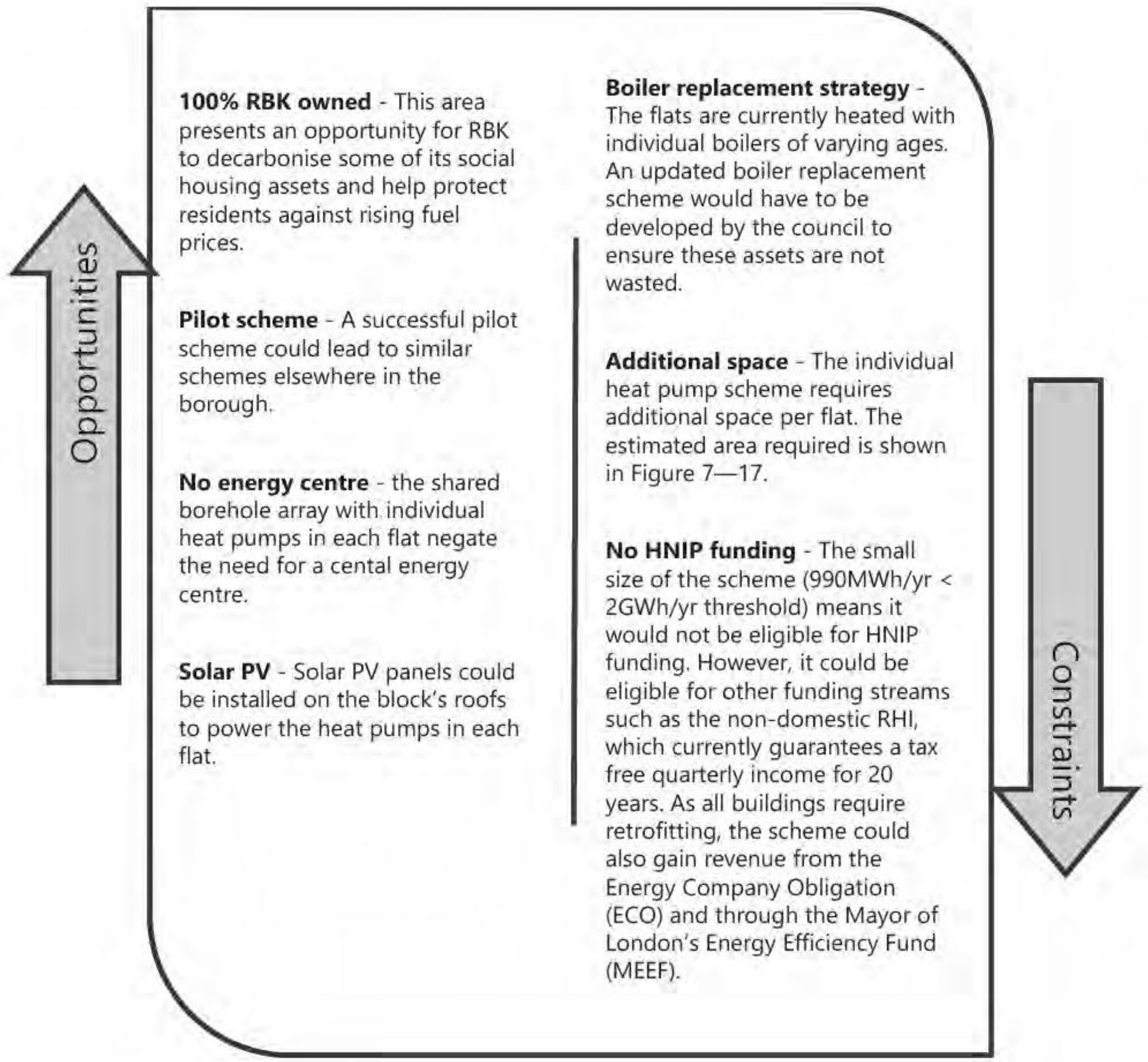


Figure 6.17: Individual heat pump elevation schematic

Opportunities and constraints



30 https://www.gov.uk/guidance/open-space-sports-and-recreation-facilities-public-rights-of-way-and-local-green-space

Initial plant sizing

Initial plant sizing was carried out using the method described in Section 5.3. Two scenarios were modelled: Scenario 1, with a GSHP array and a central energy centre. Scenario 2, with a shared GSHP array with individual heat pumps in each flat. The results are presented below.

Table 6.22 shows that the Scenario 2 heat pumps are sized to meet 100% of heat demand in each flat, leading to a higher overall heat pump capacity of 247kW, compared to 99kW in Scenario 1. However, designing the system in this way negates the need for gas boilers.

The total thermal store capacity is higher in Scenario 2, as each flat has its own small thermal store (130l). The estimated space requirement per flat for the Scenario 1 plant room is shown in Figure 6.17. Reference dimensions taken from the Kensa 6KW Shoebox[31] heat pump and 150l Gledhill thermal store[32]. The estimated area required is 790x570x1850mm (LxWxH). It is proposed this is installed in place of the existing gas boilers.

Table 6.22: Chessington initial plant sizing results

Chessington (1.0GWh/yr, 0.4MW)	Unit	Scenario 1: central energy centre	Scenario 2: individual heat pumps
Low carbon heat technology	-	Central GSHP	Individual heat pumps with shared GSHP array
Heat demand per year	MWh/yr	990	990
Low carbon heat supply capacity	MW	0.099	0.247 (3.5kW per flat)
Thermal store capacity	MWh / litres	0.20 / 6,310	0.0045 / 9,460 (130litres per flat, sizing at 1.2 hours of peak low carbon plant)
Gas boiler capacity	MW	0.40	N/A
% yearly supply from low carbon heat	%	76%	100%

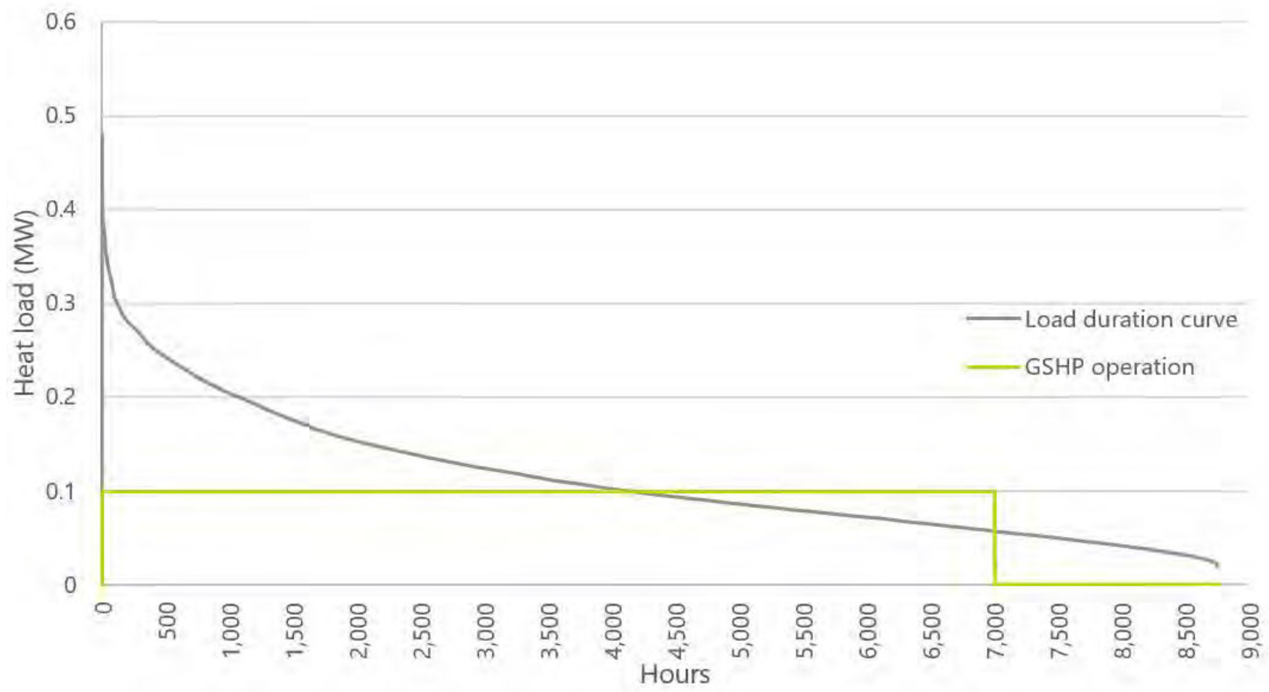


Figure 6.18: Chessington heat duration curve (Scenario 1)

31 https://www.kensaheatpumps.com/wp-content/uploads/2014/03/TI-Shoebox-heat-pump-%E2%80%93-5.3.pdf
32 https://www.gledhill.net/products/alternative-energy/torrent-stainless-sp-sol/

6.3.8 KTC CLUSTER

KTC cluster overview

Figure 6.19 shows the DHN network developed for KTC, split into two phases. Phase 1 connects the large heat loads in the South Kingston area with higher likelihood to connect. Phase 2 extends the network north through the Eden Quarter. It is proposed a WSHP supplies low carbon energy to the network, with the energy centre located at Eagle Wharf. An alternative energy centre at the Kingfisher Leisure Centre is suggested if planning permission along the riverfront proves too challenging. This could house a GSHP array on the adjacent RBK owned playing field.

The North Kingston area was excluded from the network after the initial mapping because all major heat loads are privately owned, many with individual heating systems, making DHN connection coordination challenging. The large retail heat loads in the Station Quarter, such as John Lewis and Bentalls, have also been excluded from these phases of the proposed DHN due to the large disruption to the public extending the network here would cause.

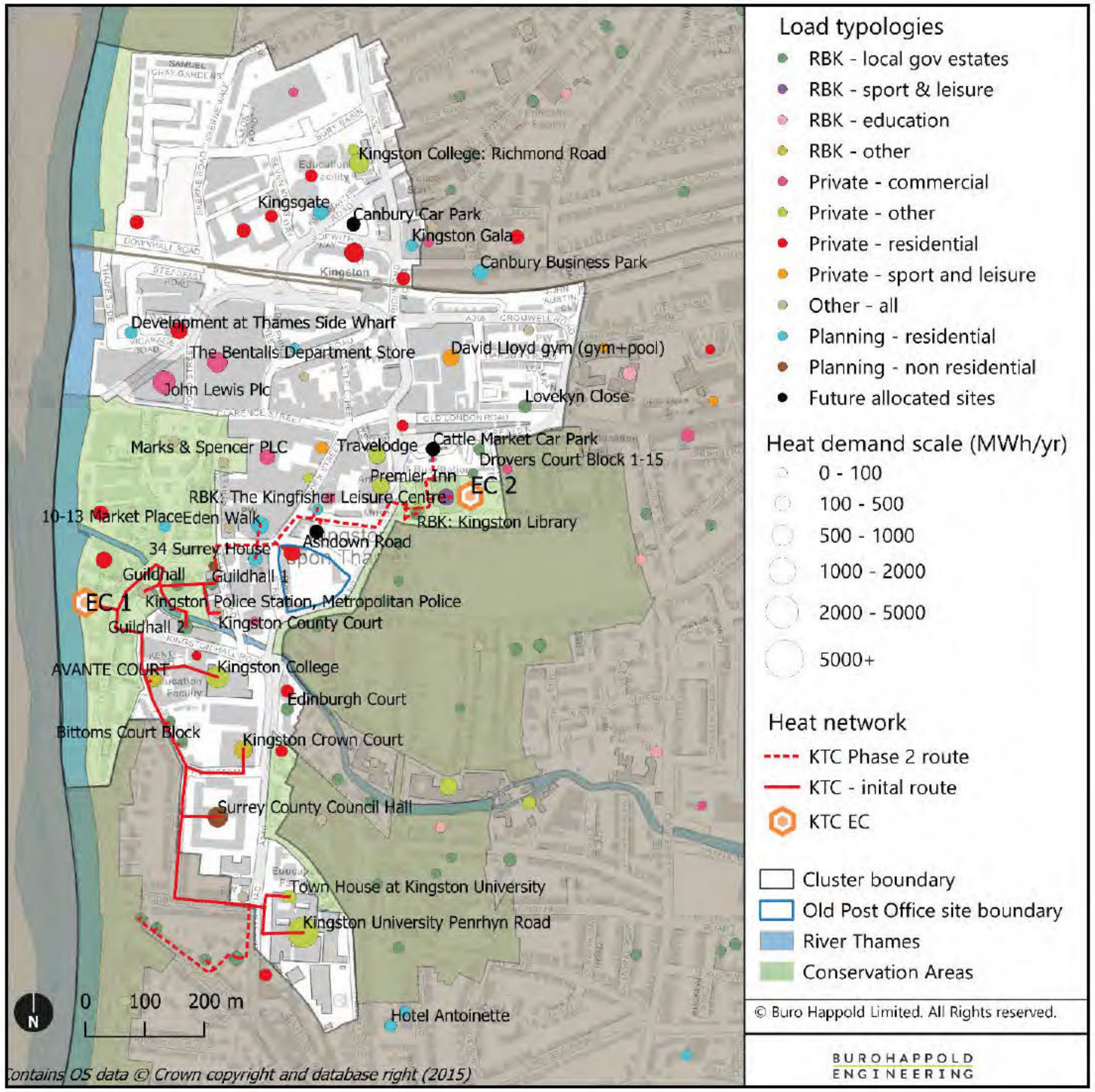


Figure 6.19: KTC route map (phase 1 +2)

6.3.8.1 PHASE 1

Summary

Phase 1 proposed a WSHP supplied by the River Thames to provide low carbon heat to the South Kingston Town Centre. Kingston University Penrhyn Campus could provide an excellent anchor load for the scheme, into which the RBK owned Guildhall can connect. The total annual heat load of the network is estimated at 17.4GWh/yr.

Overview

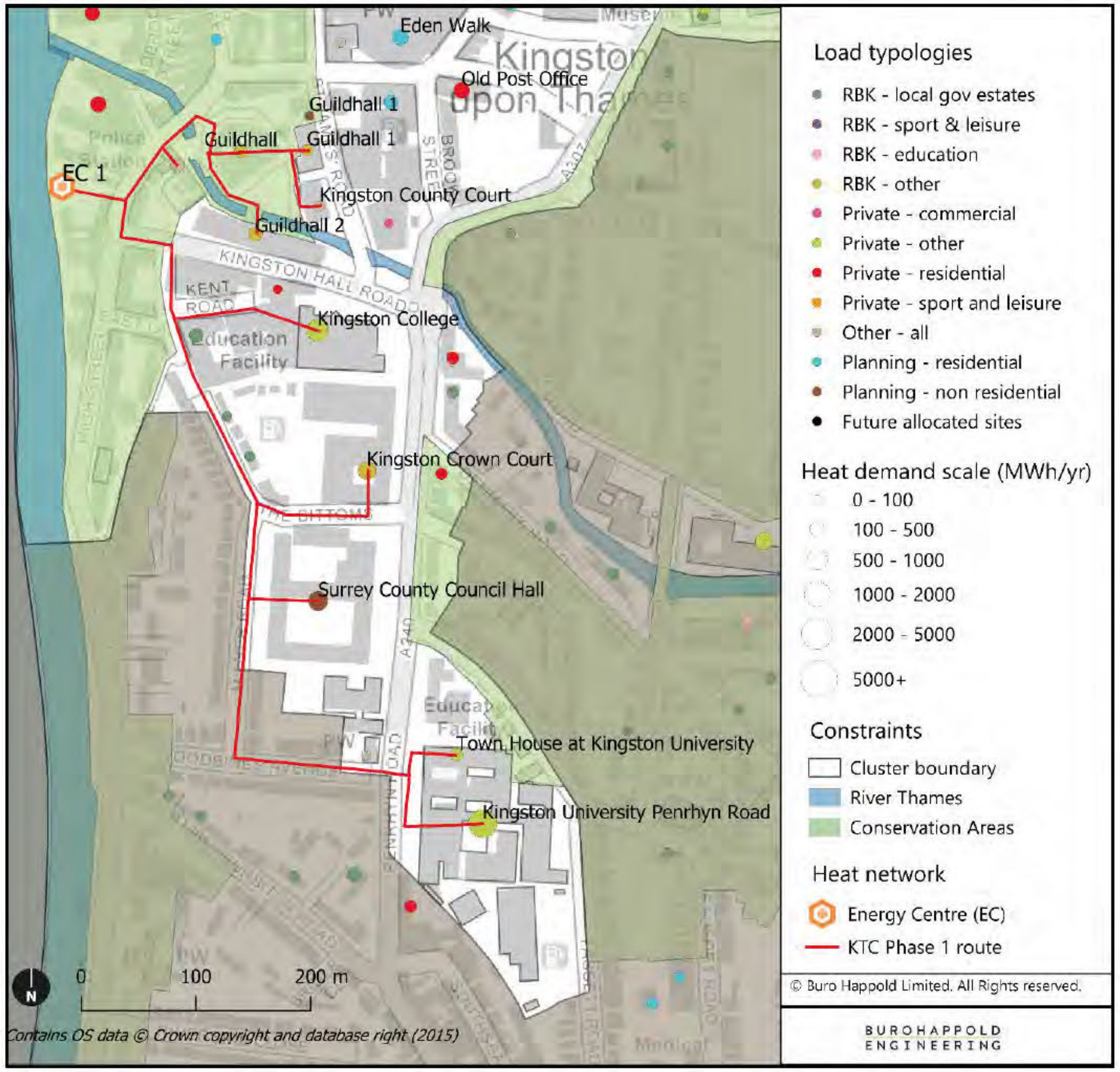


Figure 6.20: KTC Phase 1 map

Table 6.23: KTC Phase 1 performance metrics

Metric	Unit	Value
Heat demand	MWh/yr	17,440
Network length	m	1,670
Heat line density	MWh/m	10.4
Peak load	KW	5,770
Percentage of heat load RBK owned	%	22%
Percentage of heat load future	%	14%
Percentage of heat load Tier 1	%	94%
Energy centre technology	-	WSHP (with alternative GSHP at Kingfisher leisure centre)

Description

The Phase 1 network has been developed based on the likelihood of connection. Kingston University's Penrhyn campus have already begun plans for a site wide DHN powered by a WSHP and expressed an interest in serving the wider area. Therefore, the campus acts as the anchor load for the heat network.

The local government owned Surrey Council Hall and Kingston Crown Court are well placed to connect into the network. Surrey County Council Hall have plans for a refurbishment of their estate, it is suggested that any changes to the plant room are in line with connecting into a DHN.

The RBK owned Guildhall estates are well placed for connection into the first phase of the DHN. The are three RBK controlled buildings within the Guildhall complex:

- The Guildhall: initially constructed in 1935, with extensions in 1968 and 1983, this is a grade II listed building consisting of 5,878m^2 of internal space.
- Two office buildings, Guildhall 1 (2609m^2) and Guildhall 2 (11,765m^2) have since been added to the site, constructed in 1980 and 1981 respectively.

RBK are currently commissioning a review of the operational estate, with a first phase due in March 2019[33]. It is suggested that attention is paid in this report to the potential to retrofit the estate for connection to a DHN.

The busy A240 acts as a significant physical barrier to heat load connection. There are a couple of private student halls of residence that could be connected to the network. However, it was assessed that their lower likelihood to connect and additional heat load would not warrant the large public disruption that closing the A240 would bring.

All the heat loads connected in Phase 1 are listed in Table 6 24.

33 BuroHappold consultation with Tim Pritchard (RBK's Interim Corporate Head of Service – Property)

Table 6.24: KTC Phase 1 heat loads

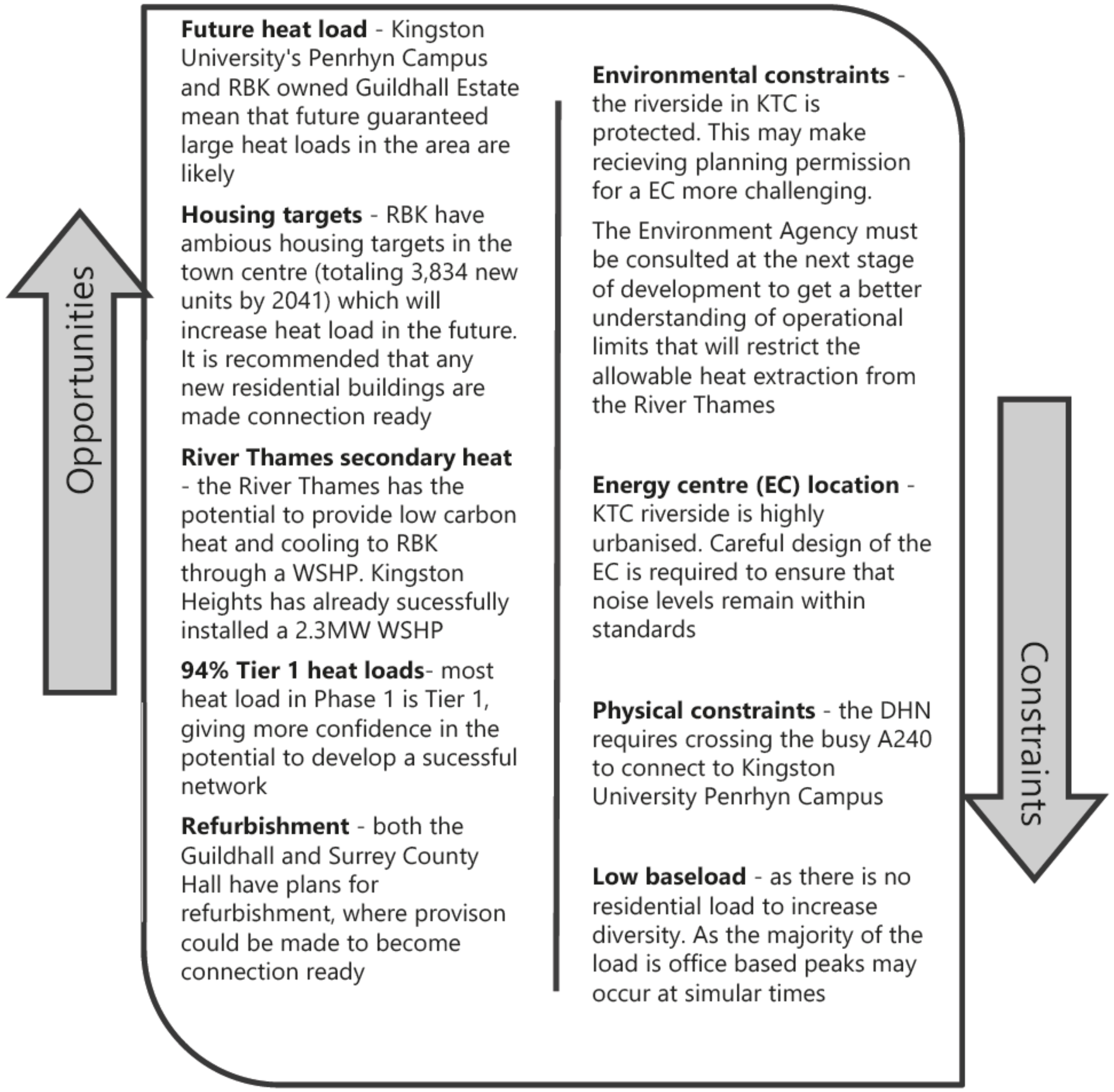
Site	Description	Heat supply	Heat load (MWh/yr)	Tier	Confidence level	Ownership	Status	No. units/ GIA (m^2)
Surrey County Council Hall	Proposed renovations in the K+20 plans	Unknown	2,450	1	CL1	Other Public	Pre-planning (renovation)	24,577 m^2
Guildhall	Renovation to existing building	Unknown	579	1	CL1	RBK	Existing / renovation	3,440 m^2
Guildhall 1	RBK offices	Unknown	296	2	CL1	RBK	Existing	2,281 m^2
Guildhall 2	RBK offices	Unknown	909	1	CL1	RBK	Existing	7,270 m^2
Kingston College	Education facility	Central boilers	3,219	1	CL2	Private	Existing	8,712 m^2
Kingston Crown Court	Crown court and offices	Central boilers	2,000	1	CL2	RBK	Existing	16,231 m^2
Kingston University Penrhyn Road	Education facility	Central boilers	6,490	1	CL2	Private	Existing	69,150 m^2
Town House at Kingston University	Education facility	ASHP	668	2	CL3	Private	Under construction	9,027 m^2
Kingston Police Station	Police station	Unknown	714	1	CL2	Other Public	Existing	3,742 m^2
Kingston County Court	Court rooms	Unknown	118	2	CL2	Other Public	Existing	1,135 m^2

Energy centre location and technology

The River Thames is well located in KTC to provide a substantial secondary heat source for the proposed DHN scheme.

The proposed energy centre is located at Eagle Wharf, on the riverfront. KTC riverfront is highly urbanised, leaving little available room for an energy centre (EC). Eagle Wharf is RBK owned public space, however it is located within the KTC conservation area. This could make obtaining planning permission challenging. However, Kingston Heights, located just north of the railway bridge, have successfully installed a WSHP to capture some of secondary heat available in the Thames.

