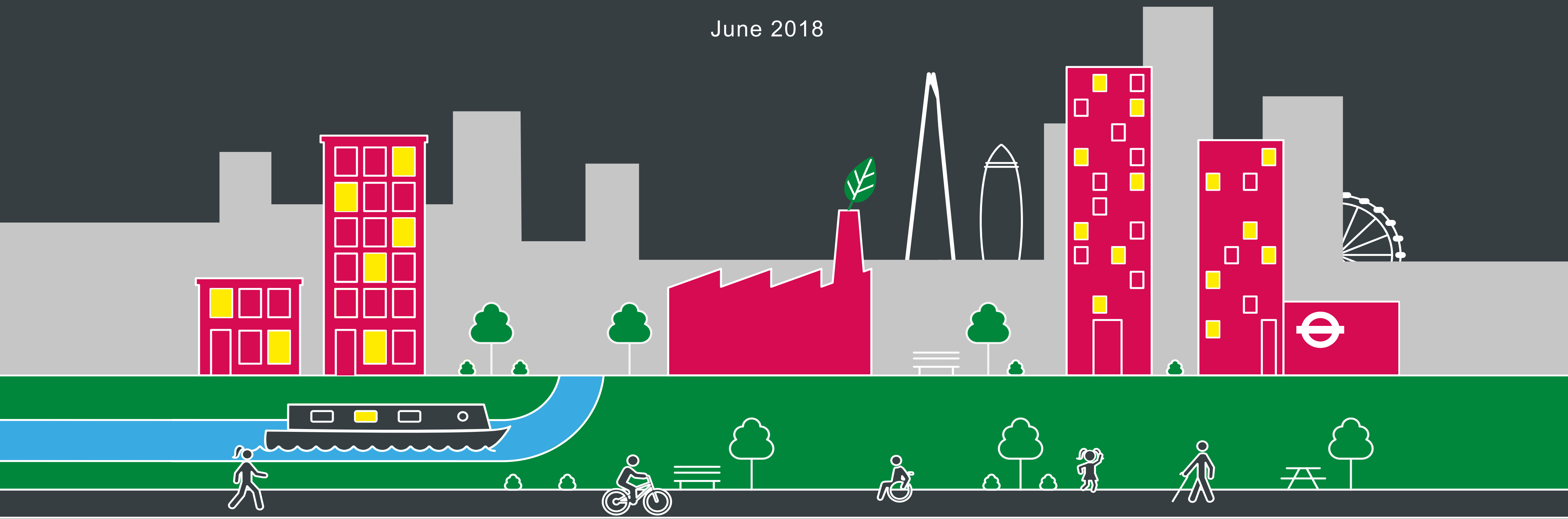
OPDC
OLD OAK AND PARK ROYAL DEVELOPMENT CORPORATION

North Acton District Energy Network Study

LOCAL PLAN SUPPORTING STUDY

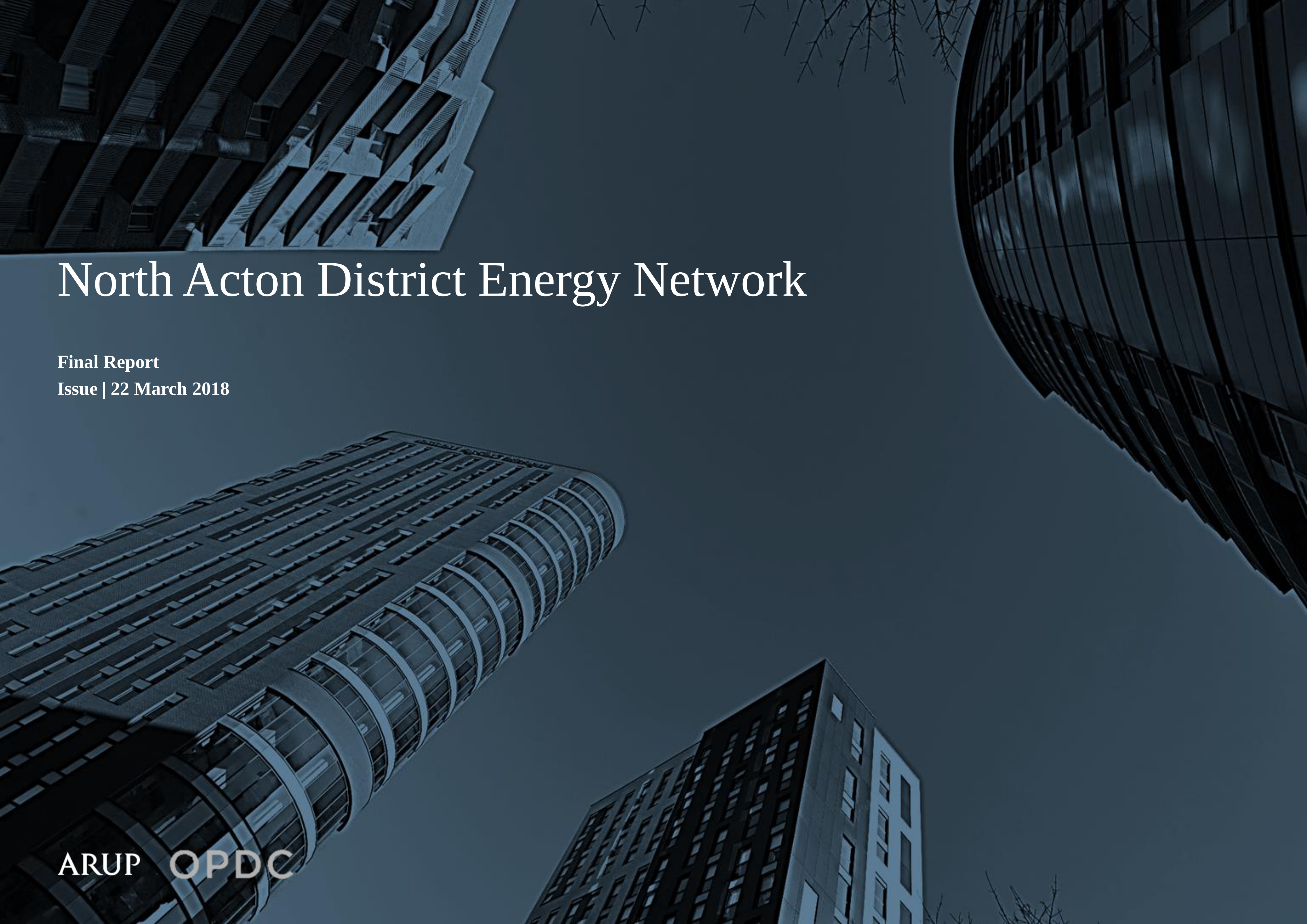
June 2018



MAYOR OF LONDON

30. North Acton District Energy Network Study

Document Title	North Acton District Energy Network Study
Lead Author	ARUP
Purpose of the Study	The report presents the outputs, findings and recommendations of a study into the potential for a low carbon decentralised energy (DE) network in the North Acton area in the London Borough of Ealing.
Key outputs	• Review phasing of new development planned in the area • Assessment of energy demand for each development • Assessment of routing options for an energy network and citing for an energy centre • Review sources of low carbon heat and provide high level assessment of their potential • A commercial and economic assessment of a heat network • A technical and environmental assessment of a low carbon heat network • Conclusions and next steps to advance a district heat network
Key recommendations	• The assessment concludes that it is not commercially or economically viable to deliver a strategic heat network • The review concludes that providing a network using gas fired CHP would be problematic as fossil fuel based systems are less carbon efficient than conventional grid electricity supply and high efficiency boilers. • To deliver carbon savings and meet Mayoral objectives, new development will have to use heat pumps and low carbon heat sources. This is more technically challenging and riskier commercially. • It may be possible for a small heat network to provide 2 or 3 new developments with low carbon heat and hot water. It may be possible to use a local aquifer to support this and to locate the energy centre in the basement of one of the developments. • Further work is required to test the flow rate and temperature of any aquifer. • The developers need to be approached to secure their support for a shared small scale local network and to agree where to cite a small energy centre. • Funding will need to be secured to develop a scheme. • An alternative zero carbon pathway for North Acton will be needed if a low carbon heat network cannot be provided.
Key changes made since Reg 19 (1)	NA - New study
Relations to other studies	Outputs cross-relate to the Utilities Study and the heat study for Old Oak North, the Environmental Standards Study, the Air Quality Study and the Infrastructure Delivery Plan.
Relevant Local Plan Policies and Chapters	• Place Policy P7 (North Acton and Acton Wells) • Environment and Utility Policies EU4 (air quality), EU9 (Minimising carbon emissions and overheating) and EU10 (Energy systems)



North Acton District Energy Network

Final Report

Issue | 22 March 2018

ARUP OPDC

Document Verification

Project Title	North Acton District Energy Scheme	Job Number	258282-00
Report Title	North Acton District Energy Network	File Reference	04-07

Revision	Date		Prepared By	Checked By	Approved By
Draft 1	**19/02/18**	Name	Catrina Cassie	Guido Bollino	Stephen Cook
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Contents

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Glossary of Terms

Abbreviation	Reference
AHU	Air Handling Unit
ASHP	Air Source Heat Pump
BEIS	Department for Business, Energy & Industrial Strategy
CAPEX	Capital Expenditure
CHP	Combined Heat and Power
CIBSE	Chartered Institute of Building Services Engineers
COP	Coefficient of Performance
DEPDU	Decentralised Energy Programme Delivery Unit
DHW	Domestic Hot Water
DNO	Distribution Network Operator
DUKES	Digest of UK Energy Statistics
EC	Energy Centre
EfW	Energy from Waste
ESCo	Energy Services Company
GIS	Geographic Information Systems
GLA	Greater London Authority
GSHP	Ground Source Heat Pump
HHW	Heating Hot Water
HNDU	Heat Networks Delivery Unit
IRR	Internal Rate of Return

Abbreviation	Reference
KPI	Key Performance Indicator
kg	kilograms
kJ	kilojoules (units of energy)
kPa	kilopascals (units of pressure)
kVA	kilovolt-ampere (units of power)
LTHW	Low Temperature Hot Water
MW, kW	Megawatt, kilowatt (units of electrical or thermal power)
MWh, kWh	Megawatt-hour, kilowatt-hour (units of electrical or thermal energy)
NO_x	Nitrogen oxide
NPV	Net Present Value
OPEX	Operational Expenditure
PV	Photovoltaic
REPEX	Replacement Expenditure
RHI	Renewable Heat Incentive
SPV	Special Purpose Vehicle
STOR	Short Term Operating Reserve
tCO_2e	Tonnes of equivalent carbon dioxide
VRF	Variable Refrigerant Flow
TUoS / DUoS	Transmission and Distribution Use of System Charges

ARUP

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We emphasise that any forward-looking projections, forecasts, or estimates are based upon interpretations or assessments of available information at the time of writing. The realisation of any prospective financial information is dependent upon the continued validity of the assumptions on which it is based. Actual events frequently do not occur as expected, and the differences may be material. For this reason, we accept no responsibility for the realisation of any projection, forecast, opinion or estimate.

Findings are time-sensitive and relevant only to current conditions at the time of writing. We will not be under any obligation to update the report to address changes in facts or circumstances that occur after the date of our report that might materially affect the contents of the report or any of the conclusions set forth within.

Executive summary

Arup was commissioned by the Old Oak and Park Royal Development Corporation (OPDC) to undertake a feasibility study for the development of a decentralised energy (DE) network in the North Acton area.

Our Approach

Existing and future developments to be assessed for the network were identified and data on energy demand collected for these developments.

A commercial assessment was made of the practical potential for connection and supply agreements to be secured with each of these developments.

A demand assessment was completed to derive the energy loads associated with all buildings/sites considered for connection to a new DE scheme.

An assessment of potential supply options was made, considering the suitability of various heat (and power) generating technologies to act as primary plant serving the DE scheme.

A preliminary route for heat network distribution pipework was determined, taking into account information gathered on existing buried services (and other potential constraints), plus the options for energy centre location.

Economic and carbon analysis was conducted for selected network scenarios to determine the potential financial and environmental performance of the scheme scenarios compared with the base case of each development having its own energy supply solution.

Demand summary

Seventeen loads were identified for assessment for connection. The loads were a combination of new development sites and existing buildings. The heating, cooling and electrical demands of these loads were assessed through a combination of data provided by developers, energy statements and the use of relevant energy benchmarks.

The total heat demand of all loads was estimated to be 24,800 MWh/year, excluding the thermal losses on the network. This load is built over a time period of 10 years The phasing of this build up is shown in Figure ES2. The peak load is around 12MW.

The majority of developments are domestic with a significant portion being student accommodation. The breakdown by typology is shown in Figure ES3.

Developments are clustered in a relatively small area, with many of these being multi-storey residential units. Therefore the overall demand density of the site is c. 54 kWh/m^2/year, which is above the typical threshold of density for a viable heat network (26 kWh/m^2/year) .

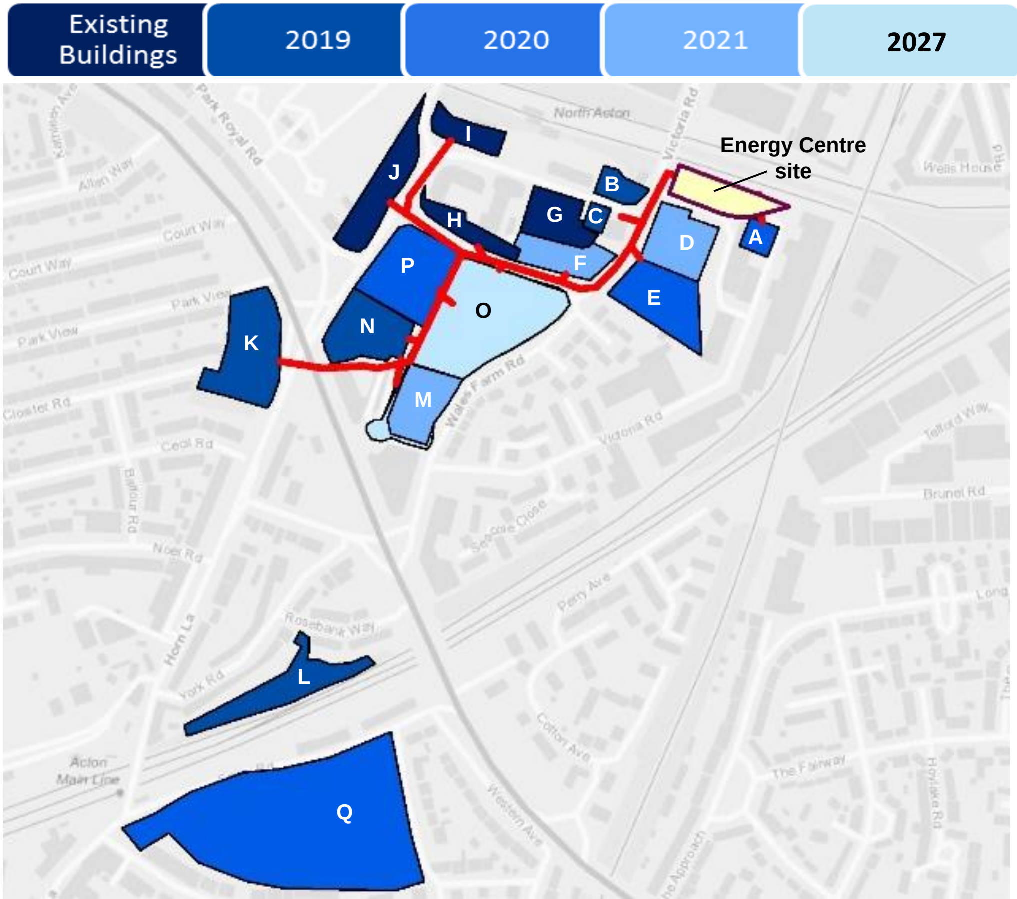


Figure ES.1 Proposed network route map and energy centre location

Executive summary

Therefore this area appears on first inspection to have sufficient demand density and technical potential for a heat network if all of the developments agree to connect.

Supply summary

The supply options for North Acton can be split into "tried and tested" solutions which provide at best limited carbon savings, and "low carbon" options which are more complex, risky or novel:

- Tried and tested: gas CHP, gas boilers, air source heat pumps, direct electric heating
- Low carbon: heat pumps from aquifer source, ground source, sewer source, canal water source and data centre heat recovery.

Based on the supply assessment, the supply mixes taken forward were as follows:

- **Option 1 Gas CHP scheme:** 3.5MWth CHP with boilers.
- **Option 2 CHP with small AQHP scheme**: 2.6MWth CHP and 600kW aquifer heat pump with boilers as peaking and back up supply.
- **Option 3 CHP with large AQHP scheme**: 1.8MWth CHP and 1.2MW aquifer heat pump with boilers as peaking and back up supply.
- **Option 4 Heat pump only scheme:** 1.2MW aquifer heat pump with 4.5MW air source heat pump plus electric boilers for peaking and back up supply.
- **Business as Usual (BAU)**: A business as usual case representing each of the developer's own proposed energy strategies was assembled to compare against the heat network scenarios.

Network summary

The proposed heat network connects fifteen of the seventeen modelling developments. All existing and early developments are assumed to be connected in 2020 with later developments connected upon completion.

Energy Centre

The most suitable option for an energy centre site was identified on land to the north of the study area. This site is understood to be owned by Network Rail. The option of co-location on a development site has also been considered for the larger development sites. This was found to be unlikely to be deliverable, due to:

- Many of the development sites are already built or under construction
- The main remaining site, the Carphone Warehouse site, has no current plans for redevelopment.

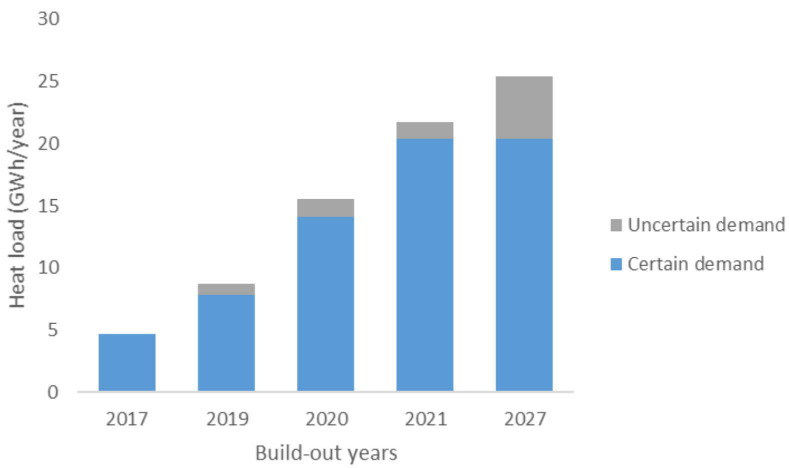


Figure ES2 Heat load build-up by year and space-type

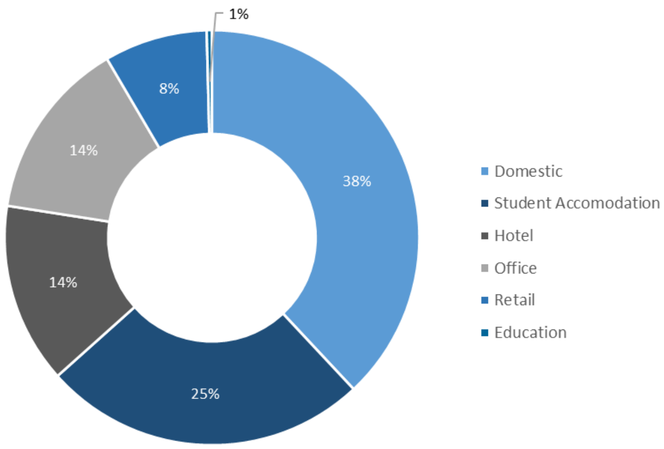


Figure ES3 Heat demand breakdown by typology

Executive summary

In the event of a wider network implementation in OPDC, the network developed in North Acton lends itself well for connection to the wider network. This is mainly due to the proposed energy centre location and the network routing chosen.

Commercial delivery assessment

There are several factors which will influence developers' appetite for procuring or negotiating a heat network connection, or which will affect a heat network promoter's ability to coerce or convince a developer to agree a connection:

- Planning obligations create the conditions for a commercial negotiation
- Heat networks are unregulated utilities
- Connection charge equals avoided cost of connection
- Aligning the timing with the developer's sales drivers
- Contracts can come before networks
- Centralised versus decentralised low carbon heat sources

We considered the potential for public or private-led schemes, and the potential for a single network promoter or a pooled approach involving some or all the developers procuring a heat network.

A public-led approach appears to be the only credible option for delivery of a heat network. The public sector could deliver a network through:

- a public ownership model
- a private sector partnership or concession model

Either option could allow for a future exit scenario for the public sector body. Retention of public ownership would give the public sector body greater flexibility to make long-term strategic decisions about growth and investment in the network (subject to available capital).

In both options, the fundamental development risk remains with the public sector, but the public sector ownership model offers lower complexity than the partnership or concession model.

Our experience of many such similar situations is that sustained project development effort will be needed from the project promoter to delver a heat network.

The alternative scenario is that a network is not pursued and that the energy future for North Acton is based on a decentralised heat model.

In this scenario, the OPDC, GLA and London Borough of Ealing would need to consider ways to ensure the delivery of a low carbon heat transition in the area.

Techno-economic and carbon conclusions

The results for the four scenarios are shown in Table ES.1 overleaf. These highlight the overall economic and carbon results.

Option 1 provides a relatively low modelled rate of return and provides no carbon savings at all; therefore the option should not be considered.

Options 2 and 3 perform the best economically, and would appear to fall within the range of economic performance which would be eligible for grant or low-cost loan support from HNIP. These two options also provide significant carbon savings over their lifetimes.

Option 4 saves the most carbon but the modelling results in a project investment return below zero, which would make it ineligible for funding support from HNIP.

Overall, the results indicate that an economically viable scheme could be developed on the basis of a hybrid system using heat pumps and CHP engines. With appropriate future proofing in the design, the CHP engines and boilers could be replaced by air source heat pumps and direct electric peaking heat supply when they are life expired, to provide a clear pathway to a nearly zero carbon heat network in the future.

Conclusions

The context for the study was the rapid pace of development across the study area, which was found to present considerable practical obstacles to the commercial delivery of a new heat network scheme. Notwithstanding, the planning system has played its role in establishing obligations on developers to negotiate in good faith for a future heat connection, if a heat network is promoted in the area.

Technically, a low carbon network could be delivered through the use of aquifer heat pumps with air source heat pumps, although the more economically viable option would involve a hybrid solution of CHP with heat pumps. A conventional CHP-led scheme with no heat pumps would not lead to any carbon savings compared with a business as usual case.

The aquifer heat pump option would require further investigation through borehole testing to confirm the available heat.

None of the scenarios presented appeared to offer an investable scheme without some gap funding, with project IRRs ranging from below zero to around 5.5%.

At the upper end of the range, the hybrid solutions (Options 2 and 3) appear to fall within the range of eligibility for HNIP funding.

All of these factors make this a location where a public sector ownership model approach appears necessary for a network to happen.

The alternative to a network approach would be to abandon the commitment to a network in North Acton and instead to focus on maximising the opportunity for energy efficient, low carbon building-scale solutions.

Recommendations

Our main recommendation from this study is that:

- OPDC, Ealing and GLA decide, based on evidence available, whether to continue to commit to a heat network in the North Acton area,

If there is no such commitment, the local plan and development management decision making should be reviewed to determine the alternative decentralised low carbon pathway for the area.

If there is such a continued commitment, the following additional steps are recommended:

- OPDC, Ealing or GLA commit staff and/or advisory resources to take on an effective and sustained heat network promoter role
- Commission a technical borehole study to confirm temperature and flow rates in the aquifer.
- Engage with the landowner (Network Rail) of the proposed energy centre site to determine the potential for acquisition or use of the site.
- Continue engagement with developers in the area – ideally through a regular developer forum – to keep up to date with developments on the ground and to refine planning timelines for heat network agreements.

Table ES1 Comparison of scenarios

Scenario	CHP (kWth)	CAPEX (£m)	IRR (%)		Gap funding (40yr)		2016 SAP Average Carbon Intensity (CO2g/kWth)	2016 SAP Lifetime Emission Savings (tCO2)	BEIS Average Carbon Intensity (CO2g/kWth)	BEIS Lifetime Emission Savings (tCO2)
			25yr	40yr	To achieve project IRR of 6%	To achieve project IRR of 12%				
Option 1 CHP	3,500	£12,213,000	-0.20%	3.30%	£2,506,380	£4,854,520	173	26,420	238	-2,360
What is the effect of adding an aquifer heat pump?										
Option 2 CHP + 600kW AQHP	2,590	£12,220,000	2.00%	4.50%	£1,354,450	£4,153,900	174	25,670	199	34,210
Option 3 CHP + 1200kW AQHP	1,840	£12,131,000	3.80%	5.60%	£354,650	£3,567,940	175	25,450	169	63,150
What is the effect of a heat pump only scheme with no gas?										
Option 4 Heat pump only	-	£14,059,000	<-3%	<-3%	n/a	n/a	235	-22,370	54	165,540

1. Introduction

1.1 Purpose and context

This report presents the outputs, findings and recommendations of a study into the potential for a low carbon decentralised energy network (DEN) in the North Acton area in the London Borough of Ealing.

North Acton falls within the combined 650ha Old Oak and Park Royal opportunity areas (OAs), an area which has been identified to have the potential for at least 25,000 new homes and 65,000 new jobs.

At the time this study commenced (September 2017), previous energy studies had identified the North Acton area as the first opportunity for commercial delivery of a heat network to serve new developments, owing to the timing of planned new developments in the area (see Figure 1.1).

The key objective of this study was to test this opportunity through a more detailed investigation of potential loads in North Acton. The second key objective was to establish whether the development of a heat network would be consistent with a zero carbon pathway for the area. This report sets out findings and recommendations on DEN options and the key actions needed to take forward the preferred option.

1.3 Scope and methodology

Scope

The study scope was focused on new development opportunities in North Acton. The key opportunity sites were identified by OPDC and London Borough of Ealing based on evidence of sites which had been recently developed or which were known to have development proposals.

Other existing loads in the area – much of which is either relatively low density housing or warehouse and office space – were not considered due to the low probability that a heat network connection could be achieved within the next few years.

Data collection

Data for the study was obtained from planning application energy statements and/or from the developers and building owners themselves. In cases where no information was provided (or where no details of future development plans could be confirmed), benchmark values were applied to derive the expected total heat demand and hourly profile. Benchmarks were obtained from published industry standards (e.g. CIBSE and the Heat Networks Code of Practice) or Arup design experience.

No existing metered data was obtained because all of the sites in the study were either future developments or too recently completed to have metered data.

It is important to note that there are inherent uncertainties in modelling future demand, particularly when, as in this study, the modelled loads relied on planning stage and benchmark values. Actual demand could vary significantly from the modelled values, as a result of:

- Changes to the scale and type of development and completion date
- Changes to the energy system installed

Data and assumptions for energy supply opportunities were obtained from prior studies, borehole records, enquiries with owners of potential supply sources and published and Arup data on supply plant such as gas CHP, boilers and heat pumps.

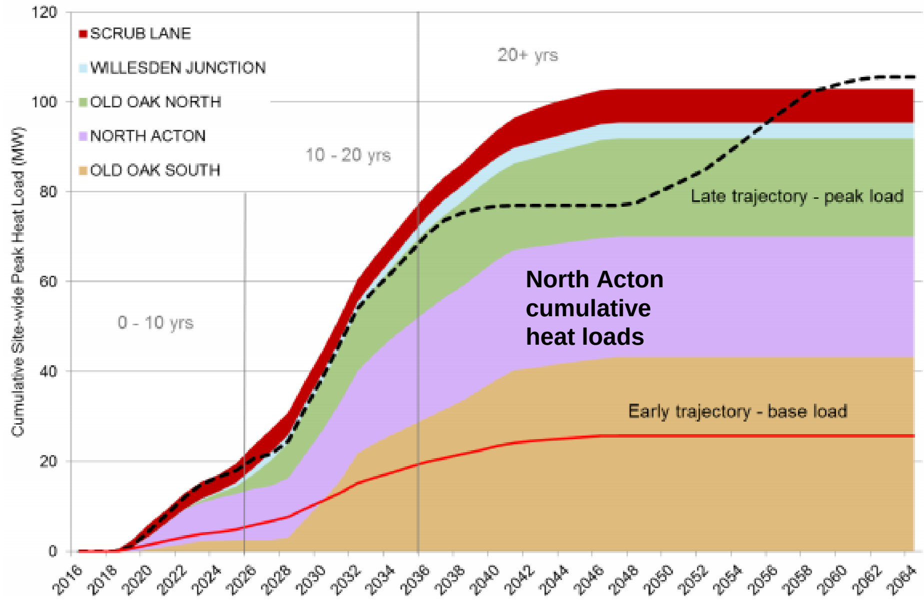


Figure 1.1 Projected cumulative heat loads from new development in Old Oak and Park Royal combined opportunity areas (reproduced from OPDC Energy study, 2017)

Modelling

Technical modelling using EnergyPro and Arup's proprietary energy modelling tool was carried out to test a variety of load configurations and supply options, including heat storage.

Following a demand assessment and identification of potential supply locations, a pipe network route was drawn, and pipe sizing undertaken.

Different scenarios were considered to test schemes with differing load mixes and supply solutions.

The preferred technical scenarios were costed and applied to a project economic model which generated a discounted cash flow projection for each scenario.

Feasibility assessment

Through desktop and site-based investigation by qualified engineers, we assessed the feasibility of the preferred scheme scenarios. This included consideration of:

- Energy centre site locations
- Feasiblity of supply options (notably aquifer and sewer sources of heat)
- Network pipe routing

Site visits were non-intrusive and took place from public highway or other publicly accessible land.