Opportunities and constraints



Initial plant sizing

The results of the initial plant sizing at detailed in Table 6.25 and Figure 6.21 below. The thermal store has been sized based on providing 2 hours of the peak low carbon heat supply of each cluster.

The WSHP and thermal store provide 87% of the networks annual heat demand, with gas boilers providing the additional heat at peak times. The gas boilers have been sized to peak, to ensure the heat demand can be met if the WSHP requires maintenance.

Table 6.25: KTC Phase 1 plant sizing results

KTC Phase 1 (16.9GWh/yr, 8.2MW)	Unit	Value
Low carbon heat technology	-	WSHP with back-up boilers
Low carbon heat supply capacity	MW	1.7
Thermal store capacity	MWh / litres	5.38 / 107,430
Gas boiler capacity	MW	8.2
% yearly supply from low carbon heat	%	70%

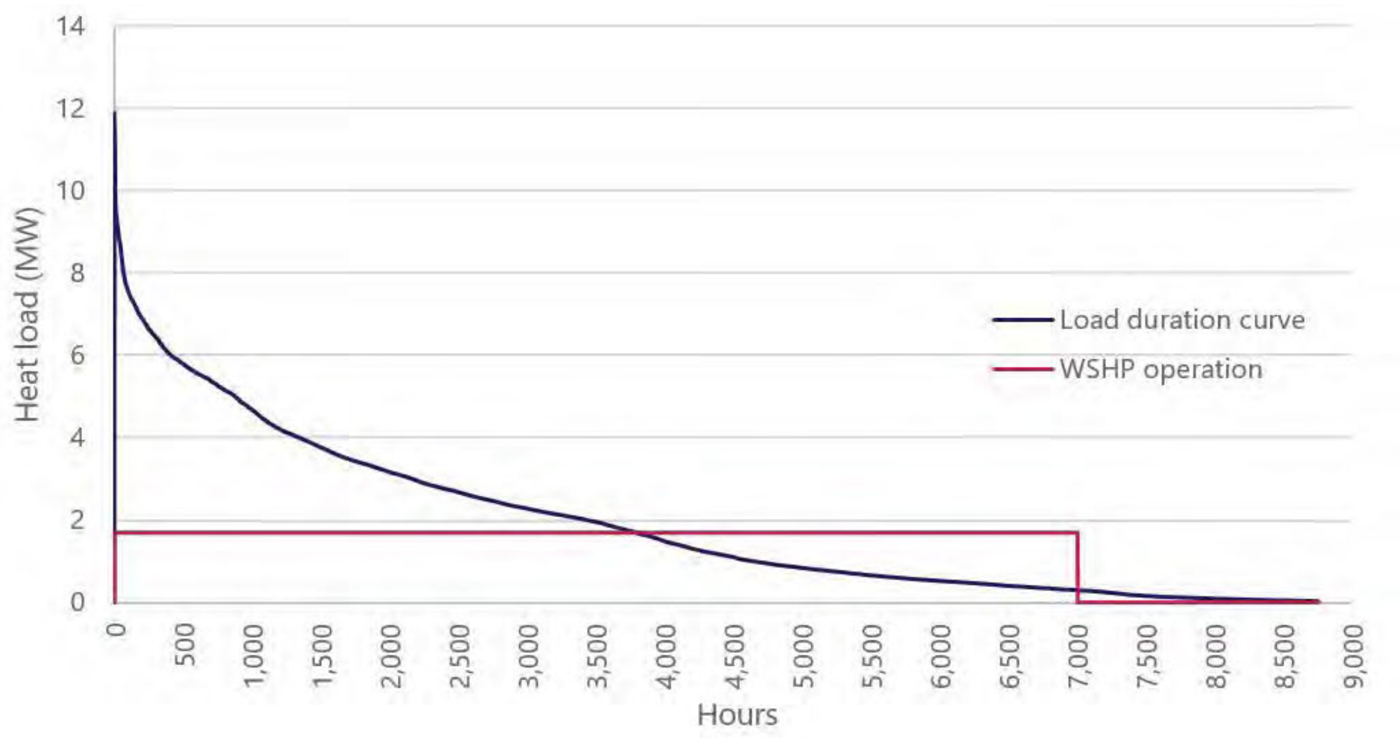


Figure 6.21: KTC Phase 1 heat load duration curve

6.3.8.2 PHASE 2

Summary

Phase 2 of the KTC scheme extends the network north, through the Eden Quarter where new mixed commercial and residential developments are substantially increasing the heat load in the area, which currently is dominated by the Kingfisher Leisure Centre. Phase 2 also connects the RBK owned housing assets in South Kingston. It is proposed that the WSHP EC at Eagle Wharf is extended to accommodate the additional 7.2GWh/yr of heat load on the network. An alternative EC at the Kingfisher Leisure Centre is also proposed if this extension is not feasible due to space or environmental constraint. This EC will be powered by a GSHP array in the adjacent RBK owned playing field.

Overview

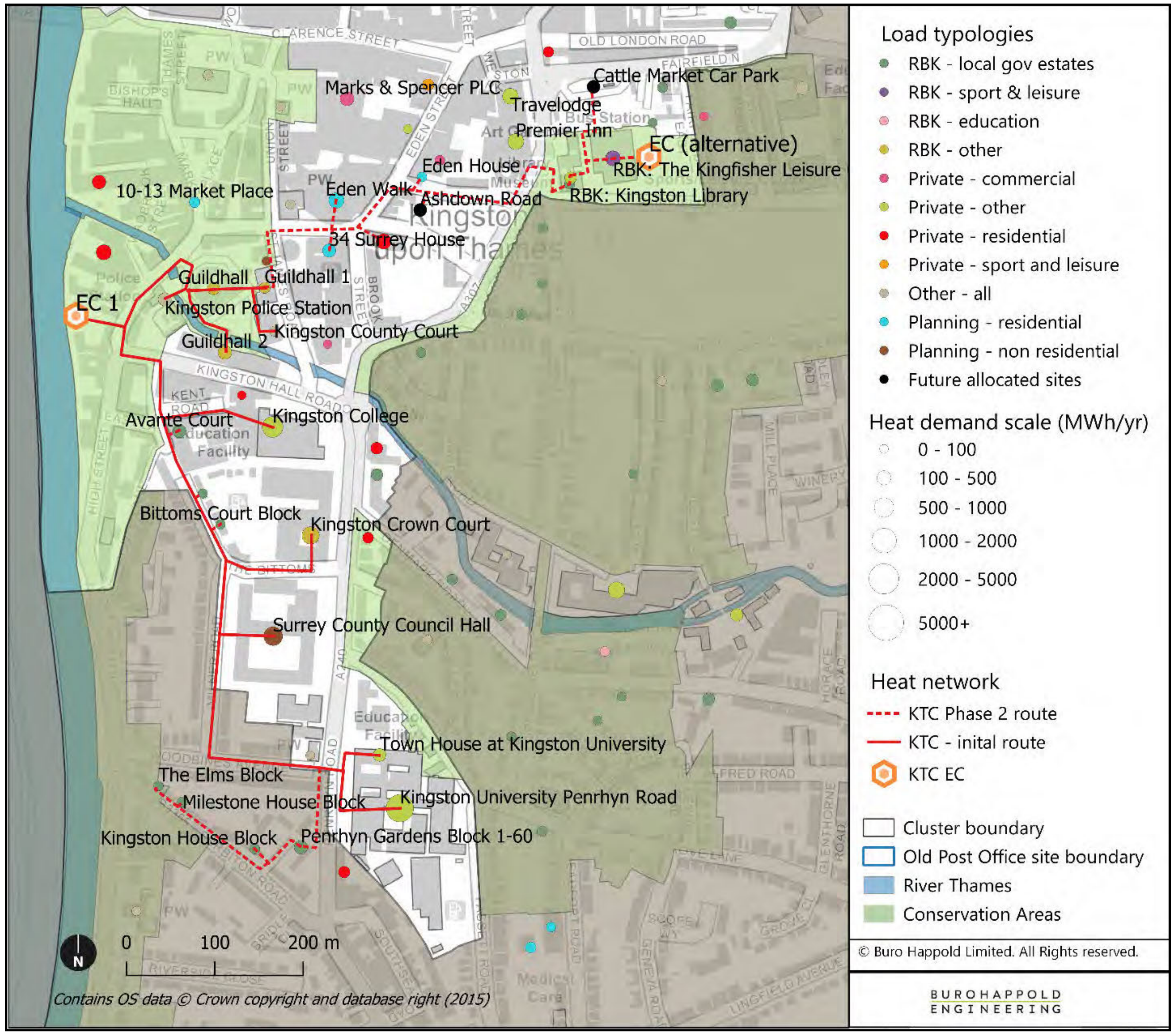


Figure 6.22: KTC Phase 2 map

Table 6.26: KTC Phase 2 performance metrics

Metric	Unit	Value
Heat demand	MWh/yr	24,670
Network length	m	2,890
Heat line density	MWh/m	8.5
Peak load	KW	12,110
Percentage of heat load RBK owned	%	27%
Percentage of heat load future	%	19%
Percentage of heat load Tier 1	%	92%
Energy centre technology	-	WSHP (with alternative GSHP at Kingfisher leisure centre)

Description

Phase 2 of the proposed KTC DHN extends north, over Hogsmill River to the Eden Quarter. The majority of heat loads here are mixed commercial and residential, meaning they will have both heating and cooling demand. However, all developments (excluding Surrey House and Eden House) have already been accepted for planning permission or are under construction. It is therefore thought that the short term opportunity to develop a DHN in this area has been missed.

Details of the additional loads connected in Phase 2 are detailed in Table 6.27. Most notably Eden Walk, with a 1.4GWh/yr estimated heat load could provide substantial long term heat load to the network if the development is made ready for future DHN connection. Eden Walk is due to be complete in 2022[34]. The Cattle Market Car Park is well placed to connect into the DHN. Ashdown Road, adjacent to The Old Post Office development, is another RBK owned surface car park. If a developer takes up the site it could also provide significant heat load to the DHN. As no plans are known for these sites, these are not included in the total heat load of the cluster.

Kingfisher Leisure Centre has been identified by RBK for refurbishment[35]. RBK's refurbishment plans are not currently in place but provision should be made in the energy centre for expansion to serve the wider network.

34 BDP, 2019. Eden Walk Facts. Available at: <http://www.bdp.com/en/projects/a-e/eden-walk/> [Accessed 15 March 2019]

35 Royal Borough of Kingston upon Thames Local Development Framework, 2008. Kingston Town Area Action Plan (K+20).

Table 6.27: KTC Phase 2 heat loads

Site	Description	Heat supply	Heat load (MWh/yr)	Tier	Confidence level	Ownership	Status	No. units/ GIA (m²)
Eden House	New mixed residential and retail block	Proposed CHP	81	3	CL2	Private	Awaiting approval	39 units / 565 m² retail
Eden Walk	New mixed residential, commercial, retail development	Proposed CHP (185kWe / 300kWth)	1,396	1	CL2	Private	Approved	45,676 m² total
34 Surrey House	New mixed residential and commercial	CHP	788	1	CL2	Private	Awaiting approval	322 units / 2,060 m² commercial
Old Post Office (Royal Exchange Kingston)	New mixed residential and commercial	CHP	1,319	1	CL3	Private	Under construction	320 units / 3963 m²
Avante Court	Residential block	Electric heating	864	1	CL3	RBK	Existing	4,988 m²
Kingfisher Leisure Centre	Sports and leisure facility	Unknown	1,269	1	CL2	RBK	Existing	3,431 m²
Penrhyn Gardens	RBK housing estate	Gas boilers	807	1	CL3	RBK	Existing	58 units
Kingston House Block	RBK housing estate	Gas boilers/ electric heaters	125	2	CL3	RBK	Existing	9 units
Milestone House	RBK housing estate	Gas boilers	167	2	CL3	RBK	Existing	12 units
The Elms Block	RBK housing estate	Gas boilers	70	3	CL3	RBK	Existing	5 units
The Bittoms Block 29-35	RBK housing estate	Gas boilers	56	3	CL3	RBK	Existing	4 units
Bittoms Court Block	RBK housing estate	Gas boilers	111	2	CL3	RBK	Existing	8 units
Kingston Library	Library	Unknown	168	2	CL1	Other Public	Existing	840 m²

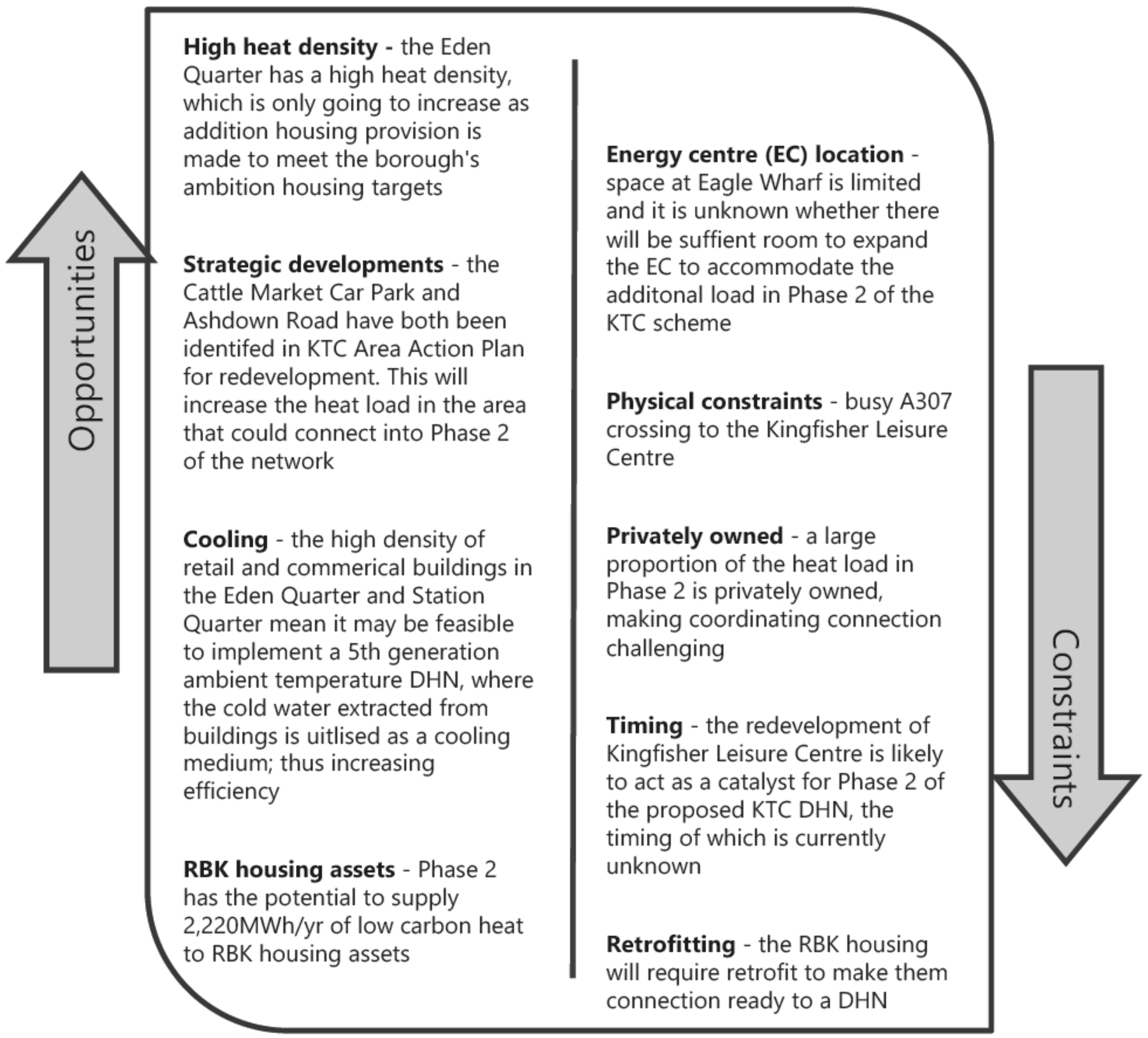
Energy centre location and technology

It is proposed that the energy centre (EC) at Eagle Wharf is extending to accommodation addition WSHP units. However, the available land area at this location is limited.

An alternative EC is proposed within the Kingfisher Leisure Centre to house a GSHP system. The RBK owned leisure centre and associated Cattle Market Car Park development is likely to act as a catalyst to the Phase 2 network. It is also located adjacent to RBK owned Fairfield Park, where the GSHP ground array can be installed.

The section of Fairfield Park adjacent to Kingfisher Leisure centre is 14,000m². Assuming an array with 4kW heat extraction per borehole and 5m minimum space between boreholes, this area could extract 2.4MW across 610 boreholes. Assuming a COP of 3 this equates to 3.6MW of useful heat; more than enough to for the cluster.

Opportunities and constraints



Initial plant sizing

The results of the initial plant sizing are shown in Table 6.28 and Figure 6.23. The WSHP and thermal store have been sized to provide 82% of the clusters annual heat demand, with boilers suppling the remaining heat at peak times.

Table 6.28: KTC Phase 2 plant sizing results

KTC Phase 1 & 2 (24.2GWh/yr, 14.6MW)	Unit	Value
Low carbon heat technology	-	WSHP or GSHP with back-up boilers
Low carbon heat supply capacity	MW	2.4
Thermal store capacity	MWh / litres	4.83 / 153,230
Gas boiler capacity	MW	14.6
% yearly supply from low carbon heat	%	70%

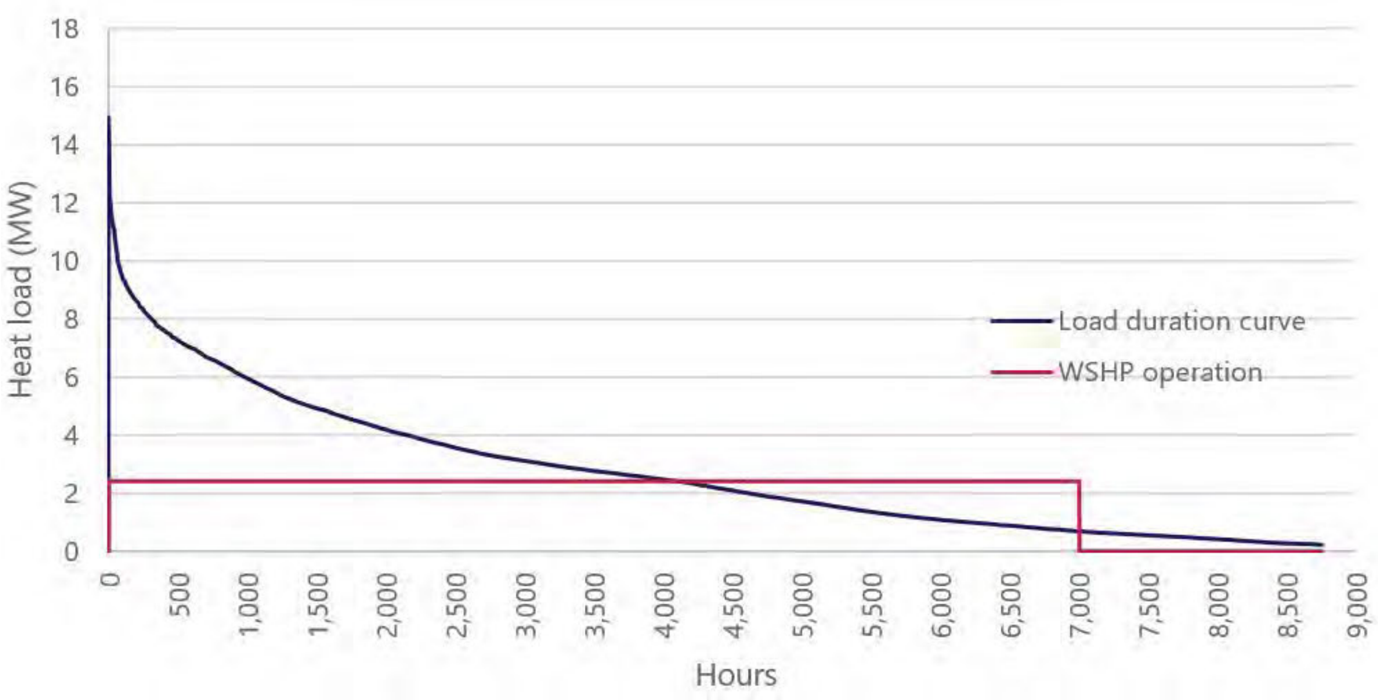


Figure 6.23: KTC Phase 1&2 heat load duration curve

Cooling loads

The large amount of commercial and retail buildings in KTC means that the area may have significant cooling loads that could be met in a 5GDH network. Benchmarks have been used to estimate the cooling load where information was not available from energy strategies or from DEC Aircon reports. It is assumed that there is no cooling required in residential buildings. The estimated peak and annual cooling loads for the main sites identified in KTC are shown in Table 6.29

Table 6.29: KTC estimated peak and annual cooling loads

Site name	Annual cooling load (MWh/yr)	Peak cooling load (kW)	Data source
Kingston University Penrhyn Road	2,697	857	DEC air-con certs
Guildhall	296	299	Benchmark
Guildhall 1	196	198	Benchmark
Guildhall 2	625	632	Benchmark
Kingston Police Station	146	112	Benchmark
Surrey County Council Hall[36]	1,057	1,069	Benchmark
Kingston College	340	305	Benchmark
Kingston County Court	44	34	Benchmark
Kingston Crown Court	633	487	Benchmark
Town House at Kingston University	352	316	Benchmark
RBK: The Kingfisher Leisure Centre	106	103	Benchmark
Eden Walk	170	1,298	Energy strategy
Eden House	4	40	Energy strategy
Old Post Office	16	277	Energy strategy
34 Surrey House	156	144	Energy strategy
John Lewis Plc	1,779	2,270	DEC air-con certs
The Bentalls Department Store	1,747	3,605	DEC air-con certs
Marks & Spencer PLC	1,113	960	DEC air-con certs

36 Assuming only 50% of the 24,500m^2 GIA at Surrey County Hall is cooled

The main cooling loads are Kingston University Penrhyn Campus, Surrey County Council Hall, John Lewis, Bentalls Department Store and Marks & Spencer. From previous BuroHappold experience, 5GDH using the ground as a heat sink are only viable if cooling meets at least 60% of the annual heat load of the network. Table 6.30 shows neither network attains this; with Phase 1 achieving the highest percentage of 38% of annual heat load.

A 5GDH network could still be considered using the river to balance network loads however this scheme would be more reliant on simultaneous heating and cooling to achieve optimal efficiencies whereas a ground source scheme can store the waste heat / coolth in the ground.

Table 6.30: Annual cooling loads per cluster[37]

Network	Annual cooling load (MWh/yr)	Annual heating load (MWh/yr)	Percentage of annual cooling load to annual heat load
KTC Phase 1	6,390	16,940	38%
KTC Phase 2	6,840	24,160	28%
KTC Phase 1+2 (plus John Lewis, Bentalls and M&S cooling loads)	11,010	30,920	36%

37 Assuming a 0.9 diversity factor per cluster

6.4 STRATEGIC NETWORK

The results of the cluster analysis indicate that a larger DHN scheme, centring on the Hogsmill Sewage Treatment Works outfall is feasible. The estimated heat demand from the CRE cluster is only utilising 9% of the estimated capacity of waste heat available from the Hogsmill outfall.

Connecting the 8.9GWh/yr CRE cluster with the 25.3GWh/yr Kingston Hospital and the Kingston Town Centre (KTC) clusters gives the potential to fully utilise the Hogsmill outfall waste heat supply and provide a large proportion of RBK with low carbon heat. Connecting the Kingston Hospital energy centre will provide additional resilience to the network, as well as a Thames fed RSHP in KTC. The proposed network is shown in Figure 6.24.

It is estimated that at least 50.5GWh of heat from the Hogsmill outfall could be available. This will require up to 2MW of additional electric power to operate the heat pumps at the energy centre. A private wire connection from a solar PV array on the Thames Water land at Hogsmill could provide supporting electricity to power the heat pumps. Integrating solar PV capacity into the new CRE design could also feed into the private wire network.