The feasibility of connections to future developments was not assessed directly. In most cases developments are subject to planning conditions that they be designed to be capable of connection to a heat network.

Commercial assessment

The recent and prospective developments which were the focus of this study are or will be obliged through planning permissions to deliver developments which are able to connect to a future heat network. In addition, they are or will be obliged to negotiate in good faith for a connection agreement with a heat network operator proposing to develop a network in the area.

This planning context provides the commercial starting point for a heat network in an area characterised by multiple private developers.

The potential for a commercially deliverable scheme was tested through engagement with developers and landowners and with the ESCo market.

Developers (or their representatives) were contacted through correspondence and by phone, with a face to face discussion held with those who were available to meet. Repeated contact was made to developers who did not respond initially.

The ESCo market was engaged through separate face to face meetings with three prominent companies.

Following a review with OPDC and the steering group, a selection of delivery options were drawn up and assessed in light of:

- the information obtained on developer obligations, willingness and ability to contract to obtain a heat connection and to purchase heat from a heat supply company;
- feedback from the ESCo market on the conditions under which private ESCos would be willing to bid for and deliver a scheme at North Acton; and
- The availability of a public sector body with the willingness, capability and access to resources needed to promote and deliver a heat network.

1.4 Low carbon context

A key objective of the study was to identify a set of supply solutions which can enable a network to deliver low carbon heat to connected developments. In recent years, carbon savings could be achieved by supplying heat networks from an energy mix led by gas combined heat and power (CHP) engines, which displace grid electricity and gas boiler heat with lower emissions.

Gas CHP has also been attractive because the scale efficiencies and electricity sales have helped to deliver financially viable network investments. Future carbon savings could then be delivered by other supply technologies when the CHP systems used at the start of the network reached the end of their lives.

As the carbon intensity of the electricity grid has steadily fallen, the savings from gas CHP have narrowed. BEIS projections that grid carbon intensity will continue to fall mean that new gas CHP systems will no longer deliver carbon savings over the lifetime of the engines.

If gas CHP is no longer a low carbon option, the challenge of identifying the low carbon supply mix for new heat networks becomes more complicated. Where a large scale heat source, such as an energy from waste facility or a large generating station, is not available (as is the case in North Acton), a range of heat pump applications are normally investigated. Heat pumps use electric power to capture natural or built environment sources of heat.

Our study has considered both gas CHP and a range of heat pump options to assess the range of options for supplying a heat network with low carbon heat.

1.5 Structure of the report

Recognising the overriding importance of commercial deliverability in this study, we have structured the report as follows:

- Chapter 2: Description of the Opportunity
- Chapter 3: Commercial Assessment
- Chapter 4: Technical Assessment
- Chapter 5: Project Economic Assessment
- Chapter 6: Conclusions

1.6 Acknowledgements

The study was commissioned by the Old Oak and Park Royal Development Corporation (OPDC). The study was part funded by the Greater London Authority and the work itself supported by a steering group attended by OPDC, London Borough of Ealing and the GLA.

In the course of the study we spoke with and corresponded with many of the developers and landowners as well as with a number of energy service companies (ESCos).

We are grateful for the input of all these parties to enable this study to be completed.

ARUP

2. Description of the Opportunity

2.1 Introduction

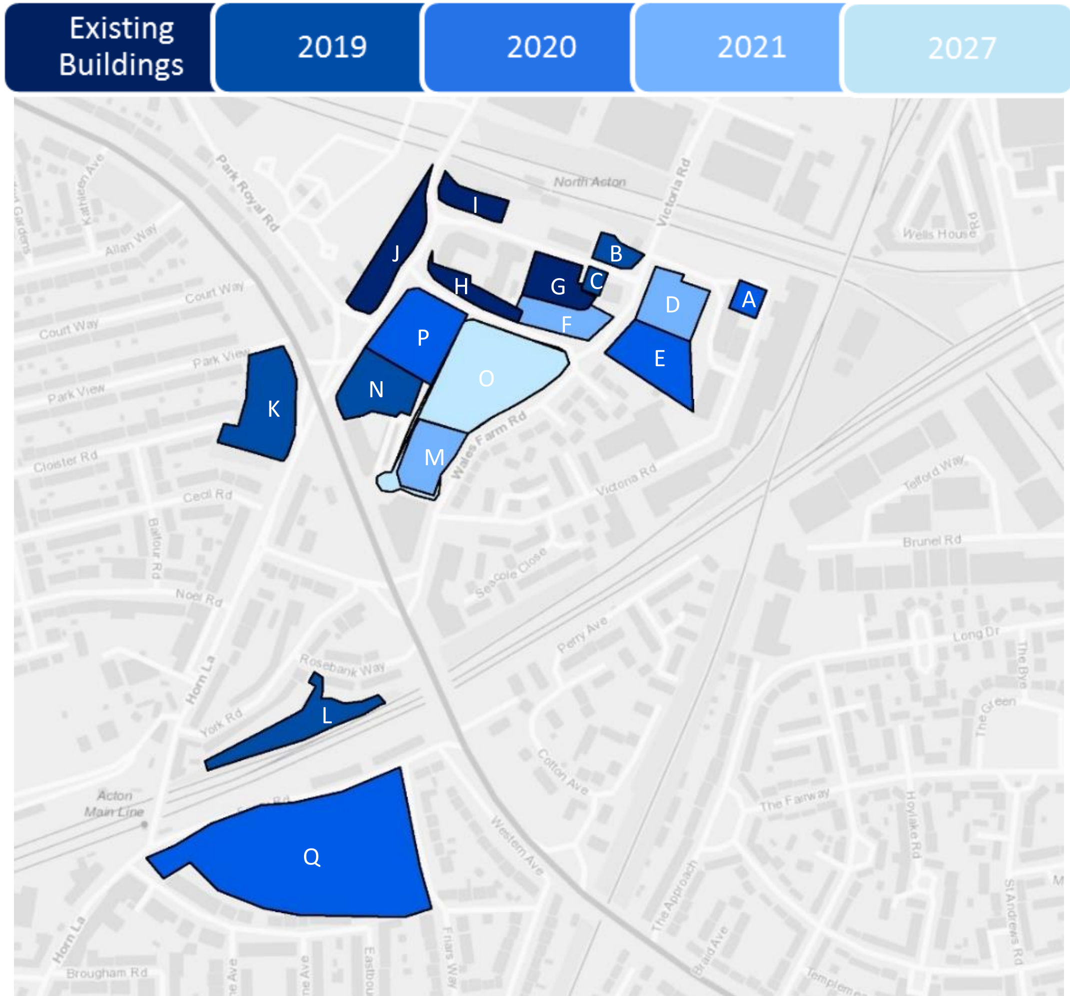
Seventeen sites were identified by OPDC and London Borough of Ealing at the beginning of this study. Each of these sites was assessed for its technical and commercial potential to connect to a heat network.

In this chapter we introduce the seventeen sites and focus on the factors which inform the likelihood of securing contracts with each developer or landowner (and their tenants or buyers) for connection to a heat network and for purchase of heat.

The sites considered are shown in the map, right, and their key development features are set out in the tables overleaf.

2.2 Business as Usual

Each development site's current or planned energy strategy was used to compare the business as usual (BAU) case of no heat network with the proposed district heating solutions. Where available, details of the developments proposed energy strategies are presented in Table 2.2.



A	Monarch House
B	Holbrook House
C	142-154 Victoria Road
D	Perfume Factory
E	Imperial College
F	The Portal
G	Former BBC Costume Store
H	Lyra Court
I	Victoria Square
J	NEC House
K	Gypsy Corner
L	Land to the rear of Western Court Rose Bank
M	2 Portal Way
N	5 Portal Way
O	Carphone Warehouse
P	6 Portal Way
Q	Friary Park Estate

Figure 2.1 Buildings of interest

Table 2.1 Summary of heat network opportunities

Ref	Development Site	Status	Start on site	Completion	Size	Annual heat load (MWh)	Comments	Source
A	Monarch House	Under construction	Q1 2018	Q1 2020	Hotel with 133 bedrooms	1,506	This site is already under construction	Energy strategy
B	Holbrook House	Under construction	Q1 2018	Q 3 2019	424 flats and 74 m^2 retail space	2,200	This site is already under construction	Energy strategy
C	142-154 Victoria Road	Planning	Q1 2018	Q1 2019	64 flats and 158 m^2 of retail space	250	The plan for this site is liable to change and completion date is uncertain.	Developer
D	Perfume Factory	Planning application submitted	Q3 2019	Q1 2021	534 flats and 10,800m^2 non-residential	3,600	Planning permission expected soon, detailed design commences Q3 2018. Time is running out to incorporate a heat connection into development.	Energy Strategy
E	Imperial College	Starting on site	Q2 2018	Q1 2020	600 student flats, 83 resi flats, 6,200m^2 non-residential	2,400	Detailed design is complete and construction is about to commence.	Energy strategy
F	The Portal	GLA stage 2 referral	Q4 2018	Q 2021	355 flats and 5134m^2 of retail space	1,321	Aiming to complete GLA stage 2 referral process in February 2018. Energy centre design has been finalised.	Energy strategy
G	Former BBC Costume Store	Existing	N/A	N/A	722 student accommodation flats and 286m^2 of retail space	1,553	This site is recently built.	Planning application
H	Lyra Court	Existing	N/A	N/A	184 student accommodation flats and 382m^2 of retail space	459	This site is recently built.	Energy strategy

Table 2.1 Summary of heat network opportunities (continued)

Ref	Development Site	Status	Start on site	Completion	Size	Annual heat load (MWh)	Comments	Source
I	Victoria Square	Existing	N/A	N/A	173 flats with 673 m^2 of retail space	727	This site is recently built.	Energy strategy
J	NEC House	Existing	N/A	N/A	659 flats 1,675m^2 of office space 930m^2 for retail and 130m^2 for educational purposes	1,996	This site is recently built.	Energy strategy
K	Gypsy Corner	Under Construction	Q1 2018	Q1 2019	1 block of 72 domestic residential flats and 1 block of a hotel with 100 bedrooms.	2,237	This site is already under construction	Planning application
L	Land to the rear of Western Court Rose Bank	Under construction	Q1 2018	Q1 2019	37 domestic flats and 77m^2 of office space.	138	The connection of this site would require crossing a major road.	Planning application
M	2 Portal Way	Final planning stages	Q2 2020	Q3 2021	368 flats	1,251	There is no key constraint however there has been a low level of interest from the developer.	Ealing Planning
N	5 Portal Way	In planning	Q1 2018	Q1 2012	3,943m^2 of office space	631	This data is according to planning, there was no evidence of the site being in construction on the site visit and the building is currently being leased by the Algerian embassy.	Developer response
O	Carphone Warehouse	Existing dev't	Not applicable	Not applicable	Not applicable	Not applicable	The existing commercial development is leased through at least 2027. There are no current plans for redevelopment of the site. A previous planning application has been used as a notional representation of potential future demand.	Energy strategy / Developer response
P	6 Portal Way	In planning	Q2 2019	Q3 2020	3,000m^2 office development	493	There are no key constraint however there has been a low level of interest in the study.	Developer response
Q	Friary Park Estate	In planning	Q4 2018	Q1 2020	709 domestic flats / houses	2,412	The connection of this site would require a major railway crossing.	Ealing planning

Table 2.2 Summary of developments' current energy strategies

Ref.	Building	BAU Energy Strategy	Source
A	Monarch House	The planned energy strategy is a 15kWe & 30kWth CHP system to preheat the domestic hot water service. Future proofed to connect to off site heat network	Energy strategy
B	Holbrook House	The planned energy strategy is an onsite CHP unit with 201kWe capacity. Future proofed to connect to off site heat network	Energy strategy
C	142-154 Victoria Road	Discussion with the developer has said that plans for this site are liable to change and no energy strategy can be provided.	Developer
D	Perfume Factory	Proposed energy centre in the basement to serve Perfume Factory and Imperial College	Energy Strategy
E	Imperial College	Proposed energy centre in the basement of the Perfume Factory to serve Imperial College	Energy strategy
F	The Portal	The current energy strategy is communal gas boiler and solar PV.	Energy strategy
G	Former BBC Costume Store	The current energy strategy is a 150kWe gas fired CHP and 70m2 solar PV	Planning application
H	Lyra Court	50kWe/ 76kWth CHP unit to provide heat and hot water at the student accommodation (60% of the annual DHW and 30% of the annual heating demand) 45m^2 and 35m^2 installed on Blocks F and G with total capacity 10.7kWp, respectively, and ASHP for space heating & cooling to the commercial areas	Energy strategy

Table 2.2 Summary of buildings current energy strategies (continued)

Ref.	Building	BAU Energy Strategy	Source
I	Victoria Square	The current energy strategy is a 60kWth/ 40kWe gas fired CHP and 35kWe/61kWth capacity, 10m^3 thermal store. 139 m^2 and 90 m^2 solar PV panels on two blocks	Energy strategy
J	NEC House	The current energy strategy is a 140kWe/203kWth CHP for the heating and hot water commercial and ancillary areas heated and cooled via VRF systems served by external ASHP	Energy strategy
K	Gypsy Corner	CHP system to preheat the domestic hot water service. Solar PV panels of 200m^2, 120m^2 and 110m^2 to be installed on the roof of the hotel, Block A and Block B, respectively.	Planning application
L	Land to the rear of Western Court Rose Bank	Block of flats has been future proofed incorporating: 1. the installation of an isolation valve or blanked off flange at each domestic standalone gas boiler to enable future bivalent operation 2. the provision of a storage cupboard for the future location of a heat interface unit along a with sufficient space provision 3.an identified route for district pipe work to enter the premises	Planning application
M	2 Portal Way	The current energy strategy is an in house CHP, details of which have not been confirmed.	Ealing Planning
N	5 Portal Way	There is no energy strategy currently available.	Developer response
O	Carphone Warehouse	There is planning permission for the possibility of expanding the energy centre to serve adjacent developments. However, upon discussion with the owner of this site there are no plans to act upon this.	Energy strategy / Developer response
P	6 Portal Way	onsite CHP unit with 200kWth/124kWe capacity and 30m3 thermal store to cover approximately 72% of the development’s annual heat load.	Developer response
Q	Friary Park Estate	The energy strategy for the is based on a local CHP system, with individual boilers for some properties, supported by solar PV panels.	Ealing planning

3. Technical Assessment

3.1 Introduction

The chapter presents the technical demand and supply assessment for the study area. The assessment included evaluating the energy demand density, the demand duration, and annual heat demand profile of the all of the developments.

3.2 Demand assessment

Seventeen loads were identified for assessment for connection. The loads were a combination of new development sites and existing buildings. The heating, cooling and electrical demands of these loads were assessed through a combination of data provided by developers, energy statements and the use of relevant energy benchmarks.

The total heat demand of all loads was estimated to be 24,800 MWh/year, excluding the thermal losses on the network. This load is built over a time period of 10 years, as shown on Figure 3.1. This figure also highlights that some of the demands are based on assumptions that developments will proceed which are not confirmed by landowners to be within their current plans. This is explained further in later chapters of the report.