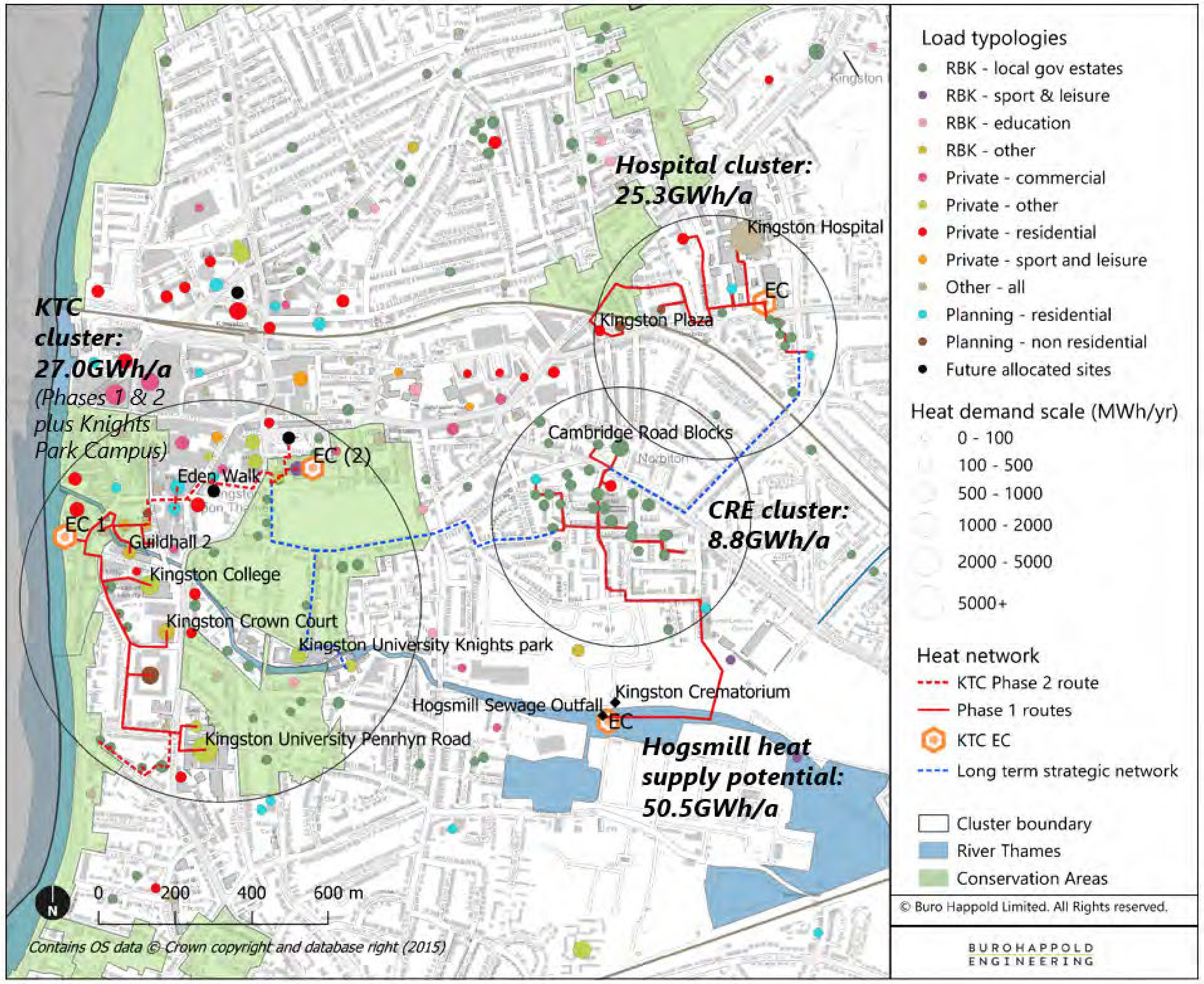


Figure 6.24: Strategic network initial route

6.4.1 GO CYCLE PROGRAMME

RBK are currently undertaking the Go Cycle programme[38]; looking at a number of key routes and spaces across the borough to improve cycling facilities and road safety. There are a number of routes currently being considered within the programme, shown in Figure 6.25. It is recommended that any future DHN construction works in close association with this programme to ensure road aren't unnecessarily dug up twice.

Attention has been paid to roads that have already been upgraded under this programme, particularly in KTC, where it is unlikely that planning permission will be granted to re-dig for DHN construction. Key areas where Go Cycle routes and the proposed DHN routes interact are:

- **Connecting Kingston and New Malden:** the proposed Go Cycle route along Cambridge Road and Kingston Road are being looked at to see how to improve safety and connectivity to those travelling by foot of bicycle. This route runs along the north boundary of the CRE, where the proposed DHN crosses Cambridge Road to connect to the social housing blocks to the north. Construction works should be aligned with planned repaving of Cambridge Road
- **Kingston Hill Road:** is being looked at to improve cycle links between Kingston and Kingston Vale. A small section of the Kingston Hospital cluster runs along the A308 to connect to Kingston Plaza, on the same route where the Go Cycle route is situated
- **Kingston Town Centre:** the DHN route in both KTC phase 1 and 2 has been developed to cause minimal disruption to the Go Cycle programme and ensure newly paved roads are not being re-dug. However, the DNH route crosses the Go Cycle routes in two places, the A240 at Kingston University Penrhyn Campus and the A307 at the Kingfisher Leisure Centre. It is not thought that this will cause major disruption to the Go Cycle programme, however coordination is important to minimise unnecessary roadworks.

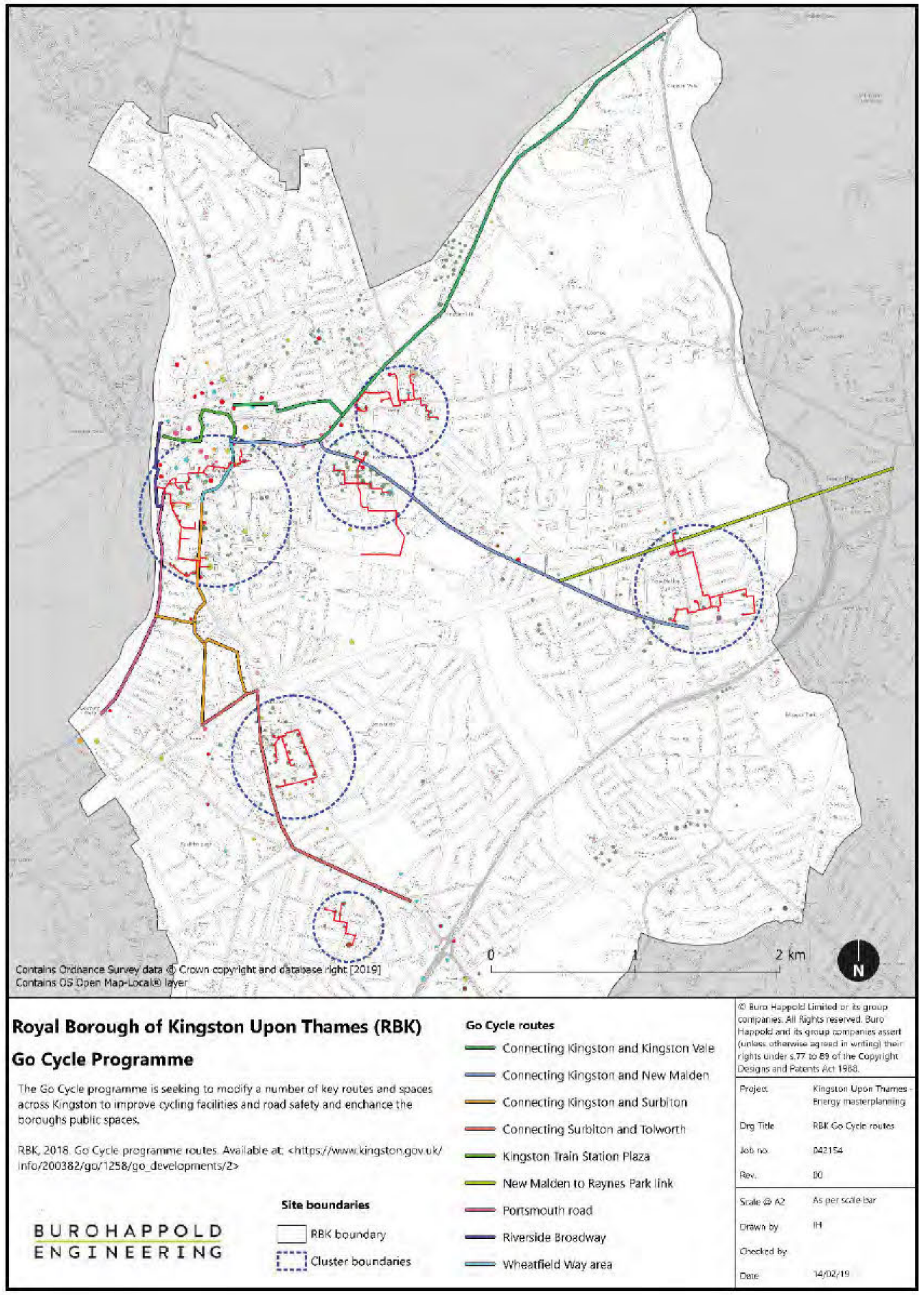


Figure 6.25: Go Cycle routes

38 https://www.kingston.gov.uk/info/200382/go/1258/go_developments/2

7 COMMERCIAL APPRAISAL

7.1 APPROACH

The proposed schemes were commercially assessed with a financial model, which estimates the return on investment over the lifetime of the project using a number of inputs. The model calculates the energy consumption of the network, the capital expenditure (CAPEX), operation expenditure (OPEX), replacement expenditure (REPEX), and income from heat sales over the lifetime of the project. A sensitivity analysis was then performed to test the schemes with various levels of capital grant funding, Renewable Heat Incentive (RHI) funding and heat sales price reduction. The process is summarised in Figure 7.1.

The three main financial outputs calculated are:

- **Internal rate of return (IRR)** – the discount rate at which the project NPV is equal to zero at the end of the project lifetime
- **Net present value (NPV)** – the cumulative present value of net project cash flow over a period of time
- **Discounted payback** – payback with positive net project cash flow taking into account the time value of money.

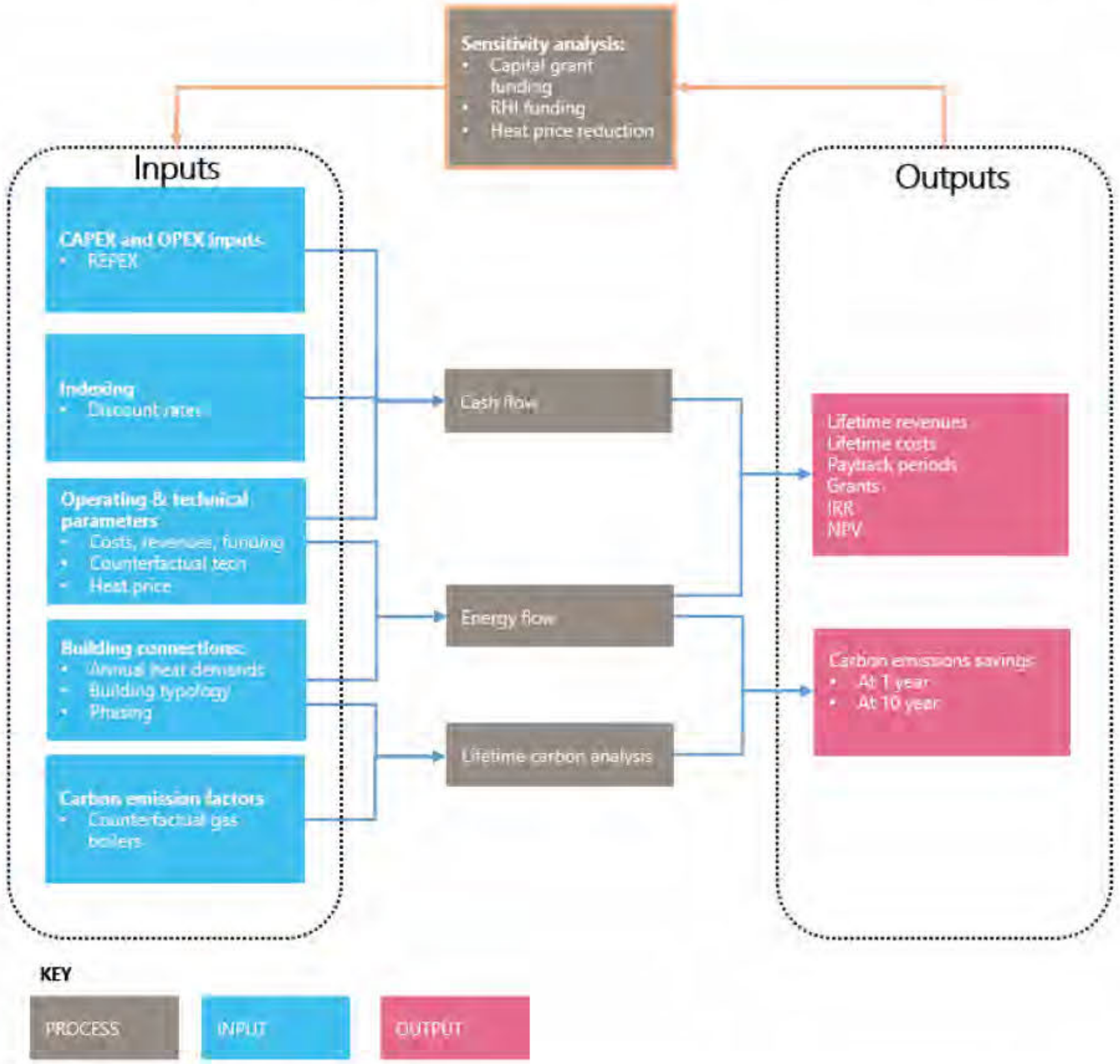


Figure 7.1: Techno-economic model process summary

7.2 COMMERCIAL STRUCTURES

There are several common commercial structures usually implemented during the development of a DHN. The commercial structure chosen will depend on the local authority's desired level of control over the project outcomes, available capital, expected IRR and the level of risk willing to be undertaken.

A DHN can typically be structured in three ways (summarised in Table 7.1):

1. Private – local authority (LA) selects an Energy Services Company (ESCo) to deliver and operate the scheme. The ESCo sells heat to customers on the network
2. Public – local authority sets up an in-house department to deliver and operate the network. The LA sells heat to customers on the network. The LA can reduce risk by contracting an experienced company to maintain and operate the network
3. Joint venture – a hybrid ownership scheme where the local authority sets up a partnership with a private sector company. Where the private sector company constructs, owns and operates the EC and associated assets. The heat network and building connections are constructed, operated and owned by the LA, who sell heat to customers.

Table 7.1: Commercial model ranking

Ownership model	Council level of project control	Risk level to council	Level of council capital required	IRR required
Fully -public - Council leads project with external construction contract. Operation is in-house.	High	High	High	Low
Private - ESCo leads project, with council playing a facilitator role	Low	Low	Low	High
Joint venture – hybrid ownership between private and public sectors	Medium	Medium	Medium	Medium

7.2.1 IDENTIFIED CLUSTERS OWNERSHIP

The ownership models shown in Figure 7.2 and Figure 7 3 were used for the techno-economic appraisal. Ownership model 1 (Figure 7.2) was used for Tolworth 2, New Malden Phase 1, KTC Phase 1 and Phase 2, Surbiton and Chessington (with central EC). This is the simplest ownership model; where one company owns and operates the whole network up to and including the building level heat exchangers and residential HIUs. In this model it is also assumed the DHN owner pays for the retrofit of existing residential and commercial buildings for connection on the network (including residential HIUs). New build connections are assumed to be connection ready at the building heat exchanger unit.

This ownership model differs slightly for the CRE cluster. The proposed EC land and secondary heat source at Hogsmill Sewage Treatment Works are both owned by Thames Water. After initial consultation with Thames Water, it is assumed that the land for the EC is provided by Thames Water, along with area on which to build the heat off-take infrastructure – subject to later commercial discussions. This will also include access to the sewage outfall location and EC for operation and maintenance purposes. All energy plant and heat off-take infrastructure is owned by the DHN owner. In return for the use of the land and Hogsmill secondary heat source, a heat price has been assumed to be paid to Thames Water by the DHN owner. It is recommended that further negations with Thames Water are made to agree an appropriate price at a later stage of network development.

Figure 7.3 shows the ownership model for Kingston Hospital. The hospital constitutes 90% of the clusters total annual heat load (excluding the proposed new residential block on the site). Consultation with the NHS Trust for Kingston Hospital identified the planned demolition of their existing EC in 2019-2022, which contains a CHP unit currently working on a 40 year old steam network. This will be replaced by a new EC which will provide low carbon heat to the hospital site on an upgraded heat distribution network. It is recommended that the network temperature is lowered to become a hot water network, in line with the 4th generation district heating guidelines. The Sustainable Development Management Plan[39] identifies interest from the NHS Trust in providing low carbon heat the wider area to reduce their carbon emissions.

As Kingston Hospital is already planning a new energy centre the heat load from the hospital site, distribution pipework to on-site buildings and any heat exchangers are not included in the model as it is likely that this would be operated by the hospital as part of their daily operations (as their current network is). Although the Hospital Trust may wish to operate the network off-site and receive the heat sales revenue for the whole network they may alternatively sell heat to the edge of their site to a separate network operator.

It is assumed the DHN Operator provides the heat to serve the wider area, as well as the additional plant room equipment. Therefore the off-site network and connections CAPEX, as well as connecting the proposed new on-site residential block, are included in the modelling. For simplicity, the techno-economic model has been set up assuming the energy centre on the hospital campus is run by the DHN operator. The DHN operator pays a rate to Kingston Hospital for the use of their facilities and land. These are preliminary cost estimates that need further negotiation with the stakeholders at a further stage of network development.

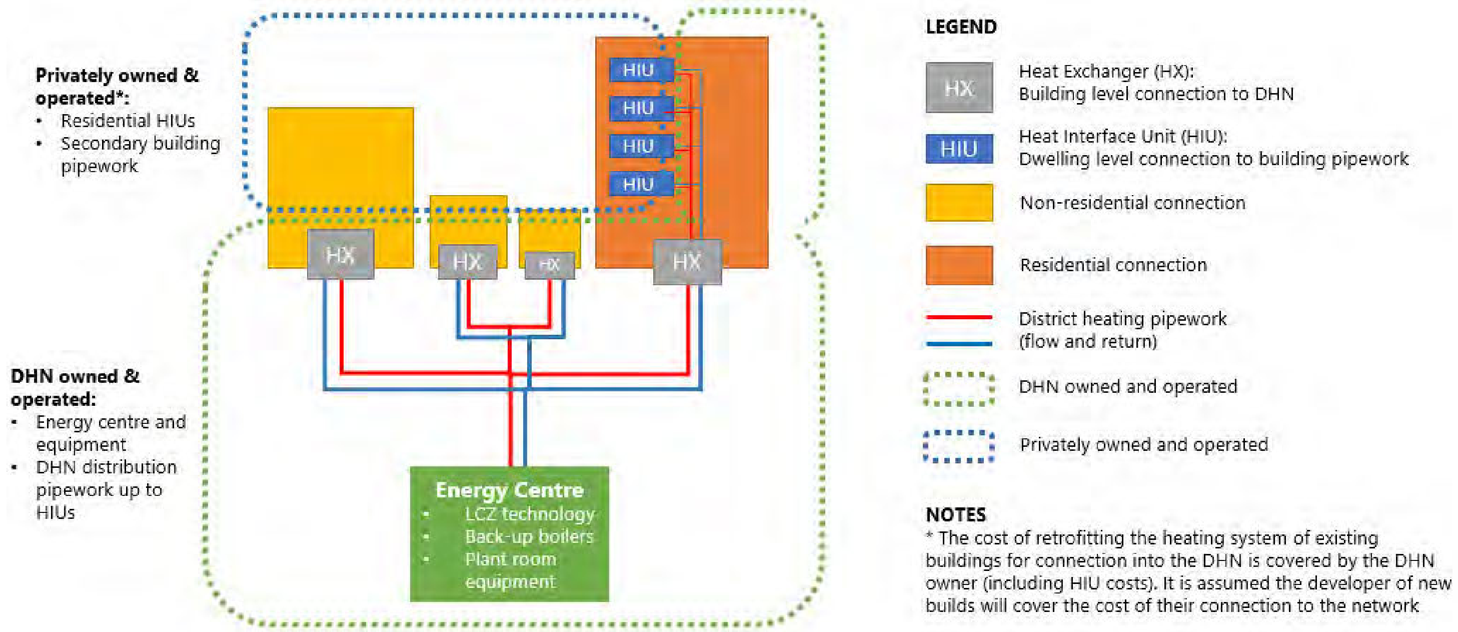


Figure 7.2: Ownership model 1

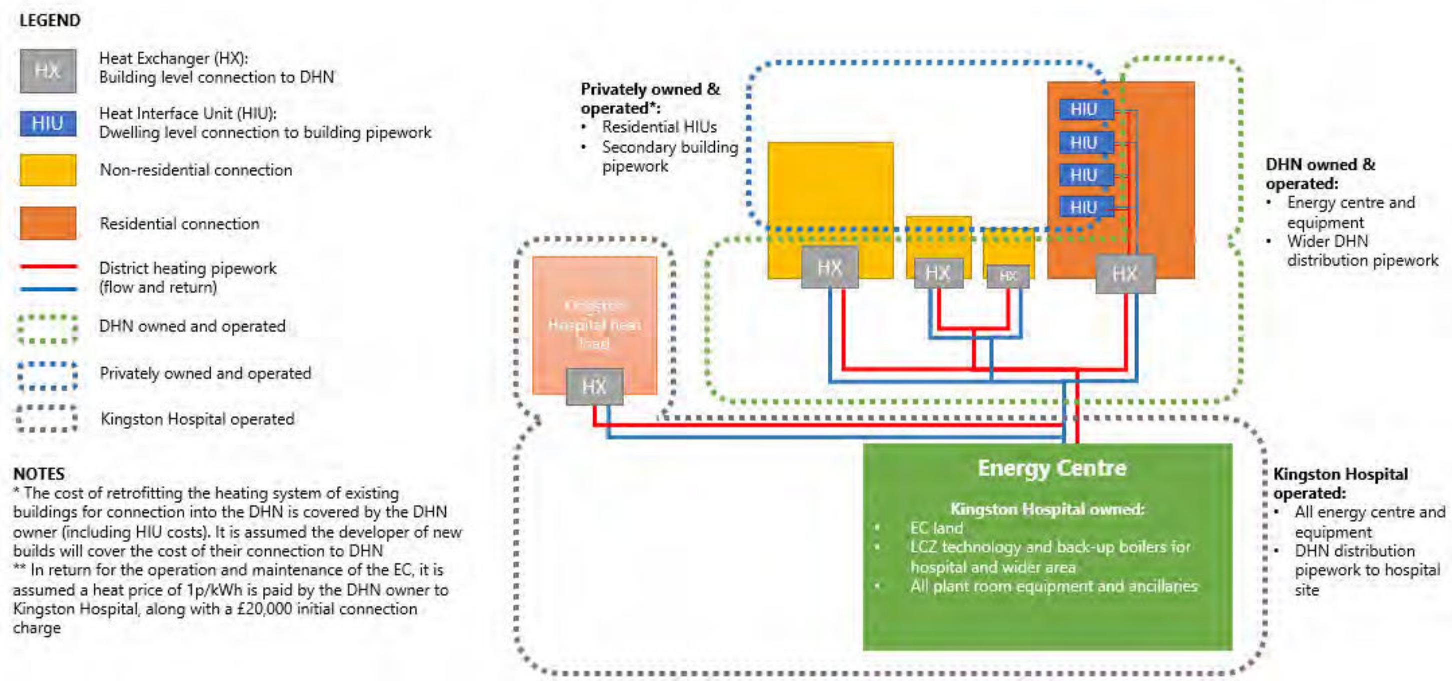


Figure 7.3: Ownership model 3 – Kingston Hospital

39 https://www.kingstonhospital.nhs.uk/media/288278/enc-i-sustainable-development-management-plan-2018-2023.pdf

7.3 TECHNO-ECONOMIC MODEL INPUTS

The key inputs and assumptions used in the Techno-economic model (TEM) are provided in Appendix G. No connection charges have been included in the models as a conservative estimation at this stage. The Chessington cluster was modelled with a central energy centre to allow for direct comparison with other clusters. A comparison with the individual heat pumps connected to a shared loop scheme is provided based on Kensa's cash flow model (detailed in Appendix B).

7.3.1 CAPEX COSTS

CAPEX costs for each of the cluster have been developed from consultation with manufactures, industry reference data and previous BuroHappold experience of similar projects. A summary of the CAPEX costs for each cluster is shown in Table 7.2 below.

The distribution pipe work CAPEX costs are based on the required pipe capacity per connection and length of pipe from the GIS network routes. The required pipe capacity is based on the total peak heat load of all downstream connections, taken from the load schedule. Pipe sizing is based on a delta-T of 30K, maximum velocity 3m/s and maximum allowable pressure gradient 100Pa/m. Standard pipe dimensions ranging from 20mm-1,200mm have been used. All pipes are assumed to be hard dig to produce a conservative estimate of cost. The unit costs of pipework are based on costs from previous BuroHappold projects.

A cost for retrofitting existing buildings is included within the CAPEX, depending on the type of existing heating system. The cost of residential unit heat interface units (HIUs) for new builds is assumed to be covered by the developer, with replacement fund built into DHN operator costs. The CAPEX costs for Kingston Hospital cluster are comparatively lower than the other clusters as it is assumed that the hospital will provide the LZC technology and EC to supply both the on-site and off-site heat demand (see Section 7.2 for full details).

Table 7.2: CAPEX cost summary

Cluster	Energy centre + LZC heat source (£)	DH Network (£)	Heating system retrofit (£)	Total CAPEX (£)
CRE	[redacted]	[redacted]	[redacted]	[redacted]
Kingston Hospital	[redacted]	[redacted]	[redacted]	[redacted]
Tolworth 2	[redacted]	[redacted]	[redacted]	[redacted]
New Malden Phase 1	[redacted]	[redacted]	[redacted]	[redacted]
Surbiton	[redacted]	[redacted]	[redacted]	[redacted]
Chessington (central GSHP)	[redacted]	[redacted]	[redacted]	[redacted]
KTC Phase 1	[redacted]	[redacted]	[redacted]	[redacted]
KTC Phase 1&2 (GSHP)	[redacted]	[redacted]	[redacted]	[redacted]
KTC Phase 1&2 (WSHP)	[redacted]	[redacted]	[redacted]	[redacted]

7.3.2 OPEX, REPEX & BUSINESS COSTS

Operational (OPEX), replacement (REPEX) and business costs were applied to each cluster, based on the rates shown in Table 7.3. The total lifetime costs for each cluster are summarised in Table 7.4.

No Heat supply equipment OPEX costs are included in the Kingston Hospital cluster as it is assumed that the NHS Trust will operate and maintain the network's EC in return for revenue for supplying heat to wider area.

Table 7.3: OPEX rates

Description	Rate	Unit	Reference
OPEX: Heat supply equipment			
Low-carbon technology 1	0.7%	% of CAPEX	40
Top-up technology 1	0.2%	% of CAPEX	44
OPEX: Network and connection equipment			
Plate heat exchangers	0.90	p/kWh	41
Secondary system O&M	24	£/unit/yr	Previous BuroHappold project (applied to residential units only)
Heat meters - metering and billing	80	£/unit/yr	Previous BuroHappold project
District network	0.04	p/kWh	44
Business rates			
Staff costs	0.25	p/kWh	44
Business costs	0.70	p/kWh	44
REPEX expenditure			
% REPEX cost incurred	70%	% of heat supply CAPEX	Assumed

Table 7.4: Total lifetime OPEX, REPEX and business costs

Cluster	Total lifetime (30yrs) OPEX costs (£m)	Total lifetime (30yrs) REPEX costs (£m)	Total lifetime (30yrs) business costs (£m)
CRE	8.94	2.88	1.69
Kingston Hospital[42]	1.66	0.78	0.49
Tolworth 2	1.55	1.03	0.99
New Malden Phase 1	1.98	1.53	0.83
Surbiton	2.60	2.05	1.03
Chessington (central GSHP)	0.51	0.49	0.19
KTC Phase 1	4.34	6.37	3.26
KTC Phase 1&2 (GSHP)	8.42	5.92	4.64
KTC Phase 1&2 (WSHP)	8.36	5.43	4.64

40 Sandvall, A. F. et al., 2017. Cost-efficiency of urban heat strategies – Modelling scale effects of low-energy building heat supply. Energy Strategy Reviews, Vol. 18, p. 212-223. Available at: https://www.sciencedirect.com/science/article/pii/S2211467X17300615
41 Department of Energy & Climate Change (DECC), 2015. Assessment of the Costs, Performance, and Characteristics of UK Heat Networks
42 No OPEX costs for heat supply equipment included in Kingston Hospital cluster, as it is assumed NHS Trust maintain and run the network

[redacted]

7.3.3 HEAT SALES PRICE

The heat sales price shown in Table 7.5 was estimated by calculating the counterfactual cost of heat from individual gas boilers. This approach ensures the DHN heat is competitively priced compared to alternative heating systems. This counterfactual heat price includes the provision and replacement of gas boilers, their maintenance and operation and the gas fuel price. The approach taken is based on the Heat Trust Heat Cost Calculator[43], using inputs and assumptions detailed in Appendix C. The Heat Trust are a consumer protection group for heat networks which networks can sign up to, to provide confidence to residents that they are getting a fair deal. The non-residential cost of heat is based on an estimate of the Eden Walk development counterfactual cost (using details from the energy strategy document). The residential cost of heat is based on an average 2 bedroom flat as defined in the Heat Trust Calculator.

The price can be split into two components: fixed and variable costs. The fixed costs include the CAPEX, OPEX and standing charge. Variable costs represent the unit cost of the counterfactual gas price. It is assumed the CAPEX and OPEX are spread evenly over equipment lifetime. These have been combined into a blended heat price based on the average heat demand of an existing 2 bedroom flat on Heat Trust (6.07MWh/a).

Table 7.5: Cost of heat summary

	Residential	Non-residential
Total blended cost (p/kWh)	[redacted]	[redacted]

New build cost of heat comparison

A blended heat cost has been applied in the techno-economic modelling based on Heat Trust figure, as presented above. Figure 7.4 shows that this demonstrates a saving to residents against the counterfactual (individual gas boilers) when modelled for a new build (with an assumed 3,500kWh annual heat demand). An average new build flat can expect to pay as much as £580/yr if individual boilers are installed, whereas connection into a DHN could cost no more than £400/yr; giving a potential saving per flat of £5,400 over a 30 year scheme lifetime.

7.3.4 CARBON EMISSIONS INPUTS

The carbon emissions of the proposed schemes was analysed using average carbon equivalent factors for UK grid electricity and gas from BIES. A carbon equivalent emissions factor is the mass of carbon dioxide (CO_2), methane and nitrous oxide emitted for each unit of energy consumed ($kgCO_2e/kWh$). BEIS produce annual projections of these factors for the UK. Figure 7.5 shows the electricity carbon factor is forecast to decrease significantly in the next 40 years due to increased uptake of renewable energy generation on the grid. These are modelled following the BEIS indexed grid average consumption-based (commercial/public sector) values. The grid gas emission factor remains constant over the 30-year lifetime at 0.184$kgCO_2e/kWh$ (the 2018 BEIS gross calorific value factor[44]).

The DHN emissions are compared against the counterfactual case (individual gas boilers) to determine relative carbon savings. The difference between each cluster's energy centre emissions and the counterfactual case equates to the scheme carbon saving.

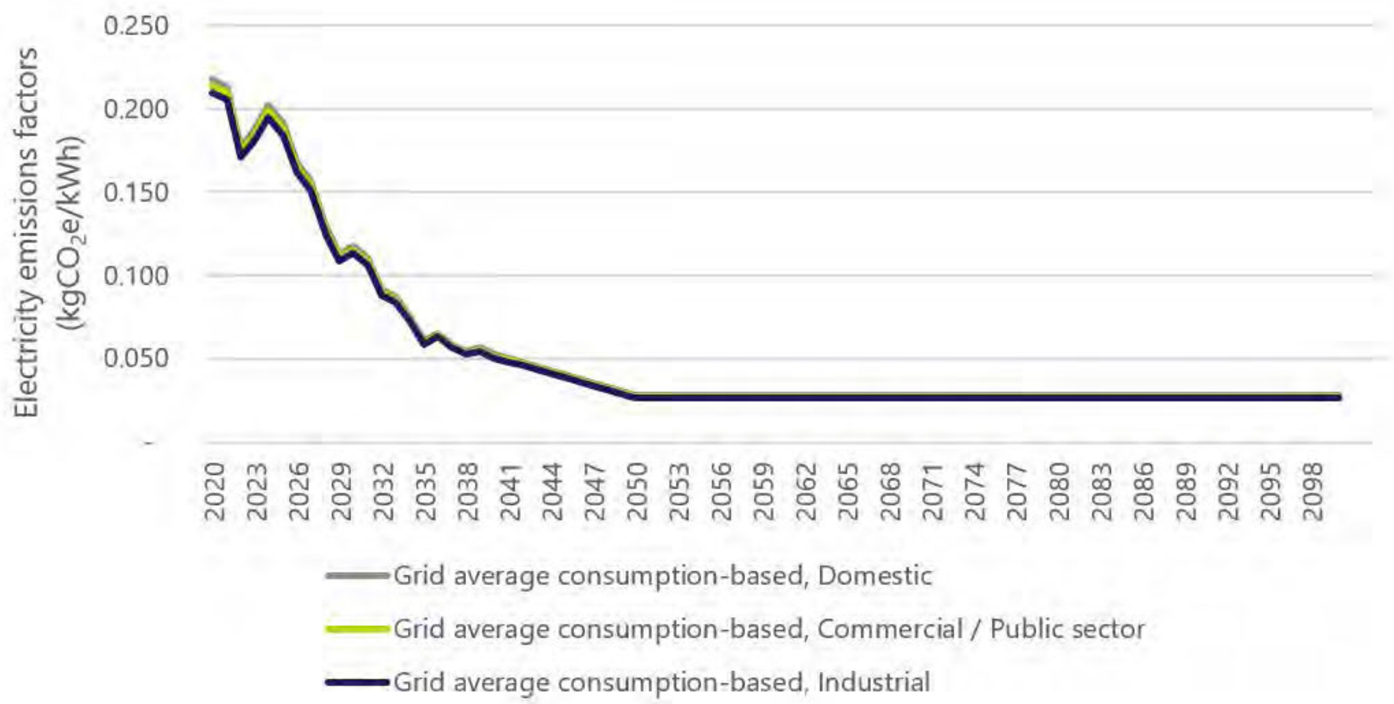


Figure 7.5: BEIS indexed grid electricity carbon factors (2017)[45]

43 Heat Trust, 2018. *Heat Cost Calculator: Further information and background assumptions*. Available at: <http://www.heattrust.org/images/docs/HCC_Further_information_and_assumptions_Jan2019_update__v1.pdf>

44 Department for Business, Energy & Industrial Strategy (BEIS), 2018. Greenhouse gas reporting: Conversion factors 2018. Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018

45 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/666406/Data_tables_1-19_supporting_the_toolkit_and_the_guidance_2017.xlsx

7.4 TECHNO-ECONOMIC MODEL: RESULTS & ANALYSIS

7.4.1 RESULTS SUMMARY

The results from the techno-economic model (TEM) model are summarised in Table 7.6. The model shows that Tolworth 2 and KTC Phase 1 & 2 (GSHP) will achieve a positive payback within a 30 year scheme (assuming a discount rate of 3.5%). This is based on the conservative approach of assuming no capital funding, RHI payments or building connection charges. All other schemes achieve a positive IRR over this period but will need further funding or incentives to meet the minimum hurdle rate identified by RBK Finance of [redacted] See Section 7.5 for funding streams available to RBK.

The Chessington scheme was compared with the two heat supply options, individual GSHPs in each dwelling and a central energy centre: Kensa Engineering have provided a simple cash flow (see Appendix B.2). The results suggest that the individual GSHP scheme will achieve an IRR of [redacted] compared to [redacted] for the centralised scheme. However, it is important to note that this scheme is wholly reliant on securing Renewable Heat Incentive (RHI) funding which may become unavailable post 2021 (see Section 7.5). The real benefit of the scheme is in the potential carbon savings, where the individual heat pump scheme achieved a year 1 emissions saving of 75%. More detailed analysis is provided in Section 7.4.2.

Table 7.6: TEM results summary

Option	Low carbon technology	NPV @ 10 years	NPV @ 30 years	IRR @ 30 years	Discounted payback	Capital costs	DH emissions saving @ year 1	DH emissions saving @ year 10
Unit		*£m*	*£m*	*%*	*yrs*	*£m*	*%*	*%*
CRE	WSHP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	39%	51%
Tolworth 2	ASHP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	34%	49%
New Malden	GSHP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	45%	55%
KTC Phase 1 & 2 - WSHP	WSHP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	39%	51%
KTC Phase 1 & 2 - GSHP	GSHP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	45%	55%
Kingston Hospital	ASHP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	34%	49%
Surbiton	ASHP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	34%	49%
KTC Phase 1	WSHP	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	39%	51%
Chessington (central GSHP)	GSHP (central energy centre)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	45%	55%

7.4.2 CARBON RESULTS ANALYSIS

Figure 7.6 shows the carbon savings of each cluster at year 20 compared to the counterfactual case of gas boilers in each connection. The carbon savings over scheme lifetimes have been calculated using the BEIS energy and emissions projections[46].

All clusters achieve significant carbon savings of above 48% at year 10 of scheme lifetime. New Malden, KTC Phase 1 & 2 (GSHP) and Chessington achieve the highest % saving for clusters with central energy centres, all obtaining 55%. As expected, KTC Phase 1 & 2 achieves the highest emissions savings verses the counterfactual due to its high heat capacity.

Chessington (individual GSHPs) achieves a 10 year emissions saving of 86%, an increase of 31% compared to the central energy centre option. This is because the GSHP is providing 100% of the heating and DHW to the scheme. Whereas, in the central energy centre scheme, 30% of the heat load is met by gas-boilers.

Figure 7.7 shows the projected carbon emissions savings verse the counterfactual for each cluster over a 30 year project lifetime. The carbon emissions savings are predicted to increase throughout the schemes lifetime up until around the year 2040, at which point they level out. This trend is strongly linked to the carbon factor of the grid electricity used to power the heat pumps (described in Section 7.3.4), which shows the carbon intensity of the electricity grid declining over time.

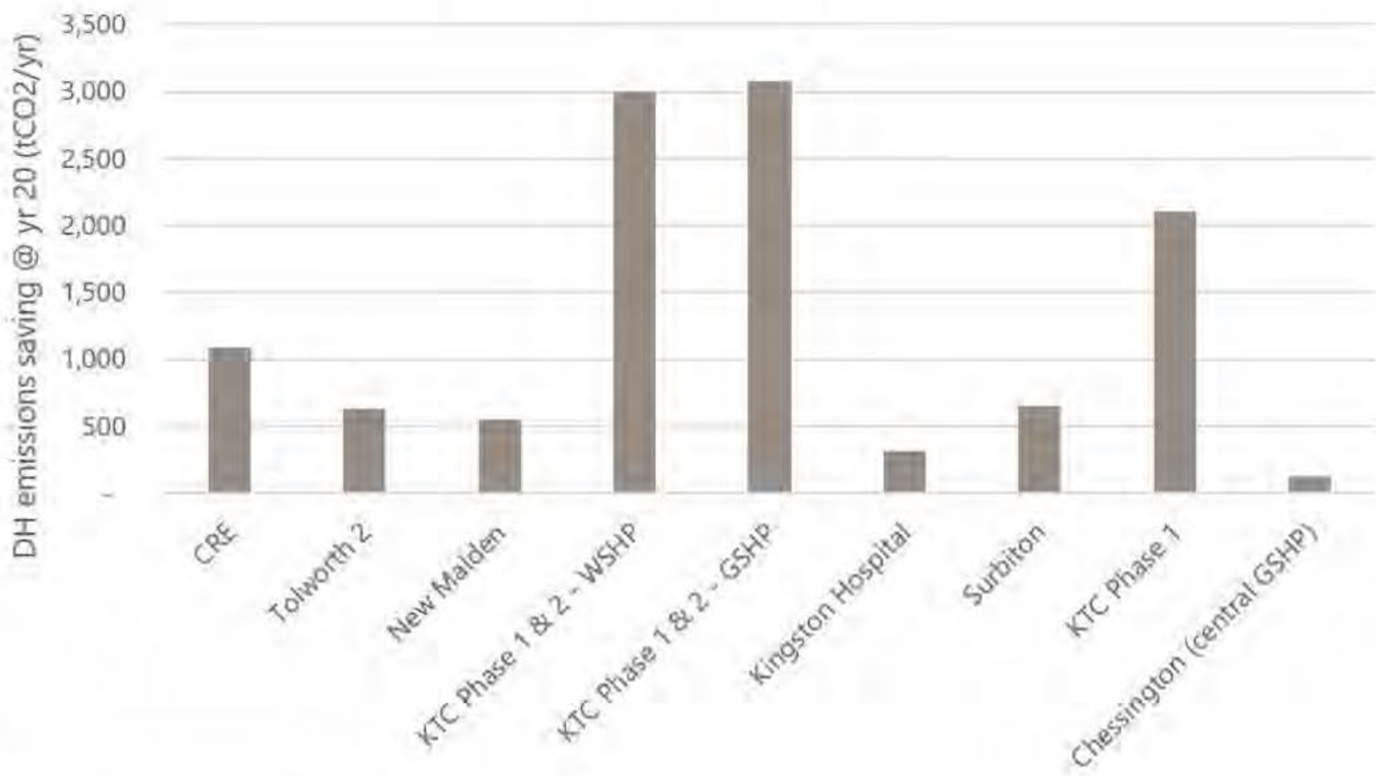


Figure 7.6: % DH network emissions savings at 10yrs

46 BEIS, 2017. Updated energy and emissions projections: 2017. *Department for Business, Energy & Industrial Strategy.* Available at: <https://www.gov.uk/government/collections/energy-and-emissions-projections>

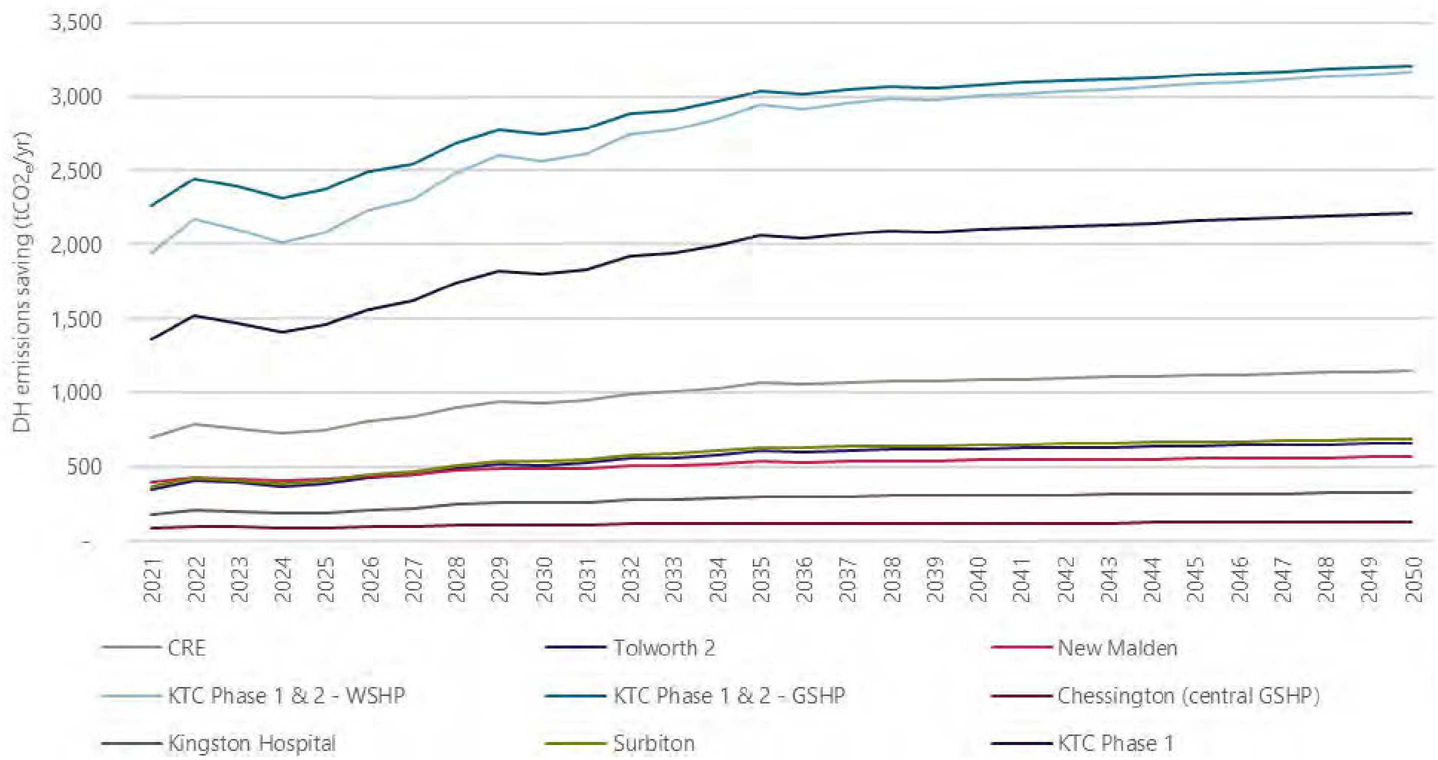


Figure 7.7: Energy centre emissions savings vs counterfactual

[redacted]

7.4.3 KTC RESULTS ANALYSIS

Figure 7.8 and Figure 7.9 show the cash flow for KTC Phase 1 & 2 with the two alternative heat supplies: WSHP and GSHP. This shows that the GSHP option has a higher initial capital cost compared to the WSHP, due to the cost of borehole drilling. However, the GSHP achieves a high NPV and quicker payback period because of the lower maintenance costs of boreholes compared to river water intake equipment. GSHP's also tend to have a higher coefficient of performance (COP), a measure of heat pump efficiency, which also contributes to the faster payback.

[redacted]

7.4.4 SENSITIVITY ANALYSIS

Sensitivity analysis – capital funding

Table 7.7 shows the results of including 20% and 40% of capital cost funding for each scheme. If 20% capital funding can be obtained for the clusters (e.g. through HNIP, connection charges or other as listed in Section 7.5), the IRR increases above the [redacted] threshold for the KTC Phase 1&2 (WSHP), Surbiton and Chessington cluster. If 40% capital funding is applied, then all the schemes IRRs increased above 4%.

Table 7.7: Estimated IRR with 20% and 40% capital funding

Option	Low carbon technology	IRR with 20% capital funding	IRR with 40% capital funding
Unit		%	%
CRE	WSHP	[redacted]	[redacted]
Tolworth 2	ASHP	[redacted]	[redacted]
New Malden	GSHP	[redacted]	[redacted]
KTC Phase 1 & 2 - WSHP	WSHP	[redacted]	[redacted]
KTC Phase 1 & 2 - GSHP	GSHP	[redacted]	[redacted]
Kingston Hospital	ASHP	[redacted]	[redacted]
Surbiton	ASHP	[redacted]	[redacted]
KTC Phase 1	WSHP	[redacted]	[redacted]
Chessington (central GSHP)	GSHP (central energy centre)	[redacted]	[redacted]

Sensitivity analysis - RHI

The IRR figures were compared to those if the schemes qualified for the non-domestic RHI tariff, which creates revenue based on the scheme's capacity over a 20 year period. As detailed in Section 7.5, the RHI is set to be discontinued on the 31st March 2021, with no replacement funding stream currently identified. However, the RHI could be replaced by a similar alternative funding stream to continue promoting the delivery of DH networks within the UK. The results, shown in Figure 7.10, show that with income from RHI the schemes IRRs increase by an average of 4%. This makes all the schemes except Kingston Hospital meet the [redacted] IRR threshold.

[redacted]

Sensitivity analysis – heat price

A sensitivity analysis was carried out to analyse the effect of a 10% reduction in heat sales price on the IRRs of each scheme. These results are summarised in Figure 7.11, where any schemes with negative IRRs are not shown. As expected, reducing the heat price reduced the IRRs of each scheme so that none reached the 4% threshold. CRE, New Malden, and Kingston Hospital produce negative IRRs.

This was then compared to a scenario with a 10% reduction in heat sales price but with 20% capital grant funding. In this scenario, Tolworth 2 and KTC Phase 1 & 2 (GSHP) achieved IRRs ove[redacted] However, CRE and KTC Phase 1 still produced negative IRRs. With 40% capital funding, the number of schemes to reach the IRR threshold increases to 6, to include Surbiton and Chessington network designs.

This highlights the importance in setting a heat sales price which is beneficial to consumers against the counterfactual cost, as well generating enough revenue to the DHN provider to create a return on investment. It is important to note that due to the blended heat price that was modelled, customers in new build flats are already achieving a saving in energy bills based on the counterfactual as set out in Section 7.3.3.

[redacted]

Chessington network design

Kensa have provided a feasibility study for a supplying heat to the Chessington cluster with individual heat pumps in each flat, connected to a central ground array. Here each dwelling pays for heat use directly through electricity prices and the only possible income for the DHN owner is through RHI payments; making the financial performance of this scheme wholly reliant on receiving RHI payments. Therefore, this scheme needs to be installed before March 2021 to ensure a revenue stream.

The individual heat pump design also has the potential to reduce consumer heat bills. Based on the indexed BEIS residential retail fuel rates in 2018 and a GSHP COP of 4, residents could pay a unit price of heat of[redacted]/kWhth, compared t[redacted]/kWhth for a gas boiler (assuming an 80% boiler efficiency).