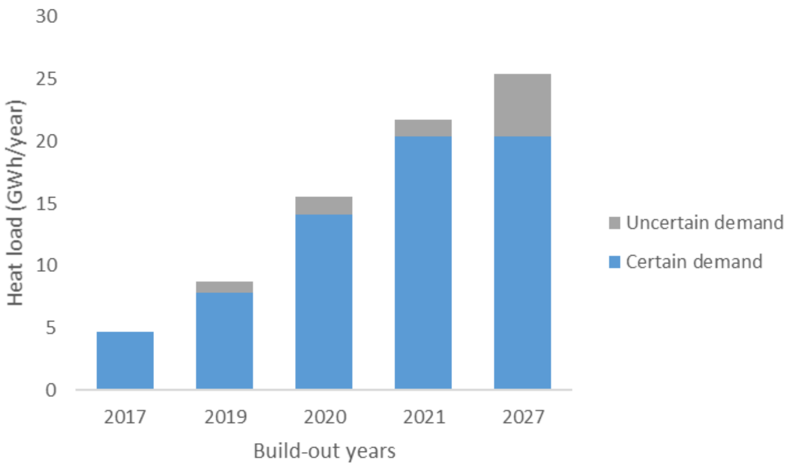


Figure 3.1 Cumulative heat demand build-up excluding thermal losses

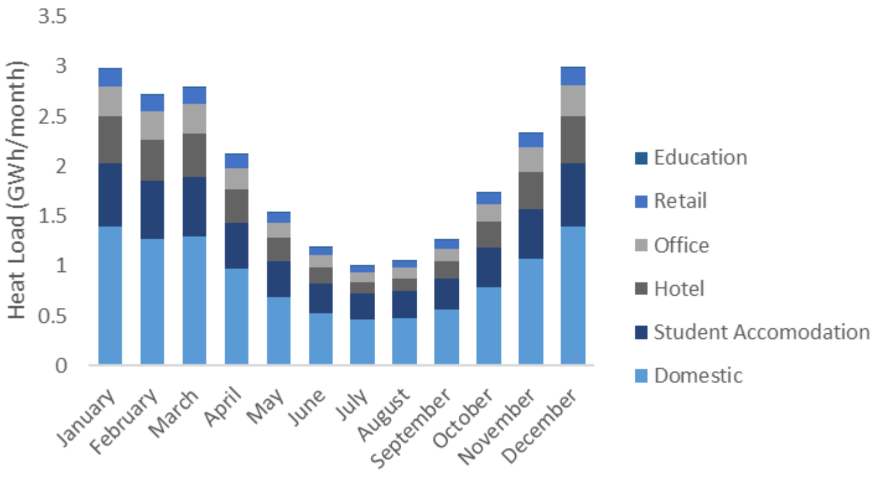


Figure 3.2 Monthly heat demand profile

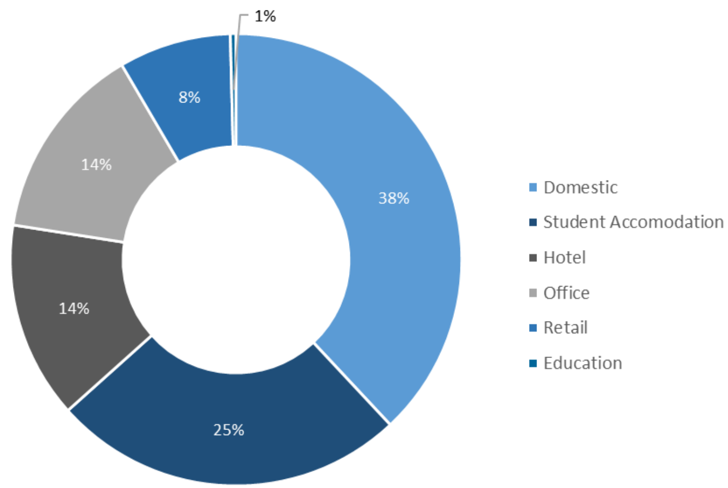


Figure 3.3 Annual heat demand profile

The monthly load profile in Figure 3.2 illustrates the variations across a calendar year. As shown in Figure 3.3, the majority of the maximum demand comes form domestic buildings and student accommodation. This means that there is a high level of diversification applied in the model.

Figure 3.4 shows the results of heat mapping of the identified loads. The heating loads are represented on the map using red circles. The larger circles represent larger heat consumption.

As it can be seen from the figure, there is a wide range of scale of heat demand between the developments. The majority of the heat load is clustered in the north of the study.

The demand density of the estimated loads area is around 54 kWh/m^2/year. This compares favourably with a benchmark value of 26 kWh/m^2/year as the typical threshold of density for viable heat networks. Although only indicative, the demand density value shows that the basic technical features of the opportunity are consistent with a heat network solution.

Figure 3.5 shows the demand duration curve for all buildings in the study. From this we can derive that the peak load is 12MW. The configuration of heat supply selected must be able to provide for peak load. However, to avoid low utilisation of capital equipment, it is common practice to have the main heat source supplying approximately one third of the peak load with heat storage and other heating technologies being used when demand is high. This gives rise to a target main plant peak output capacity of 3-4MW, with peaking plant and storage providing the remaining 8-9MW. Redundancy, or back up plant, would be in addition to these figures and would typically be sized on an N+1 basis for major plant items.

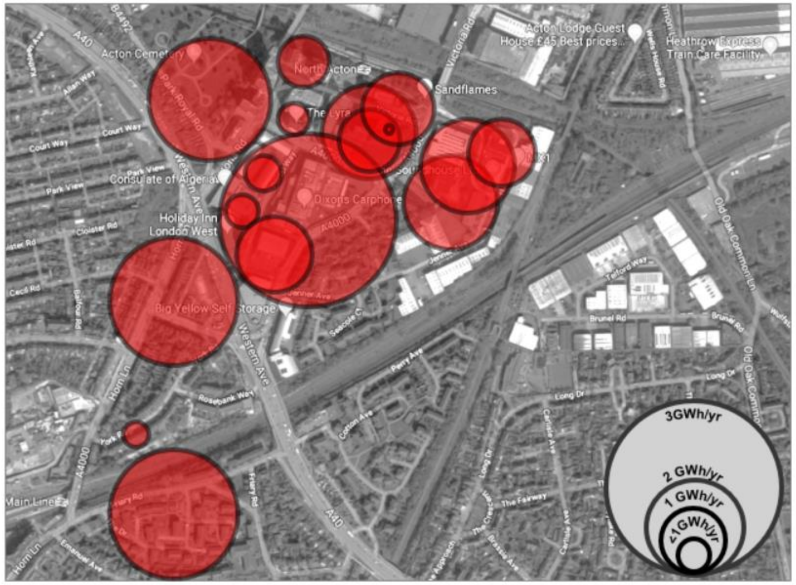


Figure 3.4 Scaled site heat demands for all study buildings

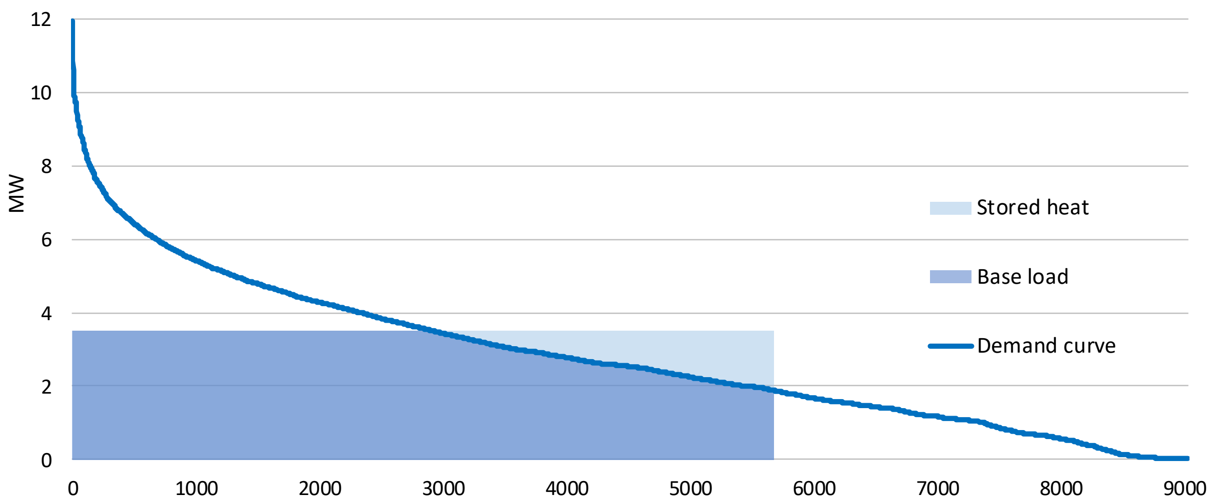


Figure 3.5 Demand duration curve for all buildings included in the study. The box represents a typical sizing of the primary heat source.

3.3 Supply assessment

The North Acton area, within the red circle in Figure 3.6, is part of a wider area of interest for district heating networks, with a number of heat potential sources available. In order to inform a high level technical assessment of heat network supply options, the following criteria were defined against the following:

- Capital costs (considered on a per kW installed basis)
- O&M costs (incorporating the expected lifespan of each technology)
- Maturity/Reliability (qualitatively)
- Resource availability (both for plant procurement and it O&M)

These criteria are set against the following technologies, identified as potential centralised primary sources of low carbon heat (and power):

- Gas-fired CHP
- Gas boilers
- Heat Pumps drawing heat from a wide range of sources of heat including aquifer, ground, canal water, air and cooling (heat rejection) systems elsewhere in the built environment

The options are summarised in Table 3.1 overleaf. Full descriptions of these technology options can be found in Appendix C.

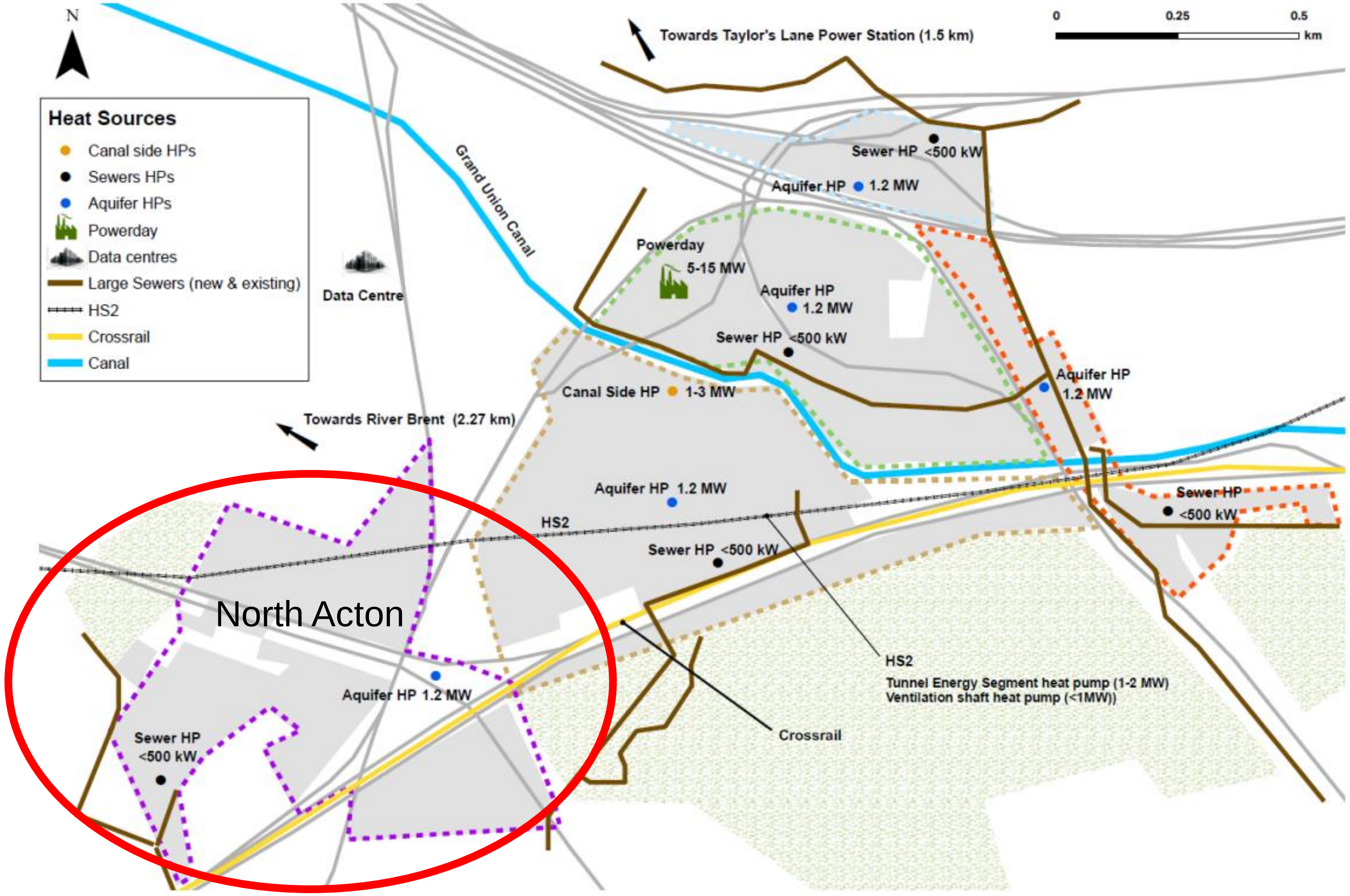


Figure 3.6 Potential heat sources in the wider OPDC area

Table 3.1 Supply technology assessment summary

Technology option	Output / Application	Cost		Practicality	Carbon emissions (in comparison to BAU)	Environmental Considerations
		Capital	O&M			
Gas Combined Heat and Power Engine (CHP)	Heat and Electricity	Medium	Medium	Gas fired CHP is well suited to district heating systems	Lower – A larger scale CHP is more efficient than developers' small CHPs, but CHP carbon savings decline as grid decarbonises	Would need to meet new London Plan standard of ultra-low NOx boiler emissions This will have an impact on space requirements and energy efficiency.
Boilers	Heat only	Low	Low	Gas boilers are a well-developed and resilient technology which have been applied in district heating schemes. Typically used for peaking and back up.	Higher	Would need to be ultra-low NOx boilers
Aquifer Heat Pump (AQHP)	Heat only	High	Medium	Drill tests will be required to confirm availability of this resource	Much lower – based on typical COP	Zero local emissions. Risks to water quality to be assessed but can be mitigated.
Large Scale Air Source Heat pumps (ASHP)	Heat only	High	High	ASHP are typically most suitable for individual building solutions rather than for a centralised energy centre	Lower	Zero local emissions. Can create cold zones in vicinity of heat pumps.
Large Scale Ground Source Heat pumps (ASHP)	Heat only	High	High	The ground can act as both a store and supply of heat. Heat can be extracted from open or closed loop systems, the former using aquifers, the latter boreholes. They are best suited to low temperature networks.	Much lower – based on typical COP	Zero local emissions. Requires multiple boreholes to achieve production at scale.
Sewage Heat Pump	Heat only	High	High	The local major trunk sewer runs under a major road. This technology is not very mature at present	Much lower – based on typical COP	Zero local emissions. Heat extraction must be limited to avoid adverse operational impact on sewage undertaker.

Table 3.1 Supply technology assessment summary (continued)

Technology option	Output / Application	Cost		Practicality	Carbon emissions (in comparison to BAU)	Environmental Considerations
		Capital	O&M			
Canal Heat Pump	Heat only	High	High	Heat pump units typically require water at temperatures above 5 to 8°C in order to operate efficiently and so will often fail during particularly cold winter conditions. For this reason, provision of a supplementary heat source is essential.	Much lower – based on typical COP	Zero local emissions. Heat extraction must be limited to avoid adverse impact on canal ecology and navigation
Data Centre Heat Recovery	Heat only	Medium	Low	The high electrical loadings of data centres mean they often experience significant cooling loads, therefore rejecting significant amounts of heat. There are no data centres in close enough proximity to consider connecting.	Much lower – based on typical COP	Zero local emissions. Heat rejection to a network provides a benefit compared with local heat reject to air.
Direct electric heating	Heat only	Low	Low	Direct electric heating is cheap, low maintenance and reliable. However, it is inefficient and costly for end users. Also, large scale adoption of direct electric could lead to significant pressure on the electricity grid to cope with much higher and steeper peak loads.	Much higher, although they will fall as the grid decarbonises	Zero local emissions. Large scale adoption would be likely to slow down the rate of grid decarbonisation due the inefficiency of this technology.

Supply conclusions

As illustrated in Table 3.1, the supply options for North Acton can be split into "tried and tested" solutions which provide at best limited carbon savings, and "low carbon" options which are more complex, risky or novel:

- Tried and tested: gas CHP, gas boilers, air source heat pumps, direct electric heating
- Low carbon: heat pumps from aquifer source, ground source, sewer source, canal water source and data centre heat recovery.

Based on the supply assessment, the supply mixes taken forward were as follows:

- **Option 1 Gas CHP scheme:** 3.5MWth CHP with boilers. This was selected to demonstrate what the most "bankable" option would look like, in terms of maximising revenue for a heat network operation and minimising feasiblity risk.
- **Option 2 CHP with small AQHP scheme**: 2.6MWth CHP and 600kW aquifer heat pump with boilers as peaking and back up supply. This was selected as a lower carbon variant to the Core Scheme. The small AQP reflects a risk assessment which models 50% of the estimated yield available from a single AQHP circuit.
- **Option 3 CHP with large AQHP scheme**: 1.8MWth CHP and 1.2MW aquifer heat pump with boilers as peaking and back up supply. This was selected as a lower carbon variant to the Core Scheme which assumes maximum yield from the aquifer opportunity. The largest size of a single AQHP possible in the scheme is not enough to provide all the baseload heat. Therefore a smaller CHP was retained provide sufficient baseload heat.
- **Option 4 Heat pump only scheme:** 1.2MW aquifer heat pump with 4.5MW air source heat pump plus electric boilers for peaking and back up supply. This scheme is based on an elimination of CHP as an option, leading to an all heat pump heat supply solution. Electric boilers are included for redundancy and for winter peaking when the output of the ASHPs will be least effective.

- **Business as Usual (BAU)**: A business as usual case representing each of the developer's own proposed energy strategies was assembled to compare against the heat network scenarios.

All the supply configurations take account of feasibility constraints within North Acton, including in particular the location of heat sources

In addition, all supply configurations have been sized to enable them to meet the eligibility criteria for a grant and/or loan from Government's Heat Network Investment Project (HNIP) funding. This includes specifying that:

- where gas CHP is the sole low carbon heat source, the CHP system provides at least 75% of the total heat supplied to the network; and
- where a network includes a mix of low carbon and renewable sources of heat (which may include CHP), these technologies must collectively provide at least 50% of the total heat supplied to the network.

3.4 Network assessment

Constraints review

There are significant site constraints that need to be considered in developing a potential DH network. These, alongside the key heat sources are identified in Figure 4.7. North Acton is an area undergoing much development at this time and is surrounded by major transport routes. The North Acton area is bordered to the southwest by the A40, a major 6-lane road connecting West London and linking to Central London and the M40 motorway. There are also numerous railway lines, marked in brown in the figure, including the main intercity lines out from Paddington, the Central Line, the Bakerloo line and the Overground network. Further constraints have been assessed and are as follows:

1. Area of conservation

There are no conservation areas within the area of this study.

Table 3.2 Supply scenarios

Scenario Option	Technology mix	Primary Energy Source	Relative Capex	Relative Feasibility	Carbon Emissions	Environmental Considerations
1. Gas CHP	3.5 MW gas CHP Gas Boilers	Gas	Medium	High – common scenario in DHN	Lower in short term compared to BAU scenario, higher over life cycle of network	Would need to meet new London Plan standard of ultra-low NOx boiler emissions
2. CHP with small AQHP scheme	2.6 MW gas CHP 600 kW AQHP Gas Boilers	Gas + electricity	Medium	Medium high – dependent on aquifer availability and power	Lower in long term according with grid decarbonisation projections.	Would need to meet new London Plan standard of ultra-low NOx boiler emissions. Risks to water quality to be assessed.
3. CHP with large AQHP scheme	1.8 MW gas CHP 1.2 MW AQHP Gas Boilers	Gas + electricity	Medium	Medium – dependent on aquifer availability and power	Lower in long term, according with grid decarbonisation projections.	Would need to meet new London Plan standard of ultra-low NOx boiler emissions. Risks to water quality to be assessed.
4. Heat pump only scheme	1.2 MW AQHP 3.5 MW ASHP Electric Boilers	Electricity	High	Medium-Low - dependent on aquifer availability and power and air source heat pump efficiency	Much lower in long term, according with grid decarbonisation projections.	Low local emissions. Risks to water quality to be assessed. ASHPs can create cold microclimate zones in vicinity of the plant.

2. Third party land

The recommended energy centre site is located on land owned by a third party (i.e. not OPDC or London Borough of Ealing). It is understood that the land is owned by Network Rail. Acquisition or lease of such land would need to be negotiated with the land owner. Network Rail is a statutory undertaker and therefore all land disposals would be subject to a demonstration that the land was wholly surplus to current and future railway operational needs.

The land over the sewer is also private land, making a sewer heat pump in this area unlikely to be viable, even if feasible.

No other third party land crossings were identified.

3. Potential pinch points

Potential infrastructure pinch points were identified at the bridge crossing over to the Friary Park Estate. No other pinch points were identified.

4. Linear infrastructure that would block routes

The major road and rail corridors represent significant obstacles to the development of a DH heating network. The proposed network has focused mainly on the zone within the major corridors.

5. Energy centre location possibilities

Two energy centre locations have been identified as well as co-location in some of the larger developments. As noted above, all site options are on private land. The site with the best potential is the railway land site to the north of the Perfume Factory (Site D).

6. Growth opportunities

The key growth opportunities are to the North and East of North Acton via Old Oak Common Lane and Victoria Road. These roads are expected to go through significant upgrades due to HS2 requirements. This may present an opportunity to coordinate and DH pipework installation into the proposed roadwork programme which could offer cost saving and sharing, subject to HS2 plans.

Phasing considerations

This analysis splits the buildings into 5 phases to analyse the time path of the scheme and made a more complete technical evaluation. The phase splits can be seen in Figure 3.8.

The most plausible buildings to be connected to a network will be those in Phases 3, 4 and 5 given that they can still be updated with minimal cost. Changing a buildings design to incorporate a heat network connection rather than a building local solution, despite being advantageous for the ease of building operation and space can be expensive if the building is in the later stages of design.

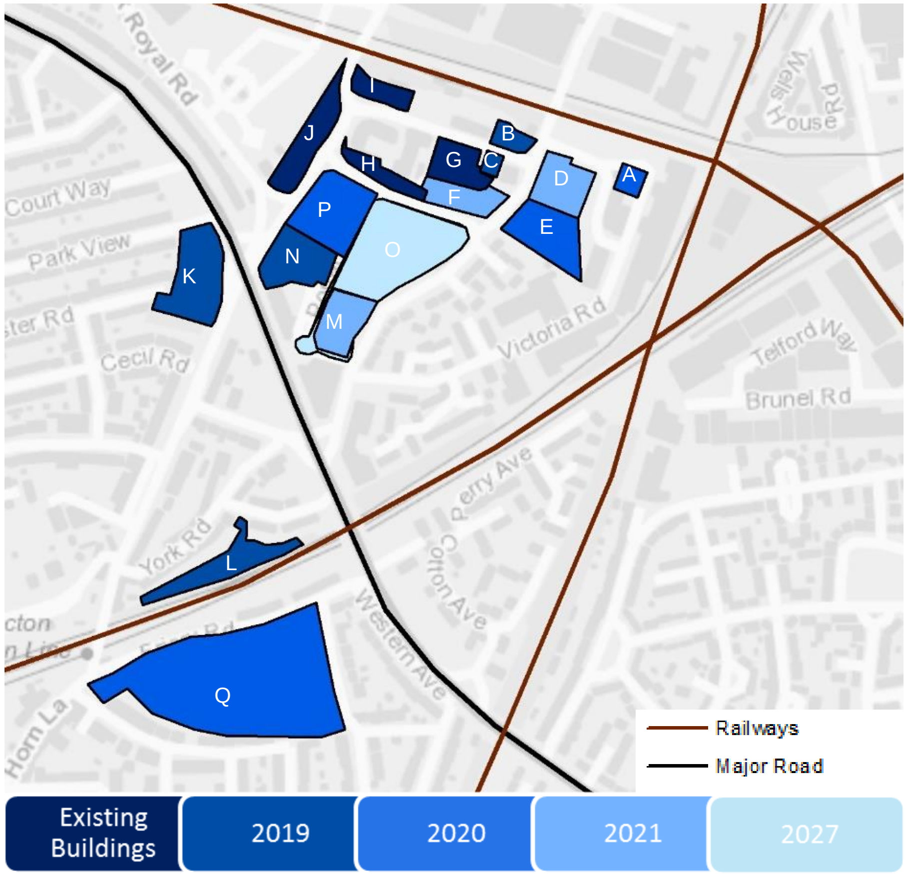


Figure 3.7 Location of development sites showing major barriers from linear infrastructure

Consequently, the buildings that are least plausible to connect to a heat network are those already existing as they already have capital tied up in their plant and will gain no space from connection.

Connection scenarios

The Core scheme connection scenario was modelled with all Phase 1, 2 and 3 buildings connected from 2020 and phase 4 and 5 buildings connected after their completion. Scenarios not including the connection of the existing buildings have also been modelled to evaluate sensitivities.

Network routing

Included in Figure 3.8 is the proposed network layout for the full build-out scenario. This would be installed in increments for the phasing of fewer buildings initially connecting to the main energy centre, with initial network elements suitably future-proofed to facilitate later expansion.

The developments Q and L have not been connected at this time due to routing difficulties for comparably low loads. The connection of the Friary Park Estate (Q) would require a major rail and road crossing, while Site L (Western Court Rose Bank) is a relatively small and distant load which is not justified as a connection on its own.

Network losses

The network has been designed according to the best practice approach outlined in the Heat Network Code of Practice for the UK to avoid heat losses.

The guide states that *the calculated total annual heat loss from the network up to the point of connection to each building when fully built out is typically expected to be less than 10%,* a conservative figure of 10% has been used in modelling.

Energy centre location

The most suitable option for an energy centre site was identified on land to the north of the study area. This site is understood to be owned by Network Rail. The option of co-location on a development site has also been considered for the larger development sites. This was found to be unlikely to be deliverable, due to:

- Many of the development sites are already built or under construction
- The main remaining site, the Carphone Warehouse site, has no current plans for redevelopment..

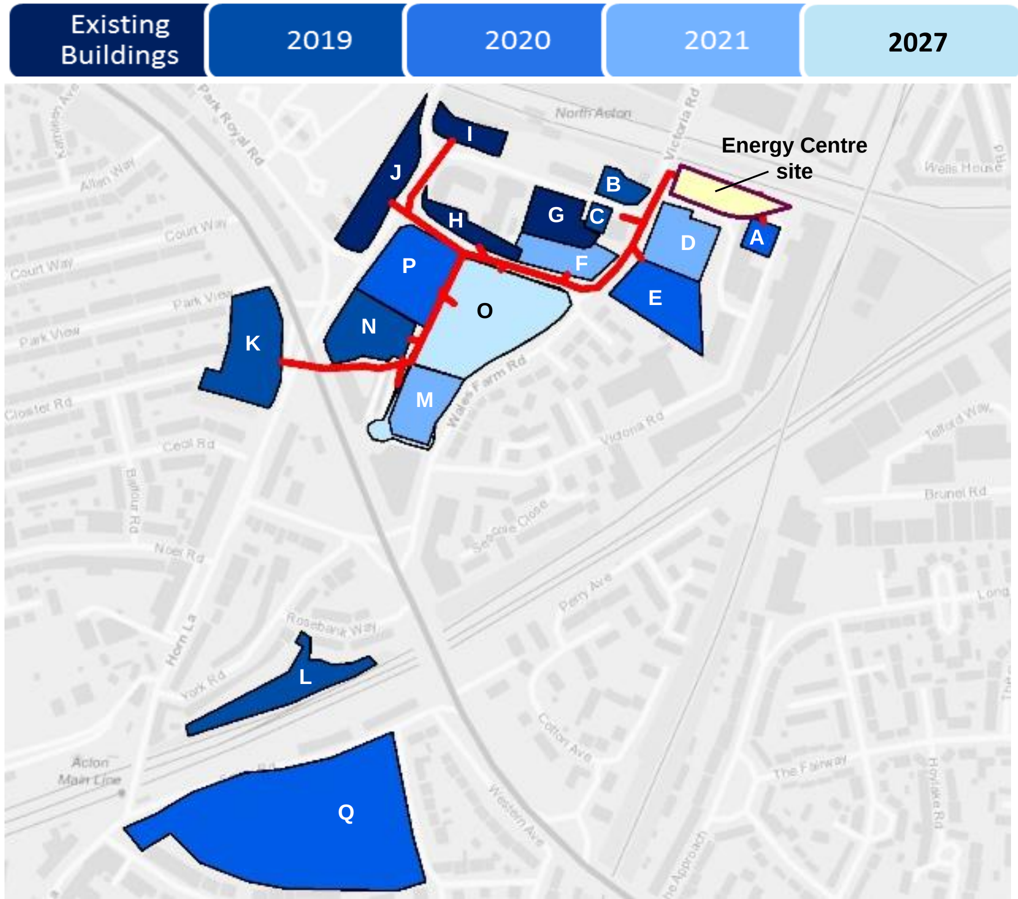


Figure 3.8 Proposed network route map and energy centre location

Connection to a wider energy network

In the event of a wider network implementation in OPDC, the network developed in North Acton lends itself well for connection to the wider network. This is mainly due to the proposed energy centre location and the network routing chosen.