The scheme has been modelled based on the installation of 6kW Shoebox GSHP in each flat and 150litre hot water cylinder. Kensa have estimated that 5,000m of boreholes are required for the scheme. Depending on design and layout this could equate to between 25 and 30 boreholes[47].

Under the assumptions detailed in Appendix B, the scheme achieves a simple payback of 13.8 years through RHI payments. Figure 7.12 shows the individual heat pump scheme achieves significantly higher carbon emissions savings compared to the central EC design because 100% of the cluster's heat demand is met by the heat pumps (i.e. there are no peaking gas boilers).

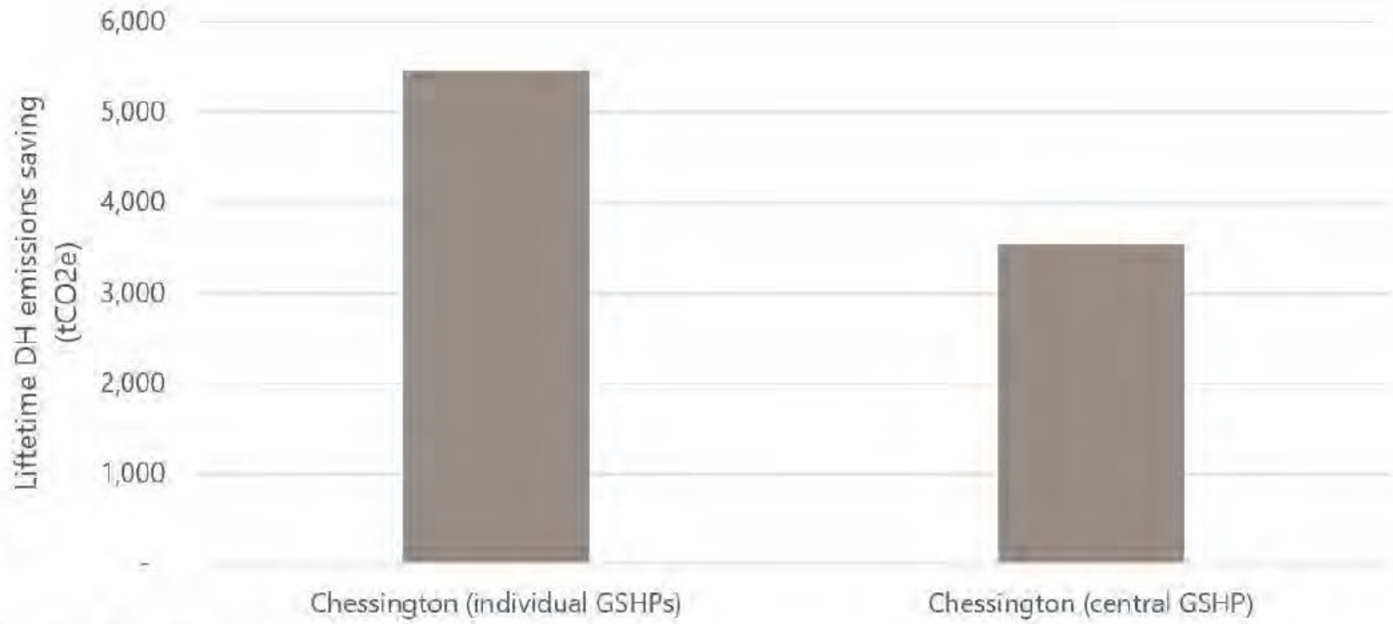


Figure 7.12: Lifetime DH emissions savings – Chessington

47 Conversation with Stuart Gadsden, 2019, Kensa Engineering.

7.5 FUNDING STREAMS

7.5.1 RHI FUNDING

The Renewable Heat Incentive (RHI) is a government funding stream that provides financial incentive to increase the uptake of renewable heat within England, Scotland and Wales. Eligible installations receive quarterly payments over 20 years (non-domestic only). The RHI rate varies depending on the technology used and payments are made on a £/kWh of renewable heat generated basis[48].

All the schemes presented meet the eligibility criteria for the non-domestic RHI tariff. However, the scheme is due to end on the 31st of March 2021, therefore revenue from this funding stream is not included within the techno-economic model. A sensitivity analysis was carried out to see the effect on IRR if it were include. The results of which are presented in Section 7.4.3.

7.5.2 HNIP FUNDING

The Heat Networks Delivery Unit (HNDU) was set up to address the barriers to market faced by local authorities (LAs) for DHN project development. The HNDU provides grant funding and guidance to LAs through the early stages of heat network development, as is currently used on the energy master plan to fund a percentage of the study fee.

For the later stages of DHN development, the Heat Networks Investment Project (HNIP) can provide capital investment to support with the associated costs of construction, operation and maintenance of a DHN. The scheme will provide £320 million of capital funding to gap fund heat network projects in England and Wales[49]. The BEIS typical project development lifecycle and HNDU and HNIP funding timeline is shown in .

To be eligible for HNIP funding the scheme must deliver a minimum of 2GWh/yr of heat. The network must also meet one of the following heat source requirements[50]:

- 75% of the heat from CHP (which can include non-renewable fuel source)
- 50% of the heat from a renewable source
- 50% of the heat from any combination of renewable or recovered heat and non-renewable fuelled CHP.

All of the proposed schemes meet these requirements, except for Chessington due to its small heat load. However, as Chessington is a fully retro-fit scheme it could receive funding through the ECO funding streams.

7.5.3 ECO FUNDING

The Energy Company Obligation (ECO) is a government energy efficiency scheme to reduction carbon emissions and reduce fuel poverty. This funding stream is aimed at retrofitting old, inefficient housing. The main eligibility criteria is a dwelling with an EPC rating of E or below.

28% of the flats in the Chessington cluster have an EPC of E or below and therefore may qualify for funding. Consultation with Kensa Engineering suggests that this could equate to £1,000-£1,500 per flat.

7.5.4 GLA DEEP FUNDING

The Decentralised Energy Enabling Project (DEEP) supports London boroughs to develop decentralised energy (DE) projects, including heat networks. It can gives technical, financial and commercial advisory help for large energy projects. The predecessor to DEEP (the DEPDU (Decentralised Energy Project Delivery Unit)) has supported 13 decentralised energy projects to market; worth a total of £100 million in investment potential.

The project can fund all work (excluding capital) related to DE projects from an early stage of energy master planning, through to feasibility, business case, procurement and commercialisation[51].

48 https://www.ofgem.gov.uk/environmental-programmes/non-domestic-rhi/contacts-guidance-and-resources/tariffs-and-payments-non-domestic-rhi
49 https://www.gov.uk/government/collections/heat-networks-investment-project-hnip-overview-and-how-to-apply
50 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/767662/heat-networks-investment-project-application-guidance.pdf
51 https://www.london.gov.uk/what-we-do/environment/energy/energy-supply

7.5.5 MEEF FUNDING

The Mayor's Energy Efficiency Fund (MEEF) provides flexible and competitive finance as well as other funding options to aid delivery of new low carbon technology, over an investment period of 20 years. This is part funded by the GLA through the European Regional Development Fund (ERDF).

MEEF can support energy efficiency, decentralised energy, and renewable energy generation projects, including innovative technologies[52]. Key metrics include:

- £500m fund size
- Invest across the capital structure, with rates as low as 1.5% for up to 20 years
- £2m of technical support funding available to support a projects business case

7.5.6 CARBON OFFSET FUND

In February 2017 the Royal Borough of Kingston adopted their Planning Obligations Supplementary Planning Document (SPD) which states that where the London Plan carbon reduction targets for new developments cannot be met (due to technical or commercial feasibility), developers must contribute to a carbon offset fund which will go towards funding the off-site CO_2 reduction measures.

For all major developments (above 10 residential units or GIA of over 1,000m^2), the financial contribution is based on the product of an established price (currently set at £60/tonne per year) and the shortfall in CO_2 tonnes saved below the minimum threshold over 30 years[53]. The revenue received by RBK from this is ring fenced for off-site carbon emission reduction and sequestering projects within the borough. There may therefore be opportunity to secure some of this funding stream for the development of a district heat network.

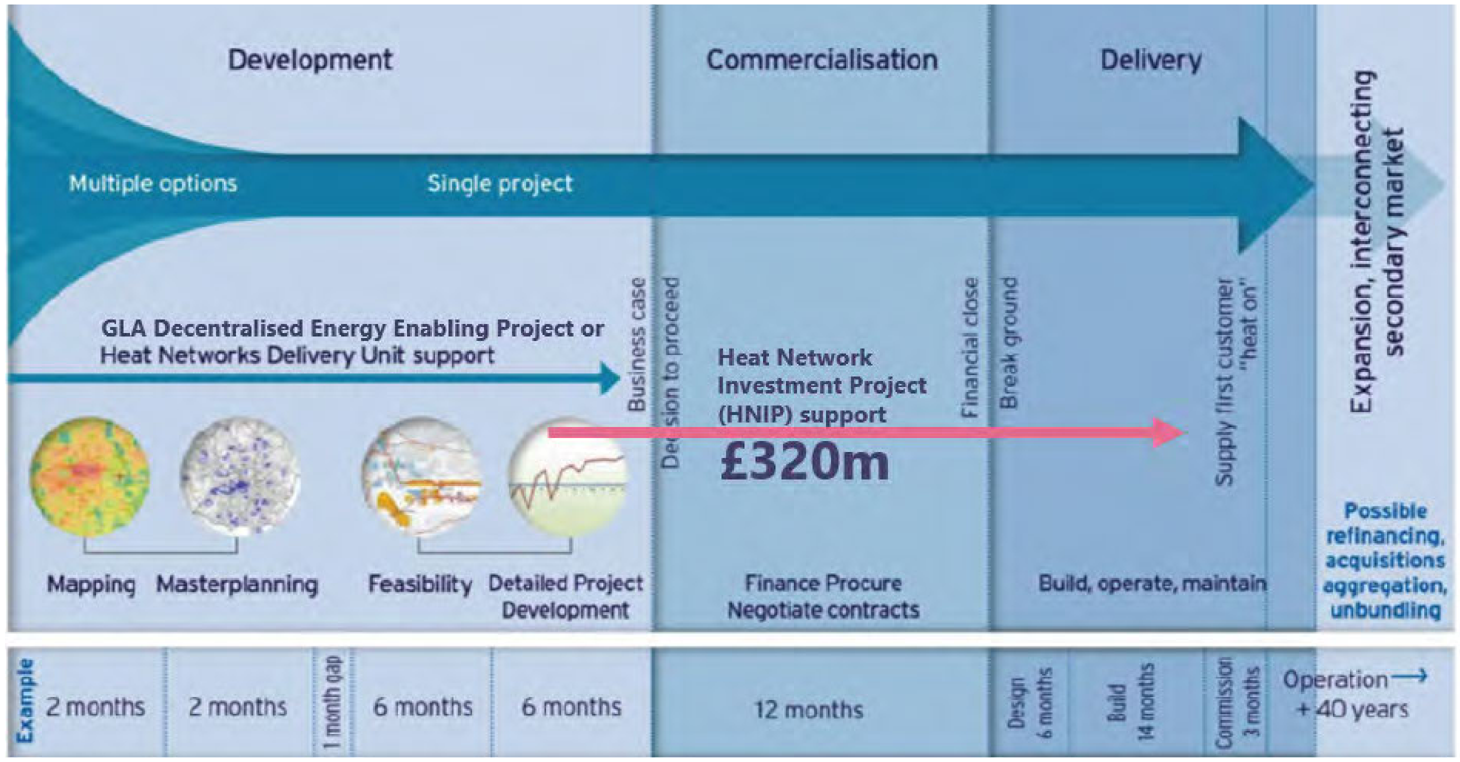


Figure 7.13: HNDU and HNIP funding timeline[54]

52 Amber Infrastructure, 2018. Mayor of London's Energy Efficiency fund (MEEF) fact sheet. Available at: <https://www.amberinfrastructure.com/media/1960/meef-fact-sheet.pdf>
53 https://www.kingston.gov.uk/downloads/download/785/carbon_offsetting_fund_guidance
54 BEIS, 2016. Heat Network Detailed Project Development Resource: Guidance on Strategic and Commercial Case. Issue 1.0. Available at: <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/717798/Strategic_and_Commercial_Case_development.pdf>

8 CONCLUSIONS AND PRIORITISATIONS

8.1 KEY CONCLUSIONS

This energy master plan updated the previous heat mapping studies within RBK and identified eight promising areas for DHN development within the borough. These areas were quantitatively assessed based on their heat density, ownership, potential for expansion, refurbishment timescales and physical constraints (Section 6).

From this initial assessment, the most promising clusters were taken forward for more detailed technical design, environmental assessment and commercial analysis. The main results are shown in the below table. The clusters were ranked based on a mixture of key quantitative and qualitative outputs (shown in Appendix D).

Table 8.1: Cluster summary

	CRE	Tolworth 2	New Malden	KTC Phase 1	KTC Phase 1 & 2 - WSHP	Kingston Hospital	Surbiton	Chessington (central GSHP)
Network:								
Annual heat demand (MWh/yr)	8,790	5,140	4,310	17,440	24,670	25,340	5,360	990
Heat line density (MWh/m)	6.3	8	3.8	10.4	8.5	15.9	3.6	3.1
No residential units on network	2632	135	325	0	1248	441	385	71
Percentage tier 1 heat (%)	90%	95%	47%	94%	92%	91%	29%	0%
Commercial performance:								
CAPEX (£m)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
LZC technology	WSHP - Hogsmill	ASHP	GSHP	WSHP– River Thames	WSHP – River Thames	ASHP	ASHP	GSHP
IRR @ 30 yrs (%) – no funding or RHI	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
IRR @ 30 yrs (%) – with RHI	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Environmental performance:								
DH emissions saving @ yr 10 (% $tCO_{2}e$)	51%	49%	55%	51%	51%	49%	49%	55%
Final ranking (1=best)	2	3	7	8	1	4	5	6

The three best performing clusters are Cambridge Road Estate (CRE), Tolworth 2 and Kington Town Centre (KTC). The key information of each of these clusters is summarised in Figure 8.1.

The outcomes of this study identified a number of key opportunities unique to Kingston that provide positive options for district heat network development. Summarised in Figure 8.2, these include two large secondary heat sources: Hogsmill Sewage Treatment Works (HSTW) and the River Thames. HSTW has an estimated waste heat supply of 50.5GWh/yr; large enough to supply the whole of the town centre and CRE heat loads. BuroHappold have been in conversation with Thames Water, who have expressed interest in utilising this waste heat in a DHN, which could bring the additional benefit of reducing heat pollution into the Hogsmill River.

Although CRE does not achieve a high IRR compared to the other schemes, it is still considered as one of the most viable options due to the large waste heat source that can be utilised for the sites planned redevelopment. The financial results area somewhat skewed by the CAPEX costs, which are higher than the other clusters because of the inclusion of the distribution pipes to Hogsmill. Due to the innovative heating solution this scheme presents it is thought that it may be eligible for additional funding streams not modelled at this stage, such as the HNIP. With RHI funding, CRE reaches the IRR threshold, achieving [redacted]. With a 40% capital funding grant (and no RHI) this increases to [redacted]. However, Figure 7—11 shows that these are highly dependent on the agreed heat sales price.

The planned redevelopment of both Kingston and Tolworth hospitals provides a great opportunity to extend their existing on-site heat networks to supply low carbon heat to the wider community. The opportunity at the CRE redevelopment should not be missed as an excellent scheme to reduce fuel costs and pollution levels in Kingston's most deprived area.

The proximity of CRE, the town centre and HSTW means in the long term these sites could be connected into one large DHN that will serve the most densely populated areas of the borough with low carbon heat: reducing carbon emissions by an estimated average of 50%.

Commercial analysis of the Chessington cluster suggests that the individual GSHP network design could achieve a quicker payback period and higher carbon savings, compared to the central energy centre design. However, this is highly dependent of receiving income through the RHI, which is due to end in March 2021.

Kingston Town Centre

- Access to secondary heat source - River Thames
- 24.7 GWh annual heat demand served
- Outline capital cost of [redacted]
- IRR o[redacted]ith no funding
- 51% CO_2 saving at year 10
- Opportunity to expand network to CRE in future

Cambridge Road Estate (CRE)

- Large waste heat source at Hogsmill Sewage Treatment Works outfall
- Opportunity to reduce fuel poverty in Kingston's most deprived area
- 2000 new homes planned
- [redacted]inital capital cost
- IRR of [redacted] with RHI funding

Tolworth 2

- Tolworth Hospital enery centre upgrade provides opportune timing to reduce CO_2 emissions to surrounding community
- Nearby social housing to be retrofitted to act as a model scheme for future RBK housing stock retrofit
- [redacted]capital cost and IRR [redacted] with no funding

Figure 8.1: key clusters

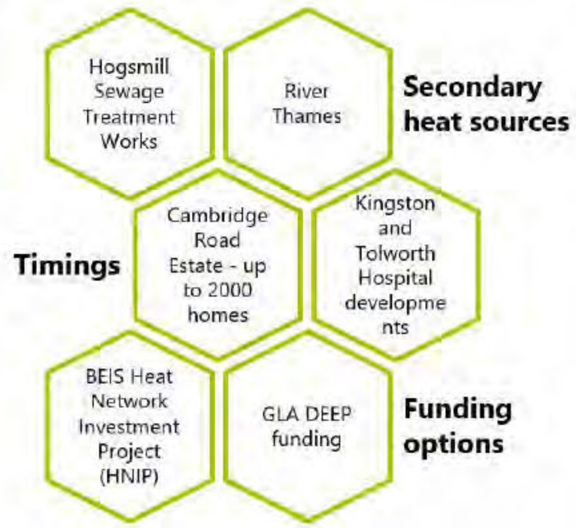


Figure 8.2: key opportunities

8.2 NEXT STEPS

The following next steps and key decisions are required before design, procurement and construction can commence:

1. *Delivery planning and Strategic Outline Case*
    - Recommendations from the masterplan should be incorporated into the Planning Policy updates underway for RBK. All major planned developments in the opportunity areas identified in this study should be ensured that they are made connection ready for any future heat networks
    - Engage with external stakeholders – present proposed schemes to the connections and target signing MoU. Soft market testing with heat network operators.
    - Internal stakeholder engagement – to develop an understanding with RBK of the arrangements required for delivery. Including, internal department to own the DHN development, funding streams within RBK, approvals process.
    - High level Strategic Outline Case to establish the need, review options for delivery and scope out detailed assessments required
    - A clear delivery roadmap to be produced and identification of champions / steering committee from within RBK to provide a route to how these schemes would be delivered and approvals and clearances processes.
    - Funding: apply for further support from GLA DEEP funding to support further studies identified
2. *Detailed Project Development including Outline Business Case*
    - Further explore the commercial and technical solutions at KTC and CRE through detailed feasibility
    - Secure heat offtake agreements with developers
3. *Procurement and Full Business Case*
    - Further scheme development to Business Case (required to make HNIP application)

8.3 INTERDEPENDENCIES

8.3.1 CAMBRIDGE ROAD ESTATE (CRE)

The preliminary costs have already been assigned for the site's energy centre and infrastructure, all of which is to be installed in Phase 1 of the project. It is therefore vital to begin planning on the DHN before an alternative, less flexible and more carbon intensive energy strategy is produce for the site. Figure 8.4 below illustrates the next steps and key decisions required to achieve this.

Of these, the critical interdependencies to the project are:

- **Securing CRE redevelopment connection** – scheme is subject to residential ballot in November 2019 and subsequent accepted planning application, targeting Phase 1 operation by 2022. A meeting with the CRE design team is proposed as soon as possible to ensure future connection to the heat network is captured.
- **Memorandum of Understanding (MoU) with Thames Water** – Positive engagement has been held with Thames Water to date. Further engagement should be carried out to further the review the viability of heat offtake and energy centre location, with a view to signing a MoU.
- **Alignment of road works with Go Cycle programme** – early engagement with Go Cycle and other planned roadworks in the area to ensure pipework can go into the ground at the same time if required. One Go Cycle route runs along Cambridge Road, along the northern boundary of the CRE, where the proposed DHN pipework will cross to connect to Cambridge Gardens Blocks heat load
- **Existing plant replacement cycles** – Ensure no boilers are replaced where this can be avoided in existing identified connections (e.g. Cambridge Gardens) as this may affect likelihood to connect in the near term. Where works are needed, consideration of future connection arrangements should be made (e.g. valve arrangements) to allow for easy future connection

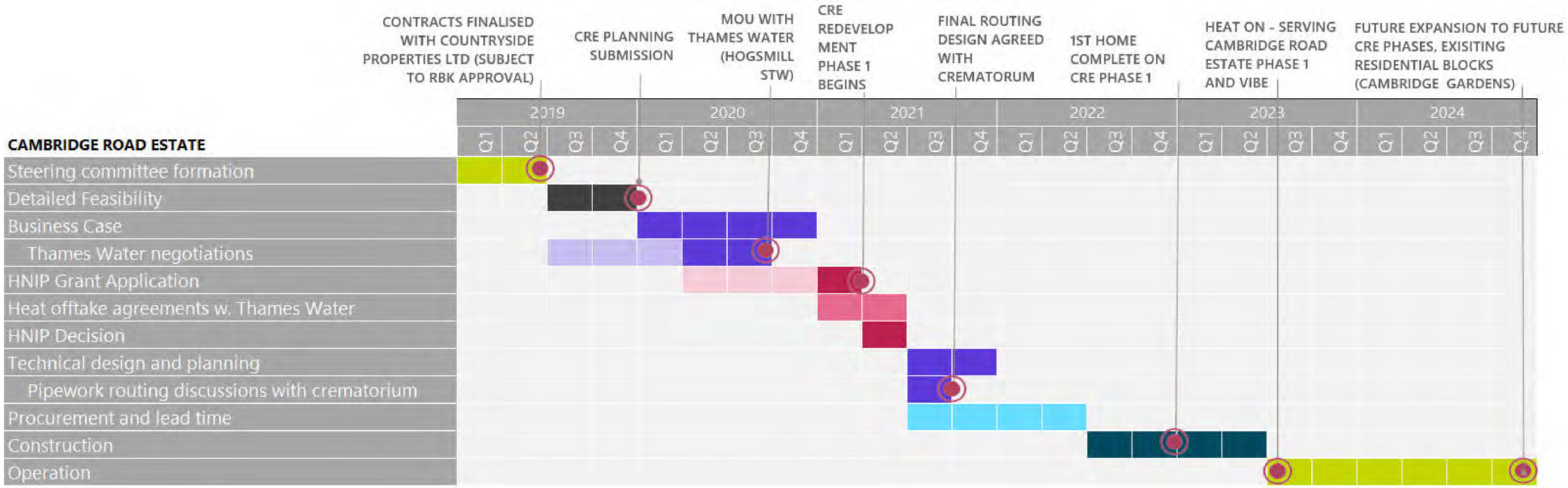


Figure 8.3: CRE outline delivery programme and key decisions

8.3.2 KINGSTON TOWN CENTRE

The Kingston Town Centre (KTC) cluster is highly dependent on finding a suitable energy centre location near to the River Thames to utilise its large secondary heat potential. The large heat load connects multiple external stakeholders as well as RBK owned commercial and residential assets, which increases the risk to the scheme. The key interdependencies are outlined below:

- **Surrey House –** a 320 residential unit development, currently awaiting planning permission. RBK to ensure development is connection ready to a future DHN. No time frames currently known as depends on planning decision. The GLA advised on June 5th 2018 that the application does not comply with the London Plan or Draft New London Plan
- **Energy centre (EC) location** – the highly urbanised KTC riverside has minimal options to locate the energy centre. Eagle Brewery Wharf has been identified as a potential location, however a more detailed feasibility of this location is required to ensure the location will comply with regulations (e.g. noise and emissions regulations from the boiler flues). Potential to locate EC below ground, however this will increase the associated civils costs
- **Reimagining Kingston Town Centre** – due for completion in April 2019, this project is likely to influence DHN routing. The outputs of the study, as well as the Go Cycle programme, should be aligned to the energy masterplannning in order to obtain the full benefit of both studies and negate unnecessary roadworks
- **K+20 Kingston Town Centre Area Action Plan** – identifies strategic development sites within the town centre, including the Cattle Market and Ashdown Road carparks, Guildhall refurbishment. The DHN proposal should align with these objectives and the proposed developments should be programmed for connection
- **Existing plant replacement cycles** – Ensure that, where possible, no boilers are replaced in existing residential units intending to connect to the network, particularly in RBK owned assets
- **Phasing opportunities for future expansion** – design to allow for future expansion, such as the Strategic Network (Figure 6—23), expansion into large commercial loads of Bentalls and John Lewis in future or expansion to the north of the railway line
- **Guildhall** – currently unoccupied. RBK have commissioned a review, phase 1 due to be complete in mid-March 2019, at which point more information will be known about its future use.