The preferable connection between the two networks would be expected to be via the Victoria Road bridge over the railway. Detailed feasibility of this crossing has not been assessed; however a recent feasibility study by Arup for a similar crossing to the east at Southall identified a range of options for routing the pipe over the bridge, including securing the pipes to the side or underside of the bridge deck or within the roadway itself.

Each of these options would incur significant additional capex, which would need to be justified through operational or commercial savings arising from interconnection of the two networks.

Since the interconnection point would be located at or close to the North Acton energy centre, sizing for the North Acton pipework would be unaffected. The selection of energy centre was made with this opportunity in mind (among other factors).

If the North Acton energy centre were located at the southern end of the study area (e.g. near Gypsy Corner, site K), the network design would specify decreasing pipe sizes as the network extended from the energy centre to the farthest point of the network. In this scenario there would be an additional cost of pipe oversizing to future proof an interconnection, or else a significant constraint on the peak supply which can be provided from one side of the network to the other.

In a future interconnection scenario, the energy centre in North Acton can act as a secondary energy centre of the wider network, adding resilience to the system.

A further future proofing factor is to ensure as far as possible that the design temperatures and pressures of each network are the same (or technically compatible) so that the interconnection can be achieved without hydraulic separation (which introduces additional losses and prevents operation of the combined network from a single energy centre.

If the two networks are developed by different operators, heat meters can be installed at the connection point to enable sales of heat in both directions (in the same way that grid interconnections operate between the UK and continental Europe electricity grids). These meter points can be installed whether the two networks are hydraulically connected or separated.

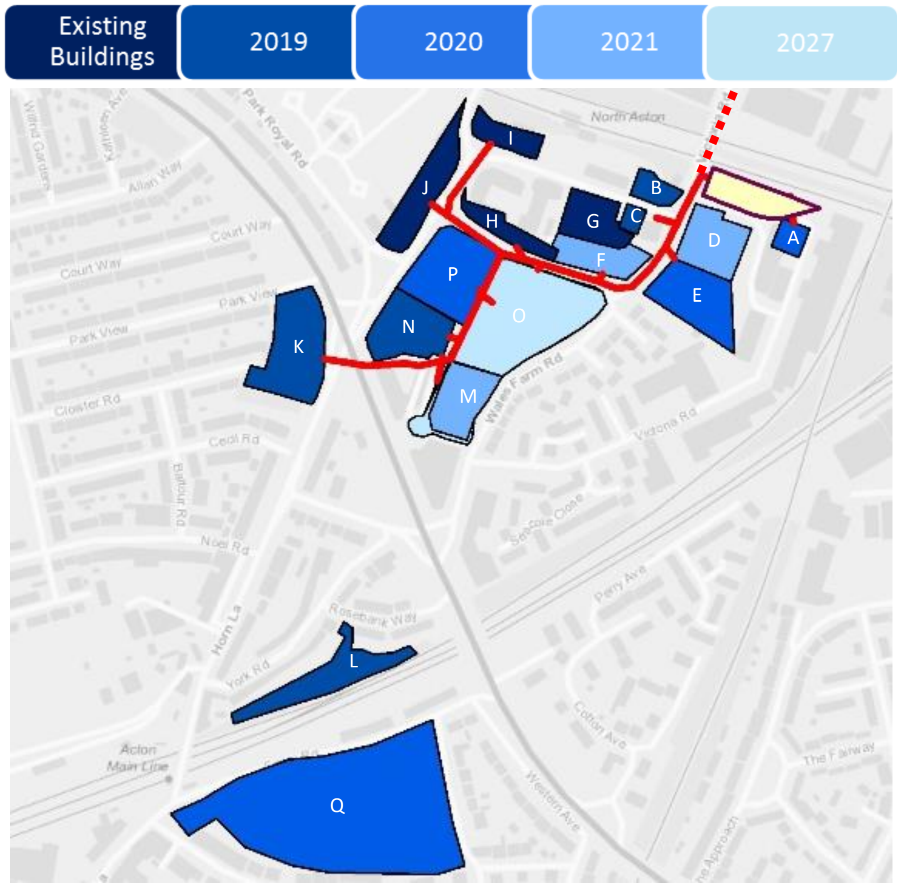


Figure 3.9 Proposed connection to a wide energy network

4. Commercial Delivery Assessment

4.1 Introduction

This chapter presents the assessment of the potential for a commercially deliverable heat network (irrespective of the economic viability of the network). It is focused in particular on the ability and willingness of developers to connect to a network, and takes account of how the timing of each development may affect this potential.

4.2 Factors affecting commercial delivery

There are several factors which will influence developers' appetite for procuring or negotiating a heat network connection, or which will affect a heat network promoter's ability to coerce or convince a developer to agree a connection. These are described below.

Planning obligations create the conditions for a commercial negotiation

As noted previously, all of the major developments in North Acton recently granted planning permission are subject to planning conditions and planning obligations compelling the developer both to provide a heat system which is compatible with a future connection to a heat network and to negotiate with a future heat network operator for a connection, even after the development is complete.

The obligation to seek to agree a heat network connection agreement is subject to such an agreement being financially viable for the development.

These planning obligations are therefore no guarantees of heat loads for a future heat network operator but they are able to bring the developers to the negotiating table. The onus will then be on the heat network operator to achieve a financial structure which allows the network to deliver a viable return on investment while offering each developer a fair price for connection and supply (as discussed below).

Heat networks are unregulated utilities

Heat networks are not a regulated utility. Therefore there is no binding contractual or statutory obligation for developments to connect. Although, as noted above, the planning system can be used to oblige developers to connect to a heat network, but such obligations are normally subject to a test of viability and are limited in time.

Connection charge equals avoided cost of connection

Therefore from a commercial delivery point of view, the key question is whether a connection offer can be made which will be financially advantageous for the developer. This, in turn, is greatly a question of timing: developments which connect to a heat network can avoid a variety of capital expenditures, which may include:

- Heat generation equipment (e.g. gas engines, gas boilers or heat pumps)
- Pollution control equipment and flues
- Gas utility connection
- Plant room space

These avoided costs can be exchanged for a capital contribution, or connection charge, paid to a heat network operator. Such costs are only "avoided" when the heat network connection is agreed prior to commencement of the development in question.

Once a development is built, there are no avoided costs for a developer associated with a heat connection, and so a developer will be unwilling to pay a connection charge. The lack of capital contribution affects the viability of the network, if the net revenues from heat sales are insufficient on their own to recover the initial cost of the infrastructure within an acceptable period of time.

Aligning the timing with the developer's sales drivers

Commercially, it is often necessary for developers to provide information to prospective tenants and buyers of the type of utility supplies they will receive and the terms and conditions of such supply. While end users can change their gas and electric suppliers at a future date, a heat network supply, once agreed, is a monopoly supplier which cannot be switched by the end user customer.

Therefore the agreement with the developer must normally be in place well ahead of the start on site so that the chosen supplier can provide model supply agreements and other information to its future customers before sales or tenancy agreements are signed.

This driver is critical for housing developments and important for tenanted commercial developments. It is less critical for student housing or other development where there would be a bulk supply to the building owner or operator, not a series of direct supply agreements with the end users.

Contracts can come before networks

An important mitigation of the timing driver is that a contract for a heat supply can be secured and delivered without a heat network. For example, an ESCo may opt to supply heat under a 25-year supply agreement using on-site temporary gas boilers for that development for the period before the network reaches the site.

This approach can create technical, aesthetic and local environmental issues and so is not normally desirable. But it can be considered an option if the parties are willing to contract but the technical or cost-effective delivery of the network is not possible in time for the occupation of the development.

Centralised versus decentralised low carbon heat sources

Heat networks have generally been developed in situations where there are demonstrable scale efficiencies from a centralised heat source compared with decentralised, in-building heat sources.

Thus most heat networks in the UK are supplied from large energy from waste plants or gas CHP engines and gas boilers, all of which operate more efficiently and are more cost effective as they get bigger.

These scale efficiencies and economies are sufficiently large to overcome the additional losses which would be incurred through distribution of heat through a primary heat network.

By contrast, low carbon heat pumps offer relatively little scale efficiencies to offset the network losses. In addition, their sources of heat – such as aquifer, ground, water or air – are themselves often dispersed and equally accessible from individual development sites.

Therefore, where a single large source of heat is not available within a given opportunity area, making the case to developers to centralise their heat demands through a heat network becomes more challenging.

4.4 Market engagement from ESCos

As part of the study, market engagement meetings were held with a sample of three private energy service companies (ESCos). The purpose of the engagement was to get feedback on the attractiveness of the North Acton opportunity to ESCos.

All three companies highlighted the uncertainty of demand in an area characterised by separate private development sites. None expressed a willingness to pursue a heat network unilaterally, but instead they indicated that a single promoter would be needed to secure and guarantee or underwrite the heat loads before the market would be willing to come forward with heat network development proposals.

4.5 Commercial delivery assessment

Table 4.1 overleaf presents a summary of our assessment of the commercial potential for connection of each development site, along with an explanatory commentary. These individual assessments have informed the discussion below.

The information collected on the opportunity sites revealed that timing is a major factor which makes a network commercially challenging. Whilst planning permissions will oblige developers to be willing to connect to a heat network, most have installed or committed to stand-alone building heating solutions. This leads to a weak appetite for negotiating a complex heat connection and supply agreement with a network promoter or developer.

Even assuming the heat network promoter can offer a discount on the heat price paid by building owners or occupiers for the stand-alone systems, a post-completion connection to a heat network represents for most developers a perceived significant complexity and risk with limited benefits.

For those developments which are further into the future and can incorporate a heat network connection into their designs and development plans, the commercial potential for a heat network connection is judged to be much stronger.

The case for connection would be further strengthened where it can be demonstrated that the network can be supplied by the largest single low carbon heat opportunity in the study area, being the aquifer source heat pump of up to 1.2MW supply. Although also accessible to individual sites, the size of the aquifer heat opportunity and the potential complexity of installing such a system lends itself to an infrastructure scale operation by a qualified energy services company (ESCo).

The timing of heat network delivery is a further factor to consider. Given that many developments are already completed or on site, an alternative to proceeding now would be to postpone connection until each development's energy systems (e.g. CHP engines and boilers) needed replacement. This might occur around fifteen years from now. At such a time the willingness to negotiate a connection would be higher, since the development would face a choice between replacing their plant themselves or securing a heat network connection and transferring supply responsibility to an ESCo.

However, the uncertainty of the timing of each site's plant replacement date is high. If OPDC committed to a heat network for the area but postponed its delivery for fifteen years, this could result in a worse overall outcome of developers selecting sub-optimal on-site solutions which are "connection ready" but where the low carbon heat network connection never comes.

4.6 Delivery options for a heat network

Taking the foregoing assessment into account, we considered the potential for public or private-led schemes, and the potential for a single network promoter or a pooled approach involving some or all the developers procuring a heat network.

In view of the facts and issues identified above, a public-led approach appears to be the only credible option for delivery of a heat network. The public sector could deliver a network through:

- **a public ownership model**: all heat connection and supply agreements with developers and end users are contracted with the public entity. The network itself would typically be procured under a conventional design-build-operate-maintain (DBOM) contract.

ARUP

Table 4.1 Summary potential commercial assessment for each development site

Very low	Low	Medium	High	Very high

Ref	Development Site	Commercial Potential	Comments
A	Monarch House	Low	This site is currently under construction. Planning obligation to engage with a future ESCo but connection at this stage would deliver no avoided costs
B	Holbrook House	Low	This site is currently under construction. Planning obligation to engage with a future ESCo but connection at this stage would deliver no avoided costs
C	142-154 Victoria Road	Medium	The plan for this site is liable to change and completion date is uncertain.
D	Perfume Factory	Medium	Planning permission expected soon, detailed design commences Q3 2018. Time is running out to incorporate a heat connection into development.
E	Imperial College	Low	Detailed design is complete and construction is about to commence. Planning obligation to engage with a future ESCo but connection at this stage would deliver no avoided costs.
F	The Portal	Low	Aiming to complete GLA stage 2 referral process in February 2018. Energy centre design has been finalised.. Planning obligation to engage with a future ESCo but connection at this stage would deliver no avoided costs
G	Former BBC Costume Store	Low	These sites are all recently built. They have planning obligations to engage with a future ESCo but connection at this stage would deliver no avoided costs.
H	Lyra Court		
I	Victoria Square		
J	NEC House		
K	Gypsy Corner		
L	Land to the rear of Western Court Rose Bank	Very low	The connection of this site would require a major road crossing. Connection would be unviable.
M	2 Portal Way	Medium	There is no key constraints; however, there has been low responsiveness from the developer
N	5 Portal Way	Medium	This data is according to planning, there was no evidence of the site being in construction on the site visit and the building is currently being leased by the Algerian embassy.
O	Carphone Warehouse	Low	The existing commercial development is leased through at least 2027. There are no current plans for redevelopment of the site.
P	6 Portal Way	Medium	There are no key constraints; however, there has been low responsiveness from the developer
Q	Friary Park Estate	Very low	The connection of this site would require a major road and railway crossing. Connection would be unviable.

- **a private sector partnership or concession model**: a private sector partner or ESCo would be procured by the authority and would jointly or wholly own and operate the network. In this latter scenario, demand risk would be retained by the public sector.

Either option could allow for a future exit scenario for the public sector body, once the network had been delivered and the key development-stage risks had been reduced or eliminated.

Retention of public ownership would give the public sector body greater flexibility to make long-term strategic decisions about growth and investment in the network (subject to available capital).

In both options, the fundamental development risk remains with the public sector, but the public sector ownership model offers lower complexity than the partnership or concession model.

Resourcing requirement

Our experience of many such similar situations is that sustained project development effort will be needed from the project promoter, on the order of a 50-100% role for 12-24 months (FTE) plus deeper technical, commercial and legal advisory services. These might be in the order of £250,000 - £500,000 by project financial close, depending on the particular commercial route selected.

4.7 No network scenario

The alternative scenario is that a network is not pursued and that the energy future for North Acton is based on a decentralised heat model.

In this scenario, the OPDC, GLA and London Borough of Ealing would need to consider ways to ensure the delivery of a low carbon heat transition in the area. This becomes not a commercial delivery question but rather a policy question. Although beyond the scope of this study, potential policy options could include:

- For developments which have not yet been granted planning permission, working with developers to maximise thermal efficiency, minimise system flow and return temperatures and incorporate heat pump solutions within their development sites. These might not involve building-wide “wet” heating systems, although direct electric heating should be avoided as far as possible due to the lower efficiency and impact on the national electricity grid.
- For existing developments, options for non-low carbon systems will need to be removed so that building owners much choose among low carbon options. This could include planned decommissioning of the gas network in the area, unless evidence could demonstrated that there was a strong prospect for the gas network to be supplied with low or zero carbon sources of gas (e.g. biogas and/or hydrogen from zero carbon sources). This would need to be coupled with Building Regulations changes to prevent switching to direct electric for the majority of heating needs.

5. Project Economic and Carbon Assessment

5.1 Introduction

This chapter presents the results of modelling of the potential district heating scheme. It provides analysis of the technical, economic and carbon results of different potential schemes.

The completed scheme in all cases is as shown in Figure 3.8 (page 24). The scheme includes all the modelled buildings except for Friary Park Estate and the Land to the rear of Western Court and Rosebank. The phasing is as described in Chapter 3.

Table 5.1 provides a breakdown of the configuration of each scenario, indicating the overall heat load, plant and CAPEX after all the buildings have been connected.

Key cost and revenue assumptions are set out in the appendices.

5.2 Economic results

Option 1 Gas CHP scheme

The results indicate that the modelled scheme achieves a negative project IRR of (0.2%) in the first 25 years. Over a 40 year timeframe this improves to a positive IRR of 3.6%. This model takes into account plant replacement every 15 years.

Option 2 and 3 CHP with AQHP

The results indicate that incorporation of the heat pump into the scheme results in a higher IRR but this is due to the increased revenues of renewable heat incentive (RHI) and the marginally cheaper heat, with the smaller CHP feeding wholesale electricity into the heat pump.

It is noted that the future of RHI is not certain and therefore these revenues would be at risk until the scheme was registered. As a public support scheme and therefore potentially State Aid, RHI would also need to be considered in the light of a total support package if HNIP funding was secured for the scheme.

Option 4 Heat pump only scheme

The results for Option 4 indicate that the elimination of CHP results in a far lower IRR compared with the other options scheme. This is due mainly to the higher cost of grid electricity (compared with CHP electricity)

The capex is also higher because a large number of air source heat pumps are required.

Table 5.1 Scenario summary

Items	1. Gas CHP	2. CHP with small AQHP scheme	3. CHP with large AQHP scheme	4. Heat pump only scheme
Total Heat Supplied* (GWh_{th})	27.2	27.2	27.2	27.2
CHP (MW_{th})	3.5	2.6	1.8	0
Boiler (MW_{th})	13.2	13.2	13.2	13.2
Aquifer Heat Pump (MW_{th})	0	0.6	1.2	1.2
Air Source Heat Pumps (MW_{th})	0	0	0	4.5
Network Losses	10%	10%	10%	10%
CAPEX (£m)	£12.2	£12.2	£12.1	£14
IRR (25 year)	-0.2%	2.0%	3.8%	<-3%
IRR (40 year)	3.3%	4.5%	5.6%	<-3%

*Total heat supplied takes account of network losses. Total demand is approximately 24.8 GWh.

5.3 Carbon results

The carbon performance of the different options needs to be understood in the context of today's policy environment. There is an inherent lag between the carbon factors used for Building Regulations Part L assessments and those actually observed and forecast for the UK's energy system. Part L assessments today apply the 3-year average carbon factors published in SAP 2012, which places grid electricity at 519gCO_2e/kWh. SAP 2016 values, which have been published but not adopted into regulations, place the factor at 398gCO_2e/kWh. The most recently published actual and projected factors from BEIS put the 2020 grid factor at 194gCO_2e/kWh.

It will be evident from these three numbers that the relative carbon performance between gas CHP and heat pumps will vary radically depending on which figures are used. Our recommendation is to use the most accurate figures (i.e. BEIS), but for comparison we have provided SAP 2012 and SAP 2016 figures as these will be the basis for a developer to compare the carbon performance of an on-site solution versus a heat network-connected solution. See Figure 5.1 for a comparison of carbon factors for each scenario, in relation to each carbon factor basis.

Under the Option 1 and using SAP 2012 carbon values, the carbon benefits are substantial. This is due to the CHP running more frequently and efficiently compared to building local CHPs, which are far more reliant on top up gas boilers.

If Option 1 was adopted, those buildings granted planning permission from 2016, might in theory be able to have their carbon offset payments reduced, providing substantial financial savings (£60 per tonne x 30 years). This includes the sites operated by Imperial and those that are still yet to apply.

However, under actual figures from BEIS, Option 1 provides no carbon savings at all and therefore the option should not be considered.

The other scenarios, which progressively reduce and then eliminate gas supplied heat in favour of electric, achieve increasingly actual emissions reductions. The hybrid options (2 and 3) are similar to Option 1 under SAP 2016, while Option 4 is radically better under actual numbers but the worst under SAP 2012 and SAP 2016 scenarios.

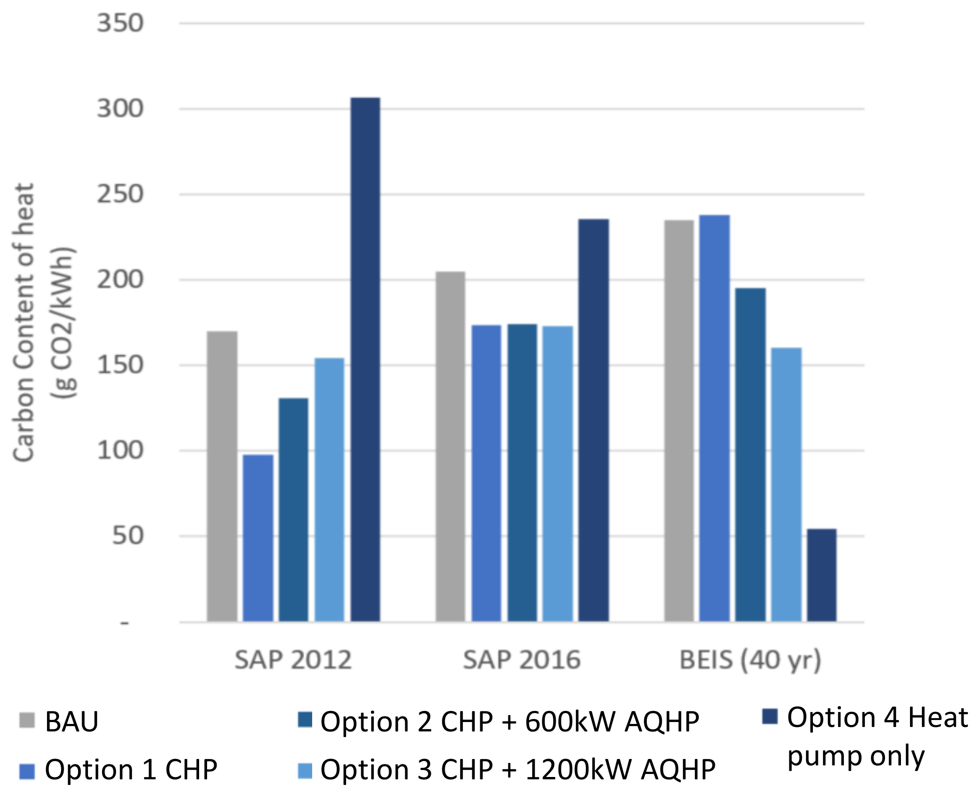


Figure 5.1 Carbon content of heat, referencing different indicators

5.4 Techno-economic and carbon conclusions

The results for the four scenarios are shown in Table 5.2 below. These highlight the overall economic and carbon results. In summary, none of the schemes modelled achieves a project internal rate of return (IRR) sufficient to meet typical thresholds for investment (6% for public, 12% for private). The gap funding requirement shown in the table represents the additional funding which would be needed to bring each scenario to the project IRR of 6% or 12% respectively.

Options 2 and 3 perform the best economically, and would appear to fall within the range of economic performance which would be eligible for grant or low-cost loan support from HNIP. These two options also provide significant carbon savings over their lifetimes.

Option 4 saves the most carbon but the modelling results in a project investment return below zero, which would make it ineligible for funding support from HNIP.

Overall, the results indicate that an economically viable scheme could be developed on the basis of a hybrid system using heat pumps and CHP engines. With appropriate future proofing in the design, the CHP engines and boilers could be replaced by air source heat pumps and direct electric peaking heat supply when they are life expired, to provide a clear pathway to a nearly zero carbon heat network in the future.

Table 5.2 Comparison of scenarios

Scenario	CHP (kWth)	CAPEX (£m)	IRR (%)		Gap funding (40yr)		2016 SAP Average Carbon Intensity (CO2g/kWth)	2016 SAP Lifetime Emission Savings (tCO2)	BEIS Average Carbon Intensity (CO2g/kWth)	BEIS Lifetime Emission Savings (tCO2)
			25yr	40yr	To achieve project IRR of 6%	To achieve project IRR of 12%				
Option 1 CHP	3,500	£12,213,000	-0.20%	3.30%	£2,506,380	£4,854,520	173	26,420	238	-2,360
What is the effect of adding an aquifer heat pump?										
Option 2 CHP + 600kW AQHP	2,590	£12,220,000	2.00%	4.50%	£1,354,450	£4,153,900	174	25,670	199	34,210
Option 3 CHP + 1200kW AQHP	1,840	£12,131,000	3.80%	5.60%	£354,650	£3,567,940	175	25,450	169	63,150
What is the effect of a heat pump only scheme with no gas?										
Option 4 Heat pump only	-	£14,059,000	<-3%	<-3%	n/a	n/a	235	-22,370	54	165,540

6. Conclusions

6.1 Conclusions

This study set out to identify a feasible and viable low carbon heat network solution for North Acton. The context for the study was the rapid pace of development across the study area, which was found to present considerable practical obstacles to the commercial delivery of a new heat network scheme. Notwithstanding, the planning system has played its role in establishing obligations on developers to negotiate in good faith for a future heat connection, if a heat network is promoted in the area.

Technically, a low carbon network could be delivered through the use of aquifer heat pumps with air source heat pumps, although the more economically viable option would involve a hybrid solution of CHP with heat pumps. A conventional CHP-led scheme with no heat pumps would not lead to any carbon savings compared with a business as usual case.

The aquifer heat pump option would require further investigation through borehole testing to confirm the available heat.

None of the scenarios presented appeared to offer an investable scheme without some gap funding, with project IRRs ranging from below zero to around 5.5%. At the upper end of the range, the hybrid solutions (Options 2 and 3) appear to fall within the range of eligibility for HNIP funding.

All of these factors – rapid development, marginal economic case and low carbon option reliant on more innovative technologies – make this a location where a public sector ownership model approach appears necessary for a network to happen.

The alternative to a network approach would be to abandon the commitment to a network in North Acton and instead to focus on maximising the opportunity for energy efficient, low carbon building-scale solutions. In such a scenario, the role of OPDC, Ealing and the GLA would revert to their statutory planning and regulatory functions.

6.2 Recommendations

Our main recommendation from this study is that:

- OPDC, Ealing and GLA decide, based on evidence available, whether to continue to commit to a heat network in the North Acton area, noting that the study concludes that a public-sector led approach appears to be necessary to make a network happen in this location.

If there is no such commitment, the local plan and development management decision making should be reviewed to determine the alternative decentralised low carbon pathway for the area.

If there is such a continued commitment, the following additional steps are recommended:

- OPDC, Ealing or GLA commit staff and/or advisory resources to take on an effective and sustained heat network promoter role
- Commission a technical borehole study to confirm temperature and flow rates in the aquifer.
- Engage with the landowner (Network Rail) of the proposed energy centre site to determine the potential for acquisition or use of the site.
- Continue engagement with developers in the area – ideally through a regular developer forum – to keep up to date with developments on the ground and to refine planning timelines for heat network agreements.

Appendix A – Development Profiles

Site A. Monarch House

Potential for connection **Low**

Planned Development

The development at Holbrook House is due to be completed in January 2019. Its primary use will be a hotel with a small are of retail space .The current energy strategy is house an in house CHP, the building design is future proofed to allow for connection to a heat network

Heat Load

The total heat demand is 1,500,000 kWh/year, 6% of the total heat load of the developments identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a low level of engagement in the process.

Advantages

By connecting to a district heating scheme Monarch House could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A1 Design and construction timeline

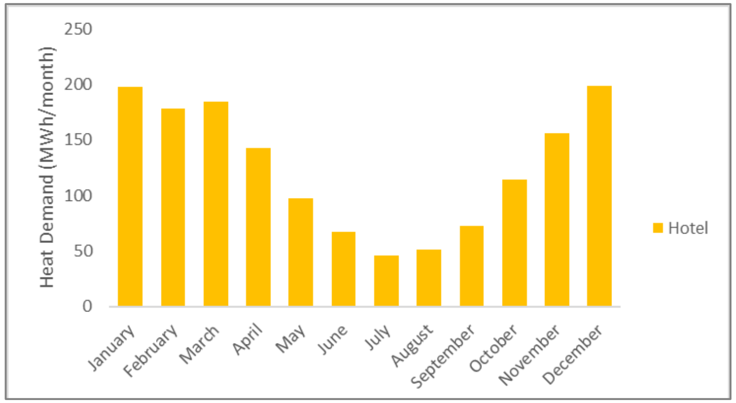


Figure A1 Monarch House annual heat demand profile

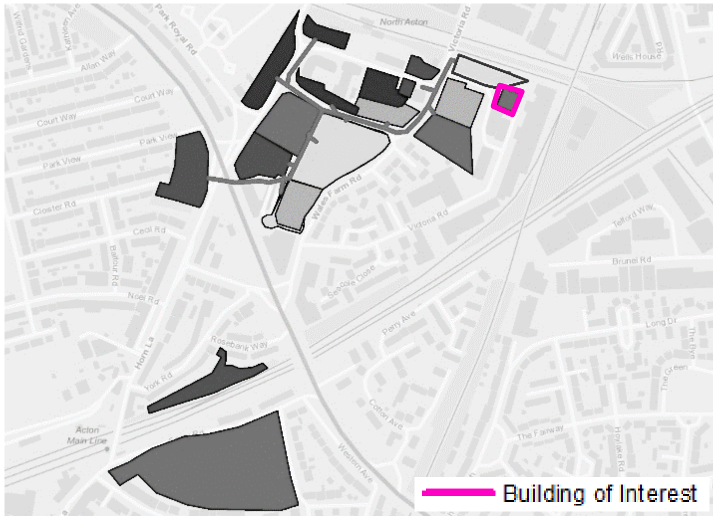


Figure A2 Monarch House location

Developer		WPP Group
Level of Engagement		Low
Contract		Bulk sale
Avoided Costs	**2020**	£186,732
	2032	
Avoided Emissions		39%

Table A2 Key development details

Site B. Holbrook House

Potential for connection **Low**

Planned Development

The development at Holbrook House is due to be completed in June 2019. Its primary use will be a domestic with a small are of retail space. The current energy strategy is house an in house CHP, the building design is future proofed to allow for connection to a heat network

Heat Load

The total heat demand is 2,200 MWh/year, 3% of the total heat load of the developments identified in the area

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a high level of engagement in the process.