8.3.3 TOLWORTH 2

Consultation with Bruce Duncan, the Estate Modernisation Programme Manager at Tolworth Hospital, suggests timescales are uncertain due to lack of confidence in funding due to low investor confidence in future markets. The suggested construction start date is 2022, with the scheme being operational at the end of 2024. They are seeking Government approval for the redevelopment in May. The current planning approval of the energy centre is to serve the hospital only, however they are open to the idea of serving a wider area. If this were the case, the Trust would likely prefer an ESCo to operate the scheme.

Key interdependencies include:

- **Retrofitting the School Lane blocks** – this is required before the heat load can be connected to the network. There is potential to install the pipework and connect the loads at a later date. However, to maximise the financial performance of the scheme it is recommended that the loads are connected as early on in development as possible
- **Timeframes** – the scheme is highly dependent on the Hospital Trust securing funding
- **Boiler replacement cycles** – further liaison required with RBK Housing to understand timescales at the School Lane blocks
- **Engagement with Tolworth Junior School** – obtain more accurate information on current heat supply, plant replacement plans and gauge interest in connection to network
- **Tolworth Hospital** – continue engagement with Tolworth Hospital to ensure designs are conducive to network expansion to wider area (size of energy centre, temperature of network etc.). Pursue a MoU for access to on-site energy centre and supplying heat to wider network.

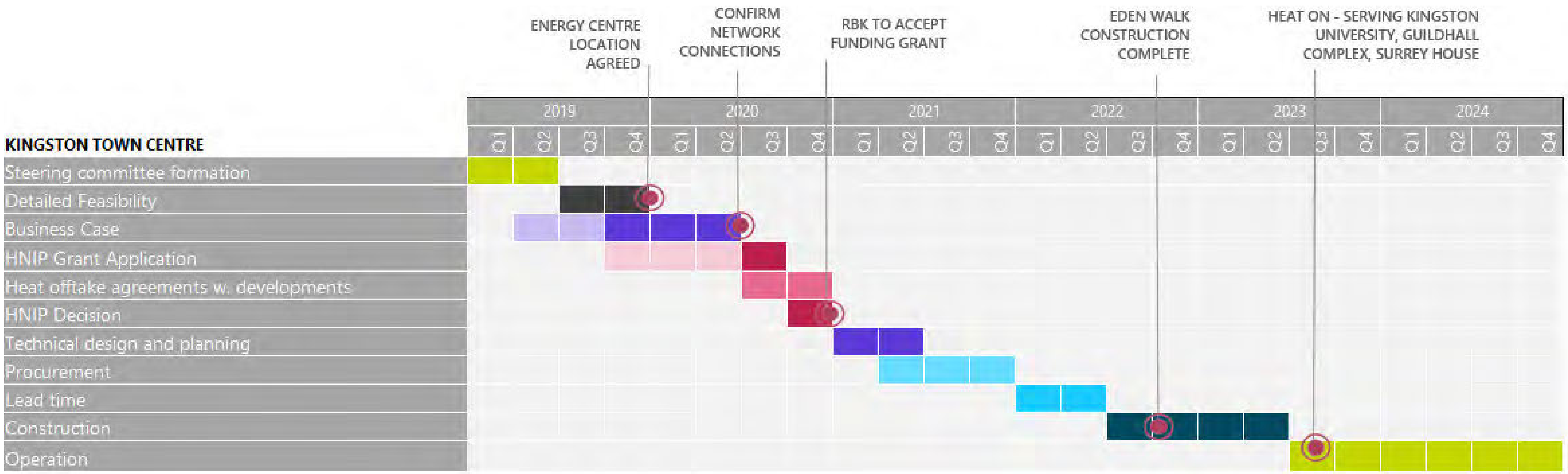


Figure 8.4: KTC outline delivery programme and key decisions

9 RISK REGISTER

DHNs require collaboration with multiple stakeholders which introduces complexity during development, from feasibility stage through to operation. This introduces inherent risks that need to be overcome, particularly surrounding ownership structures and heat supply regulations. The risks relating to developing a DHN in Kingston have been identified at ranked based on their likelihood and potential impact to the progression of the scheme. Some risks are applicable to all the identified clusters in Kingston. However, particular focus has been paid to the CRE cluster, KTC and Tolworth.

The risks have been split into the following categories:

- Technical
- Business case
- Planning Consents, Permitting and Environment
- Stakeholders
- Construction and procurement
- Operation and maintenance.

9.1 QUANTIFYING THE RISK

The risks are quantified based on their impact and probability of occurring. The impact of the risk is the outcome that may occur if the risk is not properly managed. Mitigating measures are suggested to reduce the impact and probability of each risk. Figure 9—1 shows the matrix used to assess the risk. The product of impact and probability dictates the overall risk level, and is presented both pre and post mitigation in Table 9—1.

Risk ranking		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 9.1: Risk ranking matrix

Table 9.1: Risk register

Item ref.	Risk description	Pre-mitigation			Mitigation measure	Lead by	Post-mitigation		
		Impact (I) 1-5	Probability (P) (1-5)	Risk level (I*P)			Impact (I) 1-5	Probability (P) (1-5)	Risk level (I*P)
1	**Technical**								
1.1	Heat consumption estimates vary vs actual consumption. If heat loads do not materialise (e.g. CRE and KTC new developments) the scheme may become difficult to operate economically	4	3	12	Heat demand confidence level included in feasibility study. Demands are derived from existing building data where possible. Recommend to lock non-RBK customers into long term contracts where possible (e.g. in planning agreements for new builds)	BH / RBK	3	2	6
1.2	Existing developments install renewed boiler plants; reducing the incentive for connection to DHN	4	2	8	Maintain communication with stakeholders identified in feasibility study to discuss alternative strategies in case of plant failure and update existing plant replacement strategies. Ensure RBK are aware of any planned upgrades to building secondary systems to ensure DHN connection capability. Suggest to defer any replacements where possible and use funds for DHN connection. New development connections to be ensured through planning policy	RBK	4	1	4
1.3	Heat load insufficient to justify running of LZC plant during the summer	4	3	12	Obtain hourly heat profiles where possible. Current sizing based on typical hourly heat loads profiles for clusters to ensure sufficient base load. Measure heat loads over long period of time for best possible design information. Provide large thermal store or heat pump modulation for lower summer loads	RBK	3	2	6
1.4	LZC technology availability - if the plant does not achieve the required availability it may impact running costs and carbon emissions. Significant plant failure may leave customers without heat	5	3	15	Transfer risk to operation and maintenance contractor via guaranteed minimum availability contract provisions and penalties. Back-up boilers (or alternative) provided for resilience and fuel flexibility	RBK	2	2	4
1.5	Large heat network distribution losses may lead to substantial loss in value if heat network is not adequately designed or insulated	3	2	6	Transfer risk to O&M contractor - specify high performance as per CP1 guidance and ensure detailed approval, inspection, testing and acceptance process including penalties for under performance. Minimise route lengths where possible in route proving process at detailed feasibility	RBK	3	1	3
1.6	Ground source heat potential not certain	5	2	10	Consult relevant literature as to ground conditions in London/ Kingston area (e.g. British Geological Survey maps and existing borehole data). There are many successful closed and open loop GSHP installations throughout the London area but a detailed ground survey is recommended once a suitable scheme is developed	BH	3	2	6
1.7	Lack of capacity to supply electricity required for heat pumps or natural gas for peaking boilers	4	3	12	Check utility plans to indicate if there are power cables in the area near to EC locations. Get indicative connection quote from gas/power provider to suggest fee for connection. Connection cost allowance included in techno-economic model	BH	4	2	8
2	**Business case**								
2.1	**Funding**								
2.1.1	Failure to identify funding sources adequate to meet the capital costs of the scheme. Scheme performance reliant on grant funding	5	3	15	Continuous engagement with the GLA to ensure schemes meet requirements for HNIP funding. CP1 and HNDU checklists will be carried out to ensure scheme compliance. Do not proceed if adequate funding cannot be secured	RBK	2	2	4
2.1.2	Lack of interest from commercial developers	5	3	15	Establish what IRR/ NPV values would attract commercial investment through soft market testing	BH	4	2	8
2.2	**Capital costs**								
2.2.1	Budget overspend due to poor cost controls	4	2	8	Undertake design reviews with relevant stakeholders. Consider procurement via a contractors to cover energy centre and networks	RBK	2	2	4
2.2.2	Budget underestimated due to unforeseen issues	5	3	15	10% contingency added to cost estimates	RBK	4	2	8

Item ref.	Risk description	Pre-mitigation			Mitigation measure	Lead by	Post-mitigation		
		Impact (I) 1-5	Probability (P) (1-5)	Risk level (I*P)			Impact (I) 1-5	Probability (P) (1-5)	Risk level (I*P)
2.2.3	Cost increases due to connection works at each block	5	3	15	Engage with planned developments to ensure secondary systems are connection ready to DHN. Cost of secondary system retrofit already estimated in CAPEX, however surveys of each connection required is needed for detailed costing.	RBK	3	2	6
2.3	**Revenues**								
2.3.1	Resulting cost of heat too high for residents	5	2	10	RBK required to provide additional capital funding over and above loan value in order to reduce heat cost. However, this will affect the schemes revenue performance. Tight control on scheme costs is required through detailed development	RBK	4	1	4
2.3.2	Uncertainty around access to the Renewable Heat Incentive (RHI) after March 2021	4	3	12	Access to RHI funding is ending in March 2021. It is not currently known if this will be replaced by a similar funding stream. Ensure schemes are viable without RHI funding – current base modelling at EMP stage excludes RHI.	RBK	1	3	3
2.3.3	Information not forthcoming from potential heat consumers to include in the study	2	2	4	Customers are largely RBK owned or planned developments. Metered data should be used where available	RBK	2	1	2
2.3.4	Changes to energy taxes could impose costs on the energy business	3	2	6	Any increase in tax will be transferred to customer - include change of law provision in heat contracts that adjusts charges to reflect new taxes	RBK	2	2	4
2.3.5	Occupancy risk - takes longer to build up heat demand than anticipated	3	2	6	Difficult to mitigate as dependent on housing market	RBK	3	2	6
3	**Stakeholders**								
3.1	TFL oppose street-works or propose onerous requirements	4	2	8	RBK to manage TFL interface through normal channels with assistance from RBK Highways	RBK	3	2	6
3.2	Private developments not interesting in connecting to DHN	5	3	15	Early engagement with developers, improved planning policy to include connection obligation. Ensure scheme is viable that is not reliant on developments who are not obliged to connect. Engagement already carried out with Kingston University, Kingston Hospital and Tolworth Hospital	RBK	3	2	6
3.3	Failure to gain resident support for the scheme	4	2	8	Structure proposal to make it attractive to residents and ensure a communications plan is enacted for local residents. Ensure residents are no worse off and bring savings where possible through the cost of heat	RBK	4	1	4
3.4	RBK lack of expertise to carry project forward	4	3	12	External project manager recommended to lead the scheme. Operation and maintenance can be contracted out	RBK	3	1	3
3.5	Low support from within RBK council	5	3	15	Identify a "champion" from within council to take project forward and increase awareness. RBK to manage ongoing discussions with BH input.	RBK	4	2	8
3.6	Thames Water not interested in supplying waste heat from Hogsmill Sewage Treatment Works	4	3	12	Early engagement with TW has already been carried out, who have expressed interest in the scheme. Continued engagement at all stages of DHN development is required. CRE team already in contact with TW as adjacent land owners.	RBK	4	2	8
3.7	RBK's ability to invest in the 'leg work' in setting up a DHN	4	2	8	Involve relevant RBK internal departments from project outset to raise awareness of project. Apply for funding/support from GLA/BEIS	RBK	2	2	4
3.8	Third party negotiations (Thames Water, Crematorium)	4	3	12	Early stakeholder involvement in proposed schemes once identified. Discussions with third parties as to acceptable IRRs	RBK	3	2	6
4.9	Kingston and Tolworth Hospitals not interested in supplying heat to the wider network	5	3	15	Early engagement to assess likelihood. Both Kingston Hospital and Tolworth Hospital have shown interest in the schemes when contacted. RBK to negotiate price of heat	RBK	5	2	10

Item ref.	Risk description	Pre-mitigation			Mitigation measure	Lead by	Post-mitigation		
		Impact (I) 1-5	Probability (P) (1-5)	Risk level (I*P)			Impact (I) 1-5	Probability (P) (1-5)	Risk level (I*P)
4	**Planning consents, permitting and environment**								
4.1	Failure to obtain planning permission for energy centre, particularly in KTC	5	2	10	The energy centre in KTC is proposed at Eagle Brewery Wharf, on RBK land adjacent to the River Thames. RBK to manage planning concerns going forward through engagement with local stakeholders and the planning team. Option to house EC below ground, however this would incur increase civils cost – alternative locations to be considered.	RBK	5	1	5
4.2	High noise levels from energy centre	4	3	12	Acoustic impact managed through using proven compliant heat pumps and noise insulating casing	RBK	3	2	6
4.3	High level of visual impact from energy centre	3	2	6	Flues from the gas boilers may cause concern in built up areas, particularly KTC where EC is near the Thames. Long term energy centre façade concept to be created for communication to planning team to ensure clarity of the intent. Where possible, flues integrated into building development to reduce visual impacts	RBK	2	1	2
4.4	Planning permission required for heat network	3	2	6	RBK to confirm whether permitted development rights cover installation of heating pipework in the public highways	RBK	2	2	4
4.5	Air quality issues increase cost or result in restriction on operation of energy centre	4	2	8	Air quality impact managed by ensuring flues extend to a higher level than the surrounding buildings. Early consultation with planning team advised. De-risk by installing high efficiency gas boilers	RBK	3	2	6
4.6	Failure to negotiate use of Thames Water land for CRE energy centre	4	3	12	Continue engagement with Thames Water and continue to pursue a memorandum of understanding for use of land for energy centre and waste heat off-take. If land is not available, EC could possibly be located on the CRE or Kingsmeadow land	RBK	2	2	4
4.7	Kingston Hospital and Tolworth Hospital contracts for power/gas. Existing service contracts may limit options for extending heat supply to wider network	3	3	9	Early engagement with the hospital NHS Trusts. Get key dates of planned heating system refurbishments and ensure stakeholders are aware of plans for DHN in the area. Ensure planned site network is compatible with wider DHN connection	RBK	3	2	6
4.8	Failure to obtain planning permission for WSHP at both KTC and HSTW due to environmental issues	5	3	15	Early engagement with the Environment Agency (EA) on acceptable discharge temperatures and flow rates. Not currently aware of a minimum discharge temperature into rivers set by the EA	RBK	5	1	5
5	**Construction and procurement**								
5.1	Access to properties for installation not possible in timely manner	2	2	4	RBK housing team to manage risk in conjunction with contractor. DHN scope to end at the meter at block plate heat exchanger	RBK	2	1	2
5.2	Asbestos present in existing plant rooms	3	3	9	Obtain asbestos information from stakeholders and RBK and factor into construction programme. Higher risk in town centre due to larger proportion of older building stock	RBK	2	2	4
5.4	Contract choice inappropriate and prevents project aims from being delivered	5	3	15	Review contract choice as part of development of business case. Ensure wide engagement in bid process to attract range of contractors	RBK	4	2	8
5.5	Redevelopment time windows missed	4	4	16	Early and continued engagement with all major stakeholders identified (e.g. Cambridge Road Estate, Kingston Hospital, Tolworth Hospital, John Lewis, Surrey County Hall) to ensure they are aware of the EMP project and potential to connect into a DHN. Promotion of work from within RBK and across the borough so that future developers are aware of proposed scheme	RBK	4	3	12
6	**Operation and maintenance**								
6.1	Heat delivery failure	5	4	20	Design resilience into system including redundancy for pumping, boilers etc. Make plans and procedures for emergency boiler hire for connection at building level.	RBK	3	1	3

Item ref.	Risk description	Pre-mitigation			Mitigation measure	Lead by	Post-mitigation		
		Impact (I) 1-5	Probability (P) (1-5)	Risk level (I*P)			Impact (I) 1-5	Probability (P) (1-5)	Risk level (I*P)
6.2	Lack of clarity over the department with RBK who is responsible for operation and maintenance	3	2	6	RBK to make a clear statement of responsibility as part of internal business case. Particularly important for schemexs where energy is being supplied by third party (Kingston Hospital, Tolworth and CRE)	RBK	2	2	4
6.3	High losses in primary or secondary network negate cost savings and create inefficient system	4	3	12	Commissioning and ongoing monitoring conducted to ensure performance is achieved	RBK	3	2	6

APPENDIX A BENCHMARKS AND ASSUMPTIONS

APPENDIX A.1 KEY ASSUMPTIONS IN LOAD CALCULATIONS

Peak heat load assumptions

- BSRIA55 benchmarks were used to estimate peak heat loads
- Peak heat loads do not include DHW prioritisation

A diversity factor is applied at plot level to residential DHW peak heat loads based on the Danish Standard (DS39) (see Appendix A.5). Non-residential DHW diversity applied as detailed in Appendix A.5.

A 0.8 diversity factor is applied to peak space heating loads at plot level

A 0.9 diversity factor is applied at the energy centre

New build space heating peak loads are assumed to be 25W/m2. The split of DHW and space heating has been calculated to align with this value (before diversification)

Annual heat load assumptions

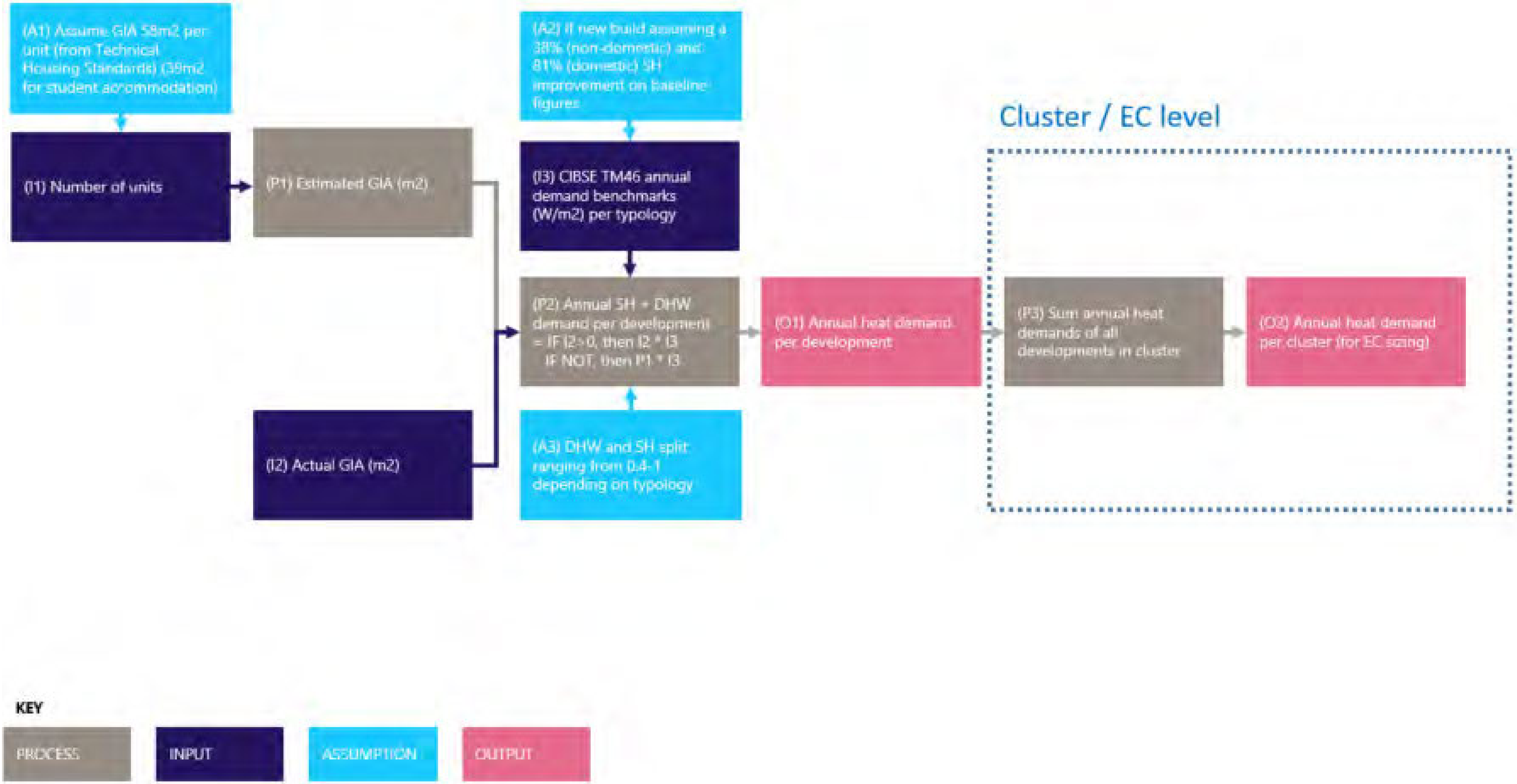
- A combination of CIBSE TM46 benchmarks and BuroHappold benchmarks based on previous experience were used to estimate annual heat loads for existing buildings
- An improvement on CIBSE TM46 baseline figures56 is applied to domestic properties to account for energy efficiency improvements in new build developments
- Space heating and DHW split varies depending on building type
- A 0.9 diversity factor is applied at the energy centre

Cooling loads

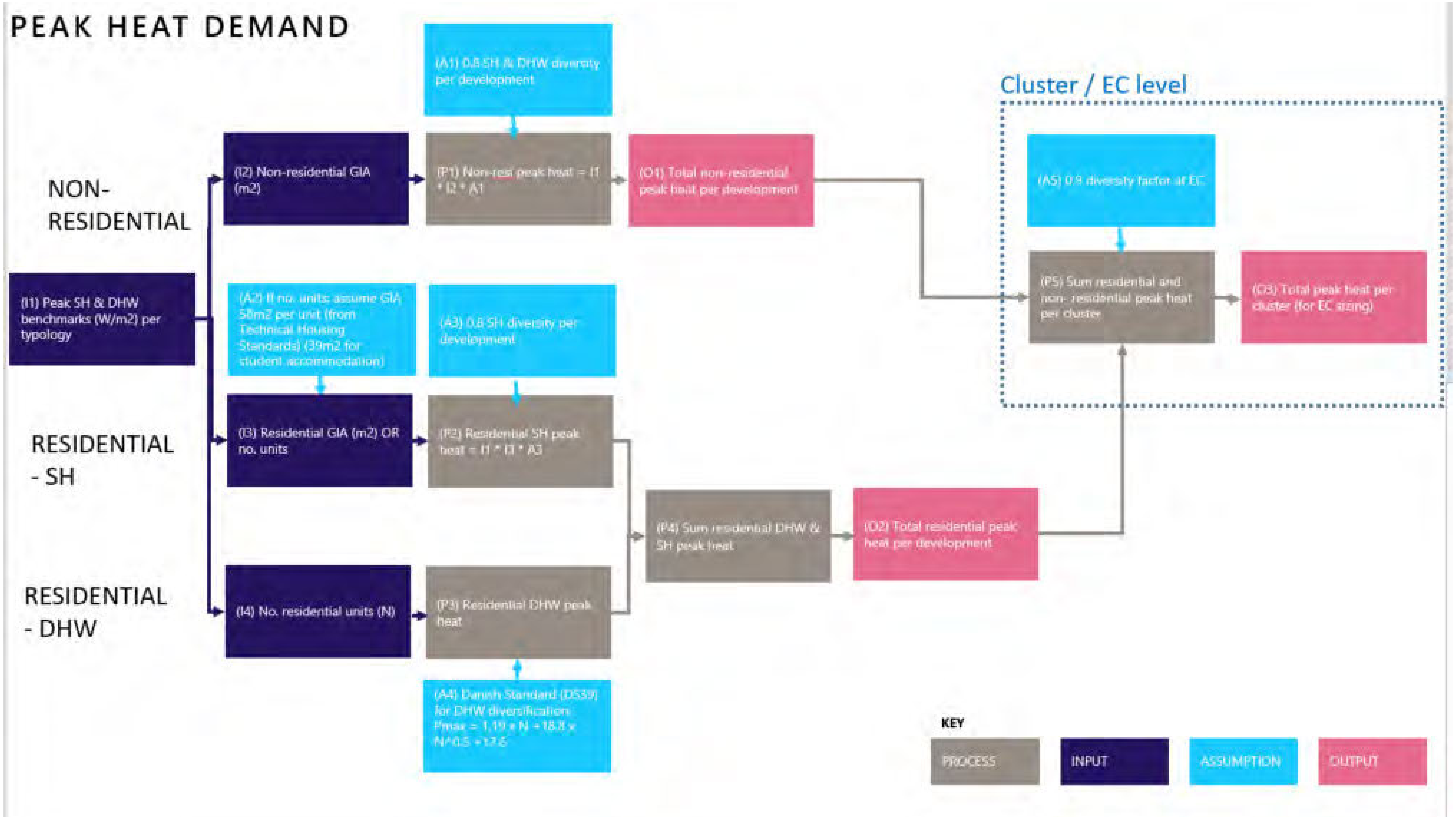
- Peak and annual cooling loads were estimated for Kingston Town Centre sites using benchmarks developed from previous BuroHappold projects and industry guidelines.

55 BSRIA, 2011. Rules of Thumb, Guidelines for building services (5th Edition) BG 9/2011. 5th ed. ImageData Ltd.
56 CIBSE, 2011. Energy Benchmarks CIBSE TM46: 2011. The Chartered Institution of Building Services Engineers London.

ANNUAL HEAT DEMAND



Annual heat load benchmarking process



Peak heat load benchmarking process

APPENDIX A.2 DHW DIVERSIFICATION

Peak DHW for residential loads was calculated using the Danish Standard (DS39) diversification curve as recommended in CP1[57], shown in the equation below:

$$Peak\ DHW\ demand\ (kW) = 1.19((N + 18.8)N^{0.5}) + 17.6$$

Where N=number of 'normal dwellings', defined as 3 5 residents and 1 bathroom. This could be an overestimate of peak heat demand for new builds in RBK because a proportion of the new housing blocks are student accommodation or smaller residential units. However, the average number of units for all new build residential blocks across the borough is 187. At the size, the DS439 curve flattens out, meaning the number of units does not have a large impact on the DHW peak load calculated.

APPENDIX A.3 FLOOR AREA BENCHMARKS

Floor area benchmarks				
Benchmark	Unit	Value	Description	Reference
Minimum Gross Internal Floor Area (GIA) (m^2)	m^2	58	Assuming a 1bedroom, 2person, 2 storey dwelling – used for residential housing blocks (excluding student accommodation)	58
Minimum Gross Internal Floor Area (GIA) (m^2)	m^2	39	Assuming a 1bedroom, 1person, 1 storey dwelling – used for student accommodation blocks only	79

APPENDIX A.4 HEAT MAP TYPOLOGY DEFINITIONS

Building Ownership	New Development? (as of 2018)	Building Typology	Typology
Local Government	No	Local Government Estate	RBK - local gov estate
Local Government	No	Education Facilities	RBK - education
Local Government	No	Private Residential (>50 units or 5000m2)	RBK - local gov estate
Local Government	No	Sports & Leisure facilities	RBK - sport
Local Government	No	Multi-address buildings	RBK - other
Local Government	No	Other public buildings	RBK - other
Other Public	No	NHS	Other - all
Other Public	No	Local Government Estate	Other - all
Other Public	No	Other public buildings	Other - all
Other Public	No	Education Facilities	Other - all
Private	No	Mixed Residential & Commercial	Private - residential
Private	No	Education Facilities	Private - other
Private	No	Office	Private - commercial
Private	No	Private Commercial (>5000m2)	Private - commercial
Private	No	Student Accommodation	Private - residential
Private	No	Nursing Home	Private - residential
Private	No	Private Residential (>50 units or 5000m2)	Private - residential
Private	No	Sports & Leisure facilities	Private - sport
Private	No	Dry sports & leisure facilities	Private - sport
Private	No	Hotels (> 99 units or 4,999 m2)	Private - other
Private	No	Museum and art gallery	Private - other
Private	No	Multi-address buildings	Private - residential
Other	No	Churches	Other - all
Other	No	Education Facilities	Other - all
Private	Yes	Education Facilities	Planning - non residential

57 CIBSE, 2015. CP1: Heat Networks: Code of Practice for the UK.

58 Department for Communities and Local Government, 2015. Technical housing standards – nationally described space standard. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/524531/160519_Nationally_Described_Space_Standard____Final_Web_version.pdf

Building Ownership	New Development? (as of 2018)	Building Typology	Typology
Private	Yes	Mixed Residential & Commercial	Planning - residential
Private	Yes	Office	Planning - non residential
Private	Yes	Nursing Home	Planning - residential
Private	Yes	Hotels (> 99 units or 4,999 m2)	Planning - non residential
Private	Yes	Private Commercial (>5000m2)	Planning - non residential
Private	Yes	Student Accommodation	Planning - residential
Private	Yes	Sports & Leisure facilities	Planning - non residential
Private	Yes	Dry sports & leisure facilities	Planning - non residential
Private	Yes	Private Residential (<50 units)	Planning - residential
Private	Yes	Private Residential (>50 units or 5000m2)	Planning - residential
Local Government	Yes	New Local Government Estate	Planning - residential
Local Government	Yes	Office	Planning - non residential
Local Government	Yes	Private Residential (>50 units or 5000m2)	Planning - residential
Other Public	Yes	NHS	Planning - non residential
Other Public	Yes	Mixed Residential & Commercial	Planning - residential
Other Public	Yes	Office	Planning - non residential

APPENDIX B CAPEX COSTS

APPENDIX B.1 KENSA ESTIMATED CAPEX COSTS FOR CHESSINGTON (INDIVIDUAL GSHPS)

The following costs and assumptions were provided by Kensa Contracting and are accurate as of March 2019[59].

Based on providing each dwelling with an individual Kensa GSHP, domestic hot water cylinder and new heating system, linked to a number of communal ground arrays, Kensa advises the following investment costs and income for the purposes of budgetary consideration.

This business model requires installation of a heat pump unit and thermal store in each residential unit, with the residents paying for the electricity they used to power the heat pump. The CAPEX includes installation of secondary system heat emitter upgrades. The communal boreholes and associated distribution plant and pipework are maintained by RBK or a private contractor, who in return would receive the RHI payments.

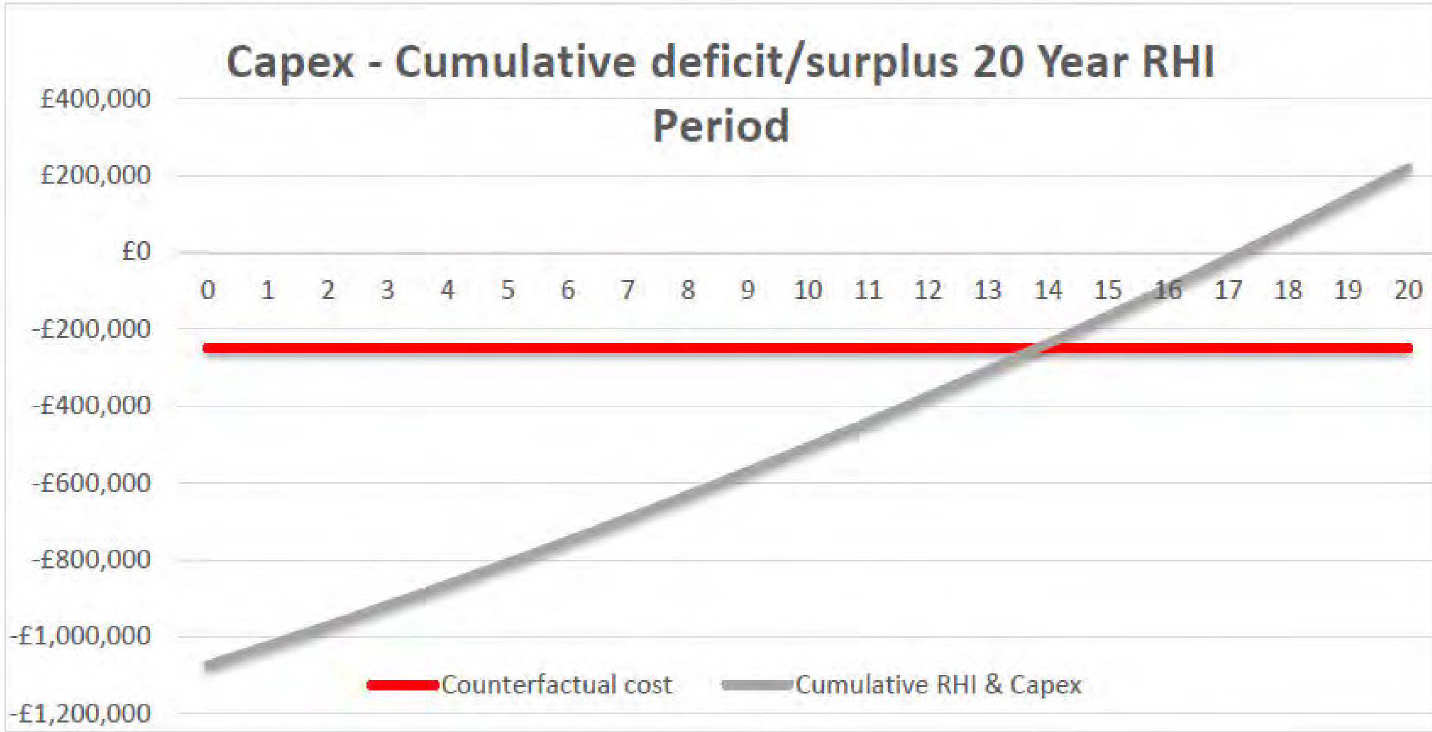
It is worth noting that this business model is reliant on RHI funding, which may not be available post March 2021. This scheme may also be eligible for ECO funding, which has not been included in the cashflow.

	Per cluster average	Per property average
No. properties	71	
Gross Price Excluding VAT*	£1,073,220	£15,116
Total ECO funding**	£0	£0
Net Price (after ECO grant fund)	£1,073,220	£15,116
Total estimated RHI income - 20 years***	£1,294,243	£18,229
Residual benefit (gross cost, less ECO, less RHI)	£221,024	£3,113
Assumed counterfactual contribution (i.e. budget like for like replacement cost)	£248,500	£3,500
IRR	4.34%	
Residual benefit (gross cost, less ECO, less RHI)	£469,524	£6,613
Pay Back Period - Years	13.8	
Estimated annual average tenant energy cost saving (year 1)	£396	
Estimated annual average CO_2 saving per property (year 1)	2250 kg CO2	

* VAT will be charged at the government prescribed rate at the time of invoicing

** ECO 3 has recently been launched. GSHP systems are eligible for both ECO 3 and RHI funding on the same project (the only renewable energy technology given this benefit). However, for social housing properties to be eligible for ECO 3, the existing EPC rating must be band E, F or G. Until a full review of EPCs is carried out, it is assumed that these properties will be ineligible for funding.

*** assumes average CPI at 2.5% inflation per year over the 20 year term.



59 Kensa Contracting, 2019. Feasibility Report: District GSHP installations for heating replacement for 71 flats at York Way, Chessington, London. [Internal report].

Scope of works included in the estimate

- It is expected that the contract will be a standard JCT contract with Kensa as Principle Contractor and Principle Designer
- Compliance with all system design requirements of MCS, including room by room heat loss calculations in accordance with EN12831, heating system design and heat emitter sizing
- M&E design drawing package
- Desktop geology study and ground array design and layout
- Desktop World War 2 UXO risk assessment
- Removal and disposal of existing electric storage heaters
- Provision of temporary electric heaters as required during the works
- Supply and installation of boreholes including all pipework and grout
- Supply and installation of trenching and headering to include manifolds, pipework, fittings and anti-freeze as required along with digging trenches and then subsequent reinstatement
- Supply and installation of ground side primary district distribution system (i.e. insulated riser pipework) to each property including all core drilling, fire stopping and trunking as required
- Supply and installation of 71no. Kensa 6kW Shoebox GSHP for the flats – Shoebox heat pumps located in internal cupboards and complete with manual read electric meters to comply with RHI regulations
- Supply and installation of 71no. heat pump compatible 150 litre unvented hot water cylinders for the flats complete with 3kW immersion heater on manually operated switch for emergency back-up – to be installed on a new shelf above the GSHP
- Supply and installation of new internal space heating system to all 71no. properties to include standard radiators, pipework, circulation pump, expansion vessel, valves, dial thermostat, twin channel programmer
- Making good to walls and ceilings as required
- Project management of Kensa appointed sub-contractors
- System commissioning
- All waste disposal
- Welfare facilities
- MCS Certification
- Post completion EPCs for all flats
- RHI application completion (although Kingston Council will have to do some parts of the application – we will guide them through this)
- ECO funding application (if we are able to secure ECO funding for this project)
- End user literature and handover pack.

Exclusions

- Asbestos R&D survey and reports for all flats
- Associated costs of asbestos mitigation
- Intrusive magnetometer survey for UXO at each borehole location – a desktop risk assessment will be carried out to determine whether this is required
- Supply and installation of new electrical consumer units – it is assumed the existing consumer units can be used
- Painting walls and locally disturbed making good
- Painting of pipework.

Assumptions

A ground thermal conductivity of 2.1 W/mK has been assumed.

Type of property	Quantity	Peak heat loss (kW)	Annual space heating demand to estimate RHI (kWh)	Annual DHW demand to estimate RHI (kWh)
2 bed flat	71	3.5	5,438	2,000

APPENDIX C HEAT SALE PRICE

APPENDIX C.1 RESIDENTIAL HEAT SALE PRICE

The residential heat sale price is calculated using the inputs presented in the table below. The analysis is based on a typical 2 bedroom flat, as defined in the Heat Trust Cost of Heat Calculator[60]. It is assumed that CAPEX and OPEX are spread evenly over project lifetime.

Parameter	Value	Unit	Reference	*Notes*
Boiler efficiency	85%	%		Assumption
Gas standing charge	[redacted]	p/day	[61]	Average
Gas costs	[redacted]	p/kWh	[86]	Average
Annual CAPEX	£ [redacted]	£/yr	[85]	Band A (based on 2 bedroom flat)
Annual OPEX	£ [redacted]	£/yr	[85]	Average from 5 company quotes, assuming one maintenance visit per year
Fuel demand	7,142	kWh/yr	[85]	2 bedroom flat

APPENDIX C.2 NON-RESIDENTIAL HEAT SALE PRICE

The non-residential heat sale price is calculated using the Eden Walk redevelopment figures and inputs outlined in the table below. It is assumed that CAPEX and OPEX are spread evenly over project lifetime.

Parameter	Value	Unit	Reference	*Notes*
Boiler efficiency	85%	%		Assumption
Gas standing charge	[redacted]	p/day	[62]	Standing charge for large commercial consumer
Gas costs	[redacted]	p/kWh	[63]	Average rate for medium business
Annual CAPEX	[redacted]	£/yr	[64]	Based on Spons boiler cost per kW (calc assumes a 8MW boiler - sized for Eden Walk peak demand, with lifetime of 12 years)
Annual OPEX	[redacted]	£/yr	[65]	0.2% of total boiler CAPEX
Fuel demand	1,642,353	kWh/yr		Eden Walk energy strategy

APPENDIX D CLUSTER RANKING TABLE

	CRE	Tolworth 2	New Malden	KTC Phase 1	KTC Phase 1 & 2 - WSHP	Kingston Hospital	Surbiton	Chessing-ton (central GSHP)
IRR @ 30 years	7	1	6	8	2	5	3	4
DH emissions saving @ year 1	3	6	1	4.5	4.5	7.5	7.5	2
No residential units	1	6	5	8	2	3	4	7
Heat line density	5	4	6	2	3	1	7	8
Annual heat demand	4	6	7	3	2	1	5	8
Percentage tier 1 heat	5	1	6	2	3	4	7	6
Percentage RBK owned heat	3	5	4	7	6	8	1.5	1.5
Fuel poverty impact (1-7)	2	4	7	8	5	6	3	1
Sum of ranking	30	33	42	42.5	27.5	35.5	38	39.5
Final ranking	2	3	7	8	1	4	5	6

60 Heat Trust, 2018. *Heat Cost Calculator: Further information and background assumptions*. Available at: <http://www.heattrust.org/images/docs/HCC_Further_information_and_assumptions_Jan2019_update__v1.pdf>
61 UK Power, 2018. Gas & Electricity Tariff Prices per kWh. Available at: <https://www.ukpower.co.uk/home_energy/tariffs-per-unit-kwh>
62 https://www.utilitywise.com/2017/09/05/no-standing-charges-for-business/
63 https://www.businessenergy.com/business-gas/sme-prices/
64 AECOM, 2017. Spon's Mechanical and Electrical Services Price Book. 48th edition. Abingdon: CRC Press Taylor & Francis Group.
65 Sandvall, A. F. et al., 2017. Cost-efficiency of urban heat strategies – Modelling scale effects of low-energy building heat supply. Energy Strategy Reviews, Vol. 18, p. 212-223. Available at: https://www.sciencedirect.com/science/article/pii/S2211467X17300615

APPENDIX E STUDY METHODOLOGY

Table 9.2: Data received for EMP load schedule

Data source	Data description
Connections and Developments List (2018)	List of planning proposals (including description, CHP yes/no, build status, planning app number)
RBK Housing Pipeline (as of 01/04/2018)	Proposed/ started new housing developments (including number residential units, site areas, building type, status)
RBK block schedule	
RBK non-housing pipeline (01/04/2018)	List of proposed/ started new non- residential developments in RBK as of 01/04/2018
K+20 proposed sites	List of proposed new developments in Kingston from Tom Bright (in the planning team at RBK) - these developments do not have planning applications yet
RBK housing block schedule	RBK housing blocks (does not include individual dwellings). Includes name, postcode, tenure type, dwellings, storeys, year built
RBK corporate sites	Gas and electricity demand (kWh) for RBK corporate sites 2018 - does not include rented properties
URS Heatmapping data	Data used in both AECOM and Arup studies (including site name, address, GIA, fuel consumption, data source)
October 17 Flex Pricing – Kingston Schools	Annual gas demand and rates for RBK schools
Revised RBK housing completions (2012_13-2016_17)	List of housing completions in RBK from 2012/12-2016/17. Including total and council targets
RBK planning list	BK planning list from years 2015 - 2018 of buildings in RBK. Including planning reference, date, address, description, planning officers, comments.
Site specific planning documents	Lidl Headquarters, New Malden House, Kingstons House, Gas Holder Site, Kingsgate, Tolworth Girls School, Eden Walk, Old Post Office, Surrey House
Kingston Hospital	From Kingston Hospital: Cooling site layout, floor area model, masterplan report, natural gas layout (including fuel demands), steam & heat site layout, standby generation layout
CRE – Strategic Development Brief	Cambridge Road Estate's strategic development brief - no planning application for development yet
Kingston Hospital development plan	Kingston Hospital NHS Trust sustainable development plan 2018-2023
Cocks Crescent SPD	RBK's Cocks Crescent (in New Malden) supplementary planning document
Eden Quarter SPD	RBK's Eden Quarter supplementary planning document
Hogsmill Valley Masterplan	Hogsmill Valley Masterplan and development appraisal
KTC Area Action Plan	Kingston Town Centre Area Action Plan (K+20 report)
Riverside SPD	RBK riverside supplementary planning document
New build planning docs	From internal RBK portal (including energy strategies where available)

GIS data used in mapping

Data description	Reference / copyright
11kV, 33kV, 132kV substations – point coordinates	UK Power Networks, 2017. Shapefile. Available at: <https://www.ukpowernetworks.co.uk/internet/en/our-services/list-of-services/electricity-generation/find-out-where-our-overhead-network-is/>
OS basemap of Kingston	OS Open Map – Local (Raster), 2018. OS data © Crown copyright and database right 2015 Available at: <https://www.ordnancesurvey.co.uk/opendatadownload/products.html>
Railway tracks	OS OpenData Vector Map OS data © Crown copyright and database right 2015
A and B Roads	OS OpenData Vector Map OS data © Crown copyright and database right 2015
Conservation areas	RBK – Vector layer
Metropolitan Open Land, Green Belt, Green Chains, Local Open Space, SSSI, School Open Space, Local Nature Reserves, Site of Importance for Nature Conservation, Allotments	RBK – Vector layer
Listed buildings	RBK – Vector layer
Locally listed buildings	RBK – Vector layer
All buildings	OS OpenData Vector Map OS data © Crown copyright and database right 2015

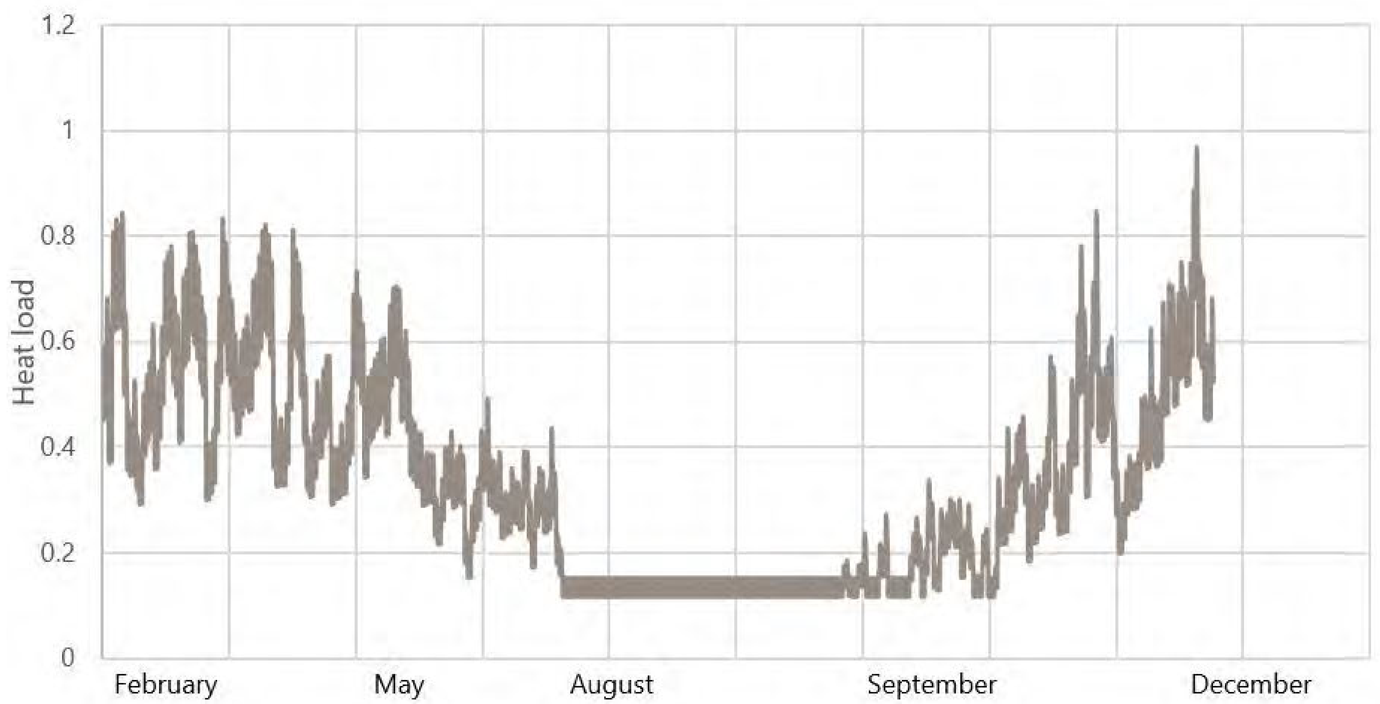
APPENDIX F ENERGY CENTRE SIZING

EC capacity sizing assumptions

Assumption	Justification
The heat load duration curve per cluster is modelled using Energy Pro. Half-hourly load profiles from previous BuroHappold projects are used. These are correlated to the building typologies in RBK. The profiles are weather adjusted using data from London in 2016.	Each building type (residential, office, hospital etc.) has different load profiles throughout the day and year. The shape of the profile effects the peak capacity required on each network. An example of a load profile used for modelling is shown in the adjacent graph.
Gas boiler capacity is sized for total network peak	It is assumed gas boilers are connected in series with a total capacity to meet the peak heat demand of the network. Although in practise this means the boilers will only be used a fraction of the year, it add resilience to the system in case the alternative low carbon heat technology fails
A diversity factor of 0.9 is applied at the Energy Centre (EC)	A diversity factor of 0.9 is applied to the sum of the peak load of each building in the cluster to calculate the total peak load of the network. This is justified because each building is highly unlikely to be operating at its peak at the same time
Thermal store is sized based on 2 hours of the peak low carbon heat technology	From previous BuroHappold projects
A delta-T of 30°C is assumed for thermal store sizing	This is a conservative estimate based on a design flow temperature of 60°C. It is likely that networks, particularly those connecting to new builds will operate at a lower flow temperature
Thermal stores are sized based on the amount of time throughout the year the low carbon heat technology is operating above the predicted heat load	This ensures that the low carbon plant doesn't have a large amount of excess capacity that is only used at peak times, thus reducing capital costs
There is no DHW prioritisation in the network	The total network peak load is calculated as the sum of the space heating and DHW per building. Diversity factors are applied to each plot. However, each building contains multiple users, all with varying heat load profiles that will not allow for DHW prioritisation. This means that the cluster peak loads are likely to be an overestimate of actual peak load
Low carbon technology run time is 80% of the year	It is assumed that the low carbon technology can only run for 7008h/yr due to temperature restrictions in heat supply. In the winter months the outside air temperature may be too low to efficiency run the ASHPs. For a period of time in the summer months it is good practise to turn off the GSHP to give the ground time to recover some heat. This will extend the life span of the borehole array

Energy centre floor areas

Cluster	Energy centre floor area (m²)
CRE	350
Tolworth 2	290
New Malden Phase 1	270
KTC Phase 1 & 2	440
Kingston Hospital (including hospital heat load)	450
Kingston Hospital (excluding hospital heat load)	280
Surbiton	290
KTC Phase 1	360
Chessington (central GSHP)	250



Example half-hourly load profile for hospital

APPENDIX G TECHNO-ECONOMIC MODEL INPUTS AND ASSUMPTIONS

Input / assumption	Value	Unit	Reference	Notes
Counterfactual technology				
Counterfactual technology	Gas boiler	*kWth*		
Counterfactual technology fuel	Natural gas	-		
Counterfactual technology thermal efficiency	89%	%		
Heat demand met by counterfactual technology	100%	%		
Low-carbon technologies				
GSHP thermal efficiency	400	%	*Previous BuroHappold experience*	
WSHP thermal efficiency	300	%	*Previous BuroHappold experience*	
ASHP thermal efficiency	250	%	*Previous BuroHappold experience*	
Heat fraction as a % of total generation (remaining met by gas boilers)	70	%	*Based on energy centre sizing*	*100% for Chessington (individual GSHPs) scheme*
Scheme				
Start year	2020	-		
Lifetime	30	*yrs*		
Equipment life expectancy				
Low-carbon technology 1	15	*yrs*	*Assumed based on previous BuroHappold experience*	
Top-up technology 1	15	*yrs*	*Assumed based on previous BuroHappold experience*	*Not used in Chessington (individual GSHPs) scheme*
Plate heat exchangers	15	*yrs*	*Assumed based on previous BuroHappold experience*	*Not used in Chessington (individual GSHPs) scheme*
Heat interface units	25	*yrs*	*Assumed based on previous BuroHappold experience*	
Heat meters	25	*yrs*	*Assumed based on previous BuroHappold experience*	*Not used in Chessington (individual GSHPs) scheme*
Network				
Parasitic pumping power	2%	%	[77]	*Not used in Chessington (individual GSHPs) scheme*
District heating standing losses	10%	%	*[[66]] (upper allowable limit)*	*Not used in Chessington (individual GSHPs) scheme*
Fuel import rates				
Natural gas purchase price	[redacted]	*p/kWh*	*BEIS 2018 indexed industrial retail price [[67]]*	

Input / assumption	Value	Unit	Reference	Notes
Electricity purchase price	[redacted]	*p/kWh*	BEIS 2018 indexed industrial retail price [78]	
Energy sales rates				
Residential	[redacted]	*p/kWh*	*See Section 7.3.3*	
Commercial	[redacted]	*p/kWh*	*See Section 7.3.3*	
Projections				
Discount rate	3.5%	%	[78]	
RHI (only applicable for sensitivity analysis)				
Support lifetime	20	*yrs*	*Non-domestic RHI [[68]]*	
Tier 1 payments up to	15% of annual hours	*%/hrs*	*Non-domestic RHI for heat pumps [80]*	
ASHP RHI rate	2.69	*p/kWh*	*All capacities (not tiered), accreditation after 1/1/19 [80]*	
WSHP & GSHP RHI Tier 1 rate	9.36	*p/kWh*	*All capacities (Tier 1 only), accreditation after 1/1/19 [[80]*	
WSHP & GSHP RHI Tier 2 rate	2.79	*p/kWh*	*All capacities (Tier 2 only), accreditation after 1/1/19 [[80]*	

66 Chartered Institution of Building Services Engineers (CIBSE) and the Association for Decentralised Energy (ADE), 2015. Heat networks: Code of Practice for the U

67 Department for Business, Energy & Industrial Strategy (BEIS), 2018. Updated Energy and Emissions Projections 2017. Available at: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017

68 OFGEM, 2019. Tariffs and payments: Non-Domestic RHI. Available at: <https://www.ofgem.gov.uk/environmental-programmes/non-domestic-rhi/contacts-guidance-and-resources/tariffs-and-payments-non-domestic-rhi>

APPENDIX H STAKEHOLDER PRESENTATION FEEDBACK

The results of this energy master plan were presented to an audience of stakeholders, RBK departments and interested local residents on the 19th February 2019. BuroHappold requested feedback from all attendees to incorporate into the next steps recommendations of this report. The feedback we received is summarised below.

Stakeholder name	Stakeholder organisation	Date feedback received	Interested in a DHN (Y/N)	Preferred Cluster	Recommendations	Barriers to development
Patrick Manwell	Environmentally interested resident - Transition Town Kingston Energy Group	20/02/2019	y	CRE	Concentrate on only CRE in taking this work further. Delivery trumps grandiose future visions	Procurement routes, negotiations with TW, rising costs as problems are uncovered.
Tony Antoniou	Programme Director (contractor) of Go Cycle programme	20/02/2019	Y			There are a number of places where the various routes and projects of the Go Cycle programme pass through the areas highlighted in the Energy Masterplan.
Marc Cooper	Regeneration Officer - Strategic Housing and Regeneration	20/02/2019	Y	CRE, Kingston Hospital & KTC	Include possible redevelopment of Kingsmeadow Leisure Centre. Is there potential to develop energy centres as part of the redevelopment of RBK owned sites in the Town Centre?	Ability of RBK to invest in the 'leg work' in terms of setting up such as network.
Paul Graham	Kingston Hospital NHS Foundation Trust (Utilities, Waste and Sustainability Manager - Estates & Facilities Department)	20/02/2019	Y		Paul to recommended to NHS trust that the internal heating system in the hospital be hot water rather than steam to allow connection to DHN	Co-operation from third parties (Thames Water, Crematorium etc.), risk of incentive funding schemes changing/being withdrawn.
Peter Mason	Environmentally vocal resident - Transition Town Kingston representative and North Kingston Neighbourhood Forum Energy working Group	21/02/2019	Y	CRE and KTC	Present figures for cost of carbon of DHN schemes compared to counterfactual fossil fuel technology	

APPENDIX I LOW CARBON TECHNOLOGY REVIEW

Heat pumps

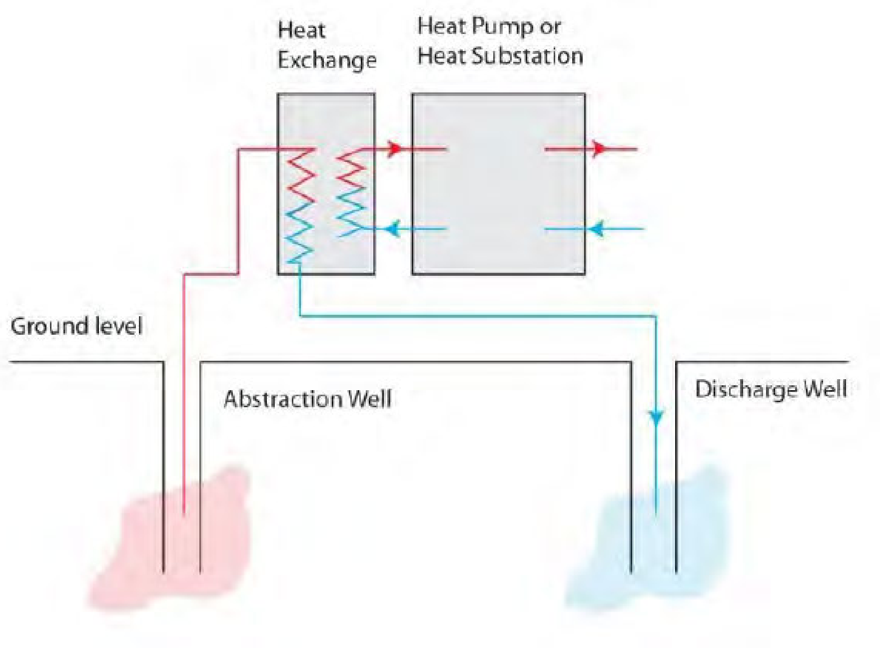
Heat pumps work by extracting heat from the outside air, ground or water and passing this into a refrigerant transfer fluid, which is then compressed within the heat pump unit to 'upgrade' the heat to usable temperatures for a domestic heating system. This compression stage uses power, meaning that heat pumps are not fully renewable, but are classed as 'semi-renewable' as they use much less primary energy than traditional central heating systems. Heat pumps to be investigated in this study are ground, water and air source units, as discussed in the following sections.

Ground-source heat pumps (GSHPs)

GSHPs can extract low grade heat from the ground via either a closed loop or open loop system. Both options are considered for the Kingston development.

GSHP – open loop

Open loop boreholes traditionally provide geothermal energy to the GSHP from an underground aquifer in the form of water abstraction, as shown in the figure below. Abandoned coal mines that are flooded with water can be used as the low grade heat source with this technology. Further understanding of the local area with regard to potential sources of such low grade heat is required in order to assess the feasibility of a district heating scheme in Kingston with a GSHP in a central energy centre.



Ground source heat pump with open loop system

GSHP – closed loop

A GSHP with a closed loop system can utilise either horizontally installed collector loops or vertically installed loops in boreholes that can reach down to depths of 150+ metres.

Shared ground array heat pump

While the majority of DHNs provide heat through a centralised energy centre, an alternative solution for residential blocks is available where an individual heat pump and hot water cylinder are installed within each dwelling, each connected to a shared borehole ground array. This gives each household the ability for direct billing from its preferred energy provider, as well as access to non-domestic RHI payments. A schematic is shown in .

This configuration is best suited to residential, low rise dwellings with limited space for a central energy centre. The main disadvantage comes in the additional space required in each dwelling for the heat pump unit, which is typically larger than a gas boiler or HIU. Space for a separate thermal store in each dwelling is also needed. This configuration also limits the flexibility for future changes to technology or fuel prices.

BuroHappold have consulted with Kensa Heat Pumps, heat pump manufactures who have delivered a number of successful schemes using the shared ground array DHN design for large scale social housing projects. Kensa have produced a 'Shoebox' heat pump range, which are small and quiet enough to fit inside a typical airing cupboard. With a power rating of 1.6kW (less than a kettle), the 6kW Shoebox Heat Pump can handle 100% of space-heating demand per the dwelling. The Shoebox heat pump has two modes, making it capable of providing temperatures of up to 65oC in DHW mode thus negating the need for an immersion heater. 100% of the DHW requirement can be met via a suitably sized hot water cylinder[69].

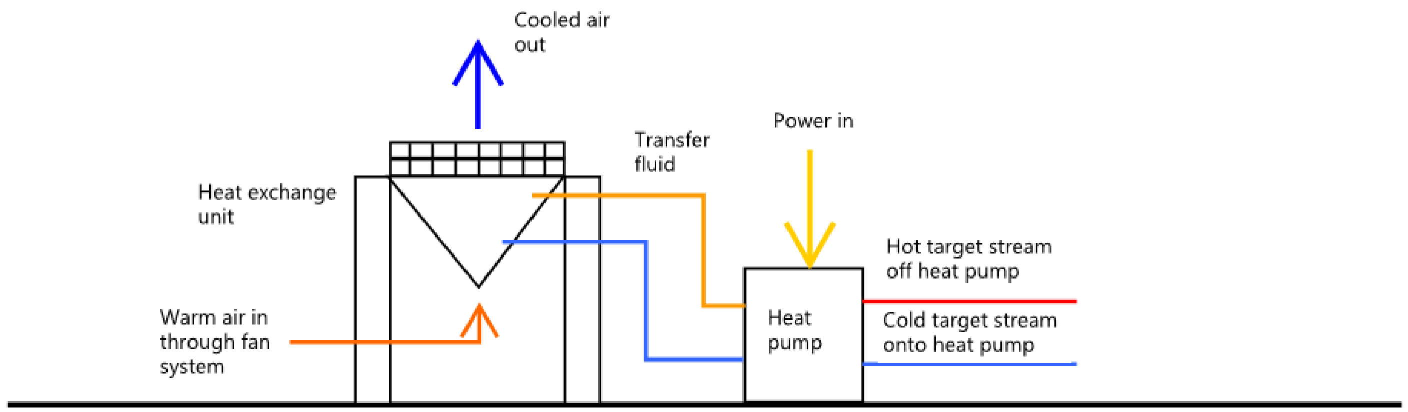
Shared ground loop schematic[70]

69 https://www.kensaheatpumps.com/the-technology/heat-sources-collectors/shared-ground-loop-arrays/
70 https://www.kensaheatpumps.com/the-technology/heat-sources-collectors/shared-ground-loop-arrays/

Air-source heat pumps (ASHPs)

ASHPs work by extracting heat from the outside air via an external heat exchange unit. They are, however, typically the least efficient type of heat pump and are subject to efficiency fluctuations with the changing outside air temperature. In winter, when heating requirements are highest, the cold outside air temperature means that ASHPs are at their lowest efficiencies.

There are many ASHP products readily available on the market that will qualify for the renewable heat incentive (RHI) scheme for the tenant. They can reach temperatures up to ~60°C, but to reach higher temperatures means a loss of efficiency. ASHPs are therefore well supported by solar thermal systems to supply or top-up the DHW requirement.



Air-source heat pumps (ASHPs)

Water-source heat pumps (WSHPs)

WSHPs work on the same principles as both air-source and ground-source heat pumps. They take advantage of the relatively consistent temperatures found in bodies of water, whether they be lakes, rivers, streams or aquifers. WSHPs typically have higher coefficients of performance (COPs) than air or ground source heat pumps, but are dependent on good water sources nearby.

In Kingston, the River Thames is identified as a good potential source of water that could be used as a low grade heat source for this technology.

Sewage heat recovery

There is a large and renewable source of heat energy constantly flowing beneath us as water discharged from showers, washing machines, and a range of industrial processes moves through the waste water network (sewers). Typically this heat energy is wasted, but sewage heat recovery can put it to meaningful use by taking the energy and upgrading it using heat pumps.

Waste water typically holds average temperatures of 20-25°C, meaning that heat networks using this heat input can achieve high efficiencies.

Gas-fired combined heat and power (CHP)

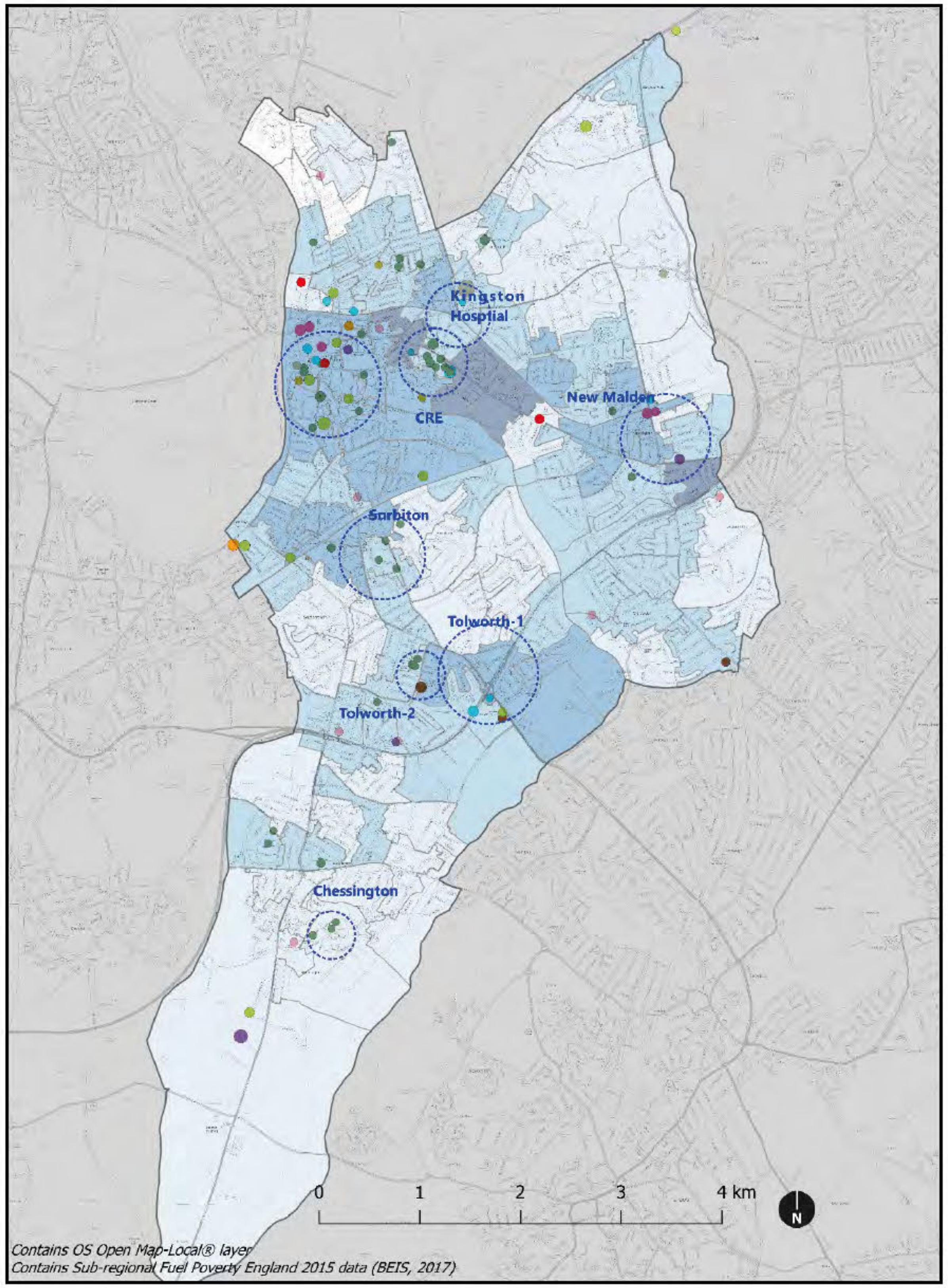
CHP engines produce heat and power from natural gas. The units increase efficiencies by capturing and utilising the heat created as a by-product of the electricity generation process. The heat generated during this process is matched to a suitable demand that would otherwise be met by a conventional gas boiler that would require additional fuel, thus reducing the associated carbon emissions. However, CHP has not been considered for the RBK study because its forecasted carbon savings (Figure 5—1) are unlikely to meet the target CO_2 emissions in the New London Plan and the new 'SAP 10' carbon intensity figures.

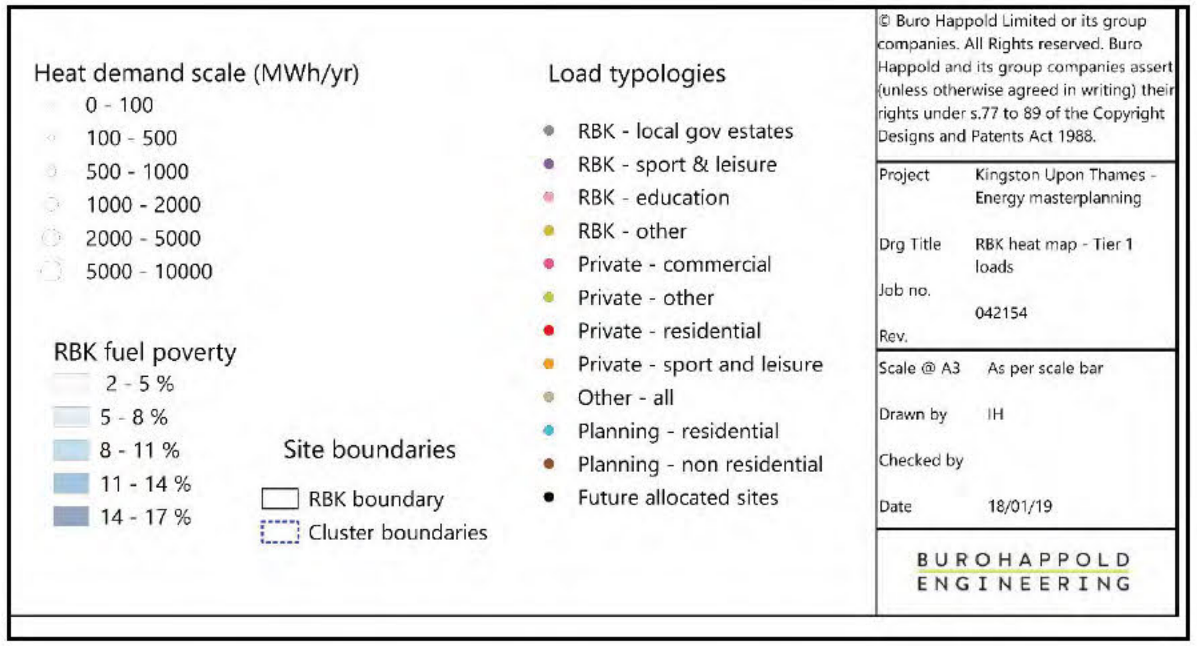
Biomass

This technology involves a biomass-fuelled boiler Energy Centre supplying a district heating network. While this can offer large reductions in terms of carbon emissions and fuel costs over traditional fossil-fuelled schemes, biomass boiler heat networks present key issues with acquiring steady fuel sources and the large fuel storage facility that would be required.

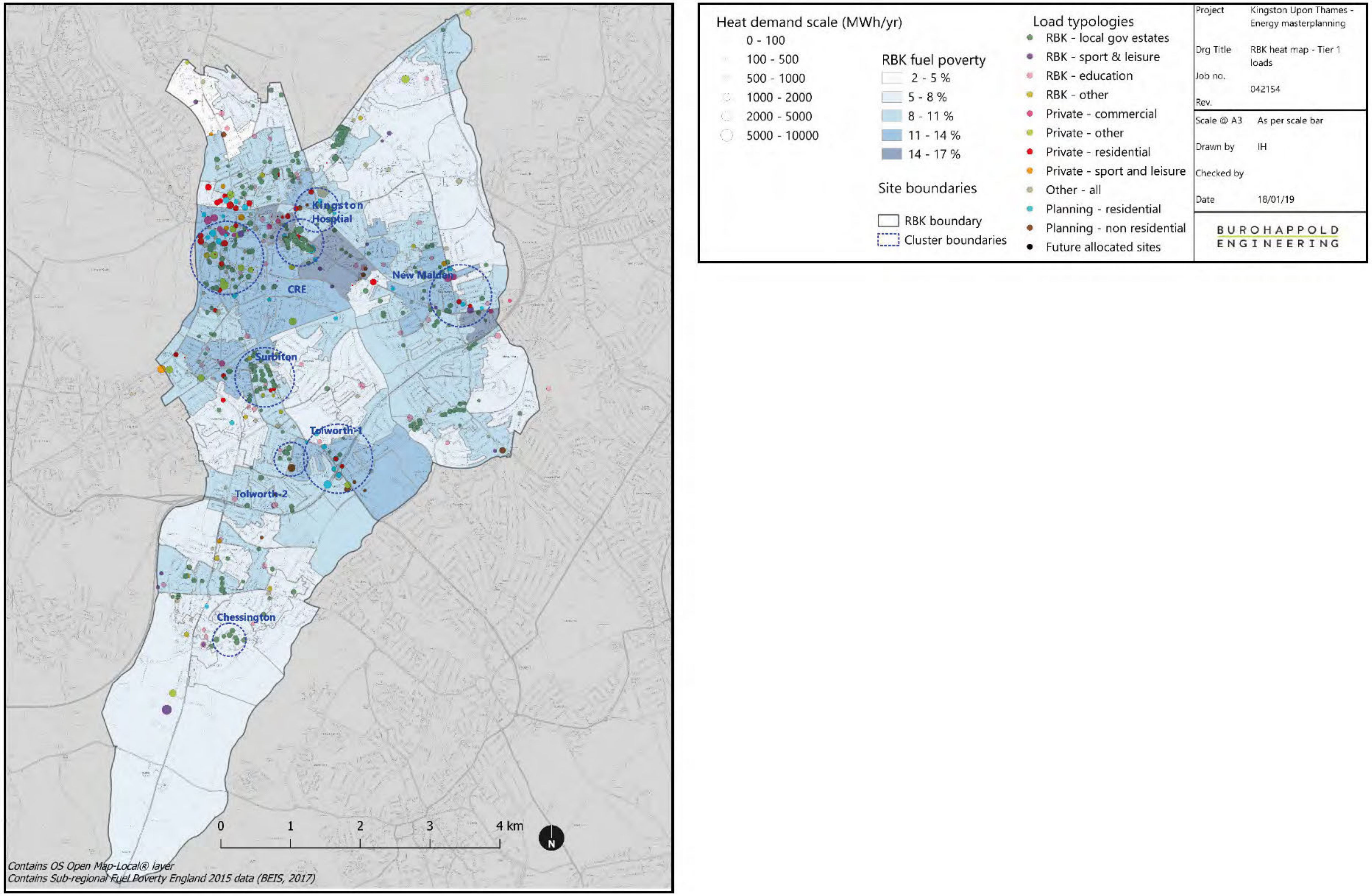
APPENDIX J HEAT MAPPING

Tier 1 heat loads only:





All mapped heat loads in RBK:



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ENERGY MASTER PLAN REPORT

REVISION 03

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