Advantages

By connecting to a district heating scheme Holbrook House could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A3 Design and construction timeline

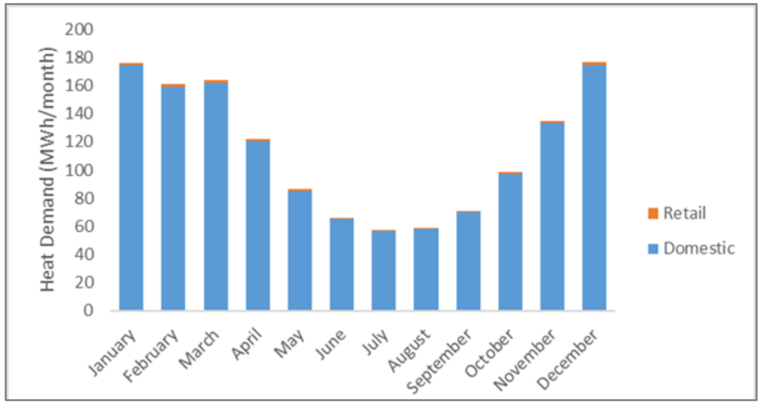


Figure A3 Holbrook House annual heat demand profile

Developer		Rolfe-Judd
Level of Engagement		High
Contract		Bulk sale with on sale
Avoided Costs	2020	£0
	2032	£419,874
Avoided Emissions		36%

Table A4 Key development details

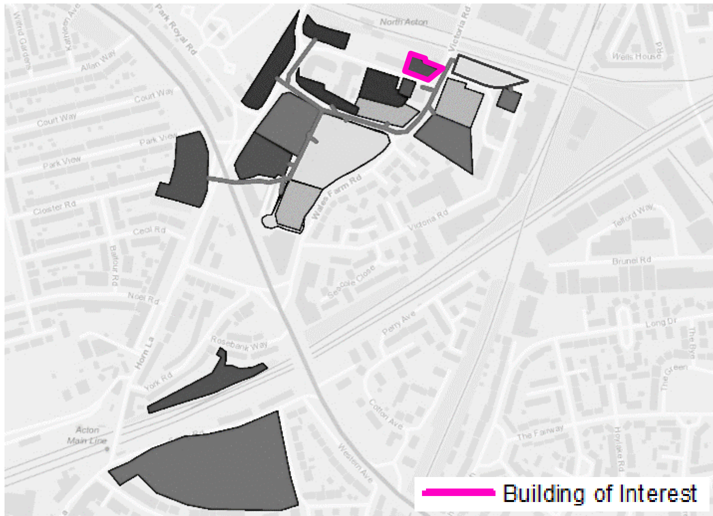


Figure A4 Holbrook House location

Site C. 142-154 Victoria Road

Potential for connection **Medium**

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A5 Design and construction timeline

Planned Development

The development at 142-154 Victoria Road is due to be completed in January 2019. Its primary use is domestic with a small space for retail. There is currently no energy strategy available and upon discussion with the developer the plans for the building a liable to change and the construction date of 2019 is unlikely

Heat Load

The total heat demand is 250,400 kWh/year, 1% of the total heat load of the developments identified in the area

Potential Constraints

.It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a low level of engagement in the process.

Advantages

By connecting to a district heating scheme 142-154 Victoria Road could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

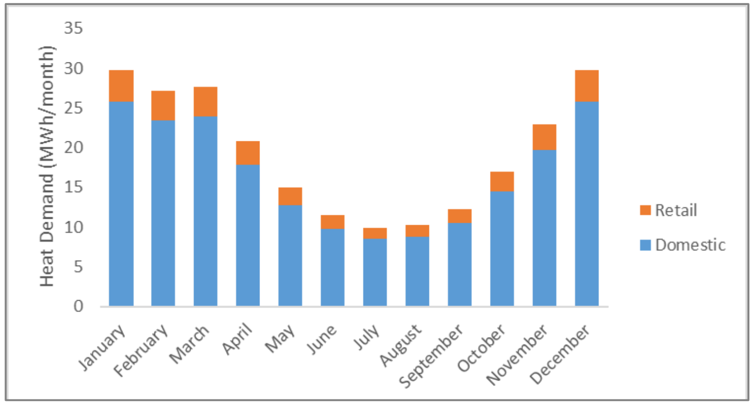


Figure A5 142-154 Victoria Road annual heat demand profile

Developer		Savills
Level of Engagement		Low
Contract		Bulk sale with on sale
Avoided Costs	2020	£0
	2032	£237,920
Avoided Emissions		39%

Table A6 Key development details

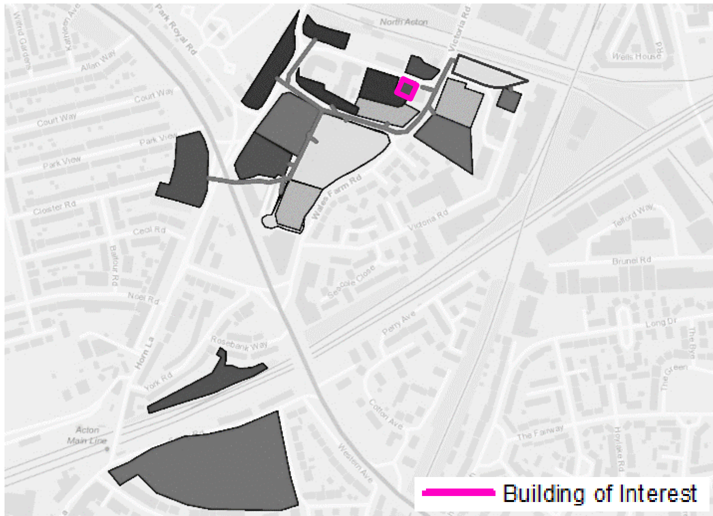


Figure A6 142-154 Victoria Road location

Site D. Perfume Factory

Potential for connection **Medium**

Planned Development

The Perfume Factory development is due to be completed in January 2021. Its primary use will be domestic, with some space for retail, office and educational use. The current energy strategy is to house a CHP in the basement to serve both the Perfume Factory and Imperial College

Heat Load

The total heat demand is 3,630,000 kWh/year, 6% of the total heat load of the developments identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a high level of engagement in the process and are interested in connecting to a district heating scheme

Advantages

By connecting to a district heating scheme the Perfume factory could significantly reduce its carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A7 Design and construction timeline

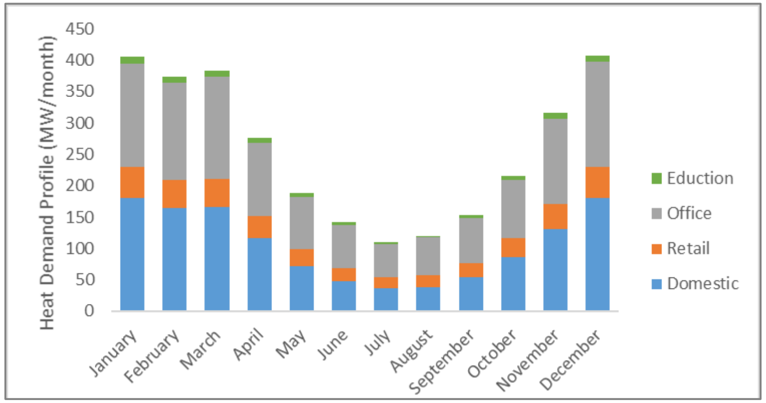


Figure A7 Perfume factory annual heat demand profile

Developer		Essential Living
Level of Engagement		High
Contract		Bulk heat with on sale
Avoided Costs	2020	£536,363
	2032	
Avoided Emissions		37%

Table A8 Key development details

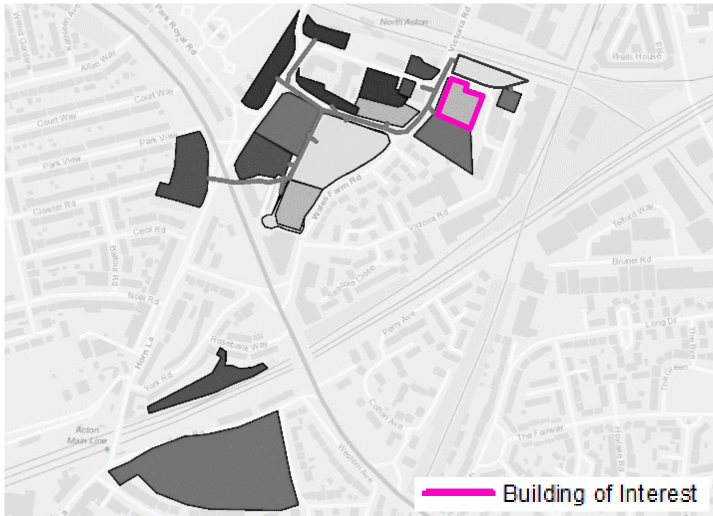


Figure A8 Perfume factory location

Site E. Imperial College

Potential for connection **Low**

Planned Development

The Imperial College development is due to be completed in January 2020. Its primary use will be Domestic, with some space for offices on the ground floor. The current energy strategy is to house a CHP in the basement to serve both the Perfume Factory and Imperial College.

Heat Load

The total heat demand is 2,420,000 kWh/year, 10% of the total heat load of the developments identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a high level of engagement in the process and are interested in connecting to a district heating scheme.

Advantages

The avoided costs from connecting to a district heating network are significant and the projected emission reduction is 36%. As this development is for student accommodation the heat will be sold in bulk with no on sale as this is typically how a student accommodation facility operates.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A9 Design and construction timeline

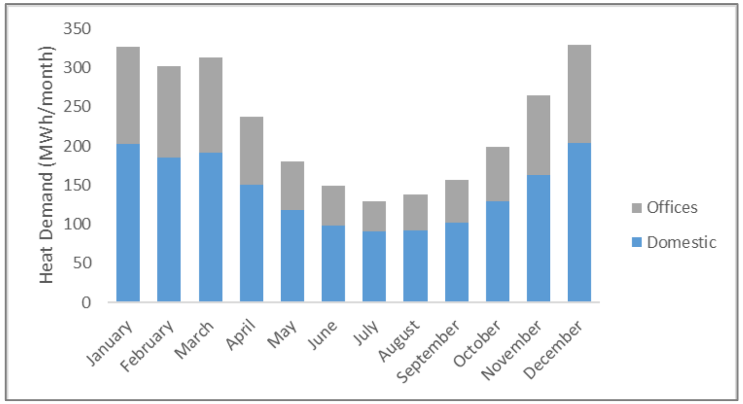


Figure A9 Imperial College annual heat demand profile

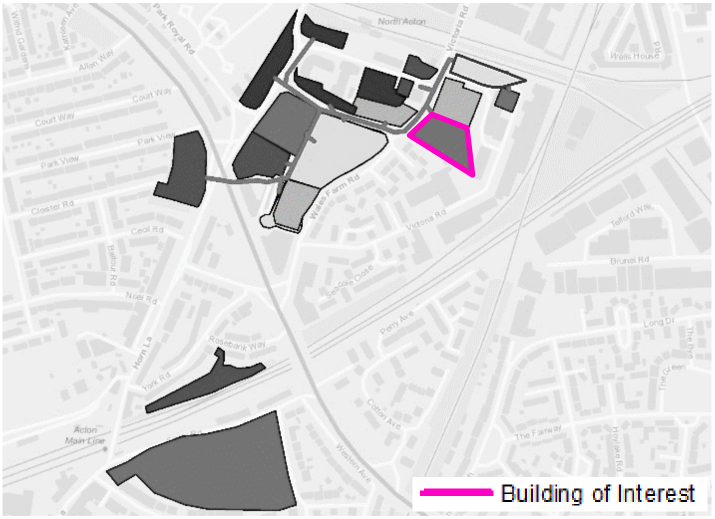


Figure A10 Imperial College location

Developer		Imperial College
Level of Engagement		High
Contract		Bulk sale
Avoided Costs	2020	£470,106
	2032	
Avoided Emissions		36%

Table A10 Key development details

Site F. The Portal

Potential for connection **Low**

Planned Development

The Portal development is due to be completed in January 2021. Its primary use will be Domestic providing 355 new homes, with 5,134m^2 of retail space. The current energy strategy is house a communal gas boiler and solar PV to serve the buildings energy needs.

Heat Load

The total heat demand is 1,320,000 kWh/year, 2% of the total heat load of the developments identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a high level of engagement in the process and are interested in connecting to a district heating scheme.

Advantages

By connecting to a district heating scheme The Portal could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A11 Design and construction timeline

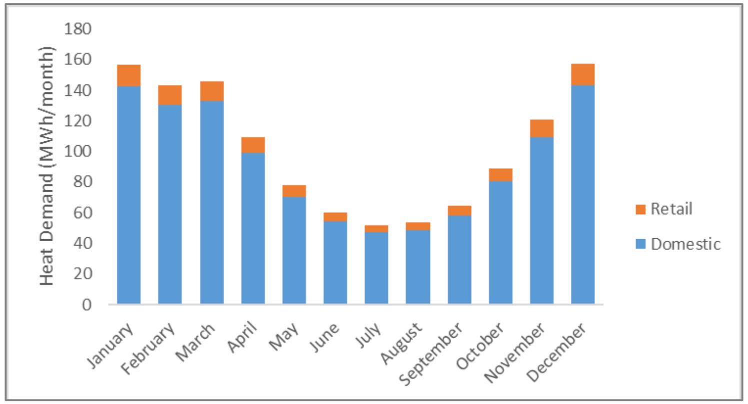


Figure A11 The Portal annual heat demand profile

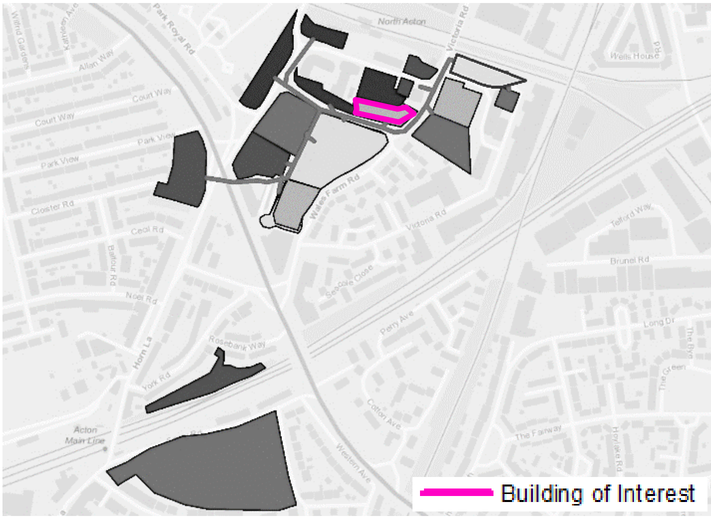


Figure A12 The Portal location

Developer		Lichfield's
Level of Engagement		High
Contract		Bulk sale with on sale
Avoided Costs	2020	£426,590
	2032	
Avoided Emissions		37%

Table A12 Key development details

Site G. Former BBC Costume Store

Potential for connection **Low**

Planned Development

The Former BBC studio development is one of the existing buildings. Its primary use will be domestic student accommodation, with 286 m^2 of retail space. The current energy strategy is a CHP with a 150 kWe CHP unit and 70m^2 of solar PV.

Heat Load

The total heat demand is 1,550,000 kWh/year, 6% of the total heat load of the developments identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a low level of engagement in the process.

Advantages

By connecting to a district heating scheme the Former BBC Studio could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation	Existing Building															

Table A13 Design and construction timeline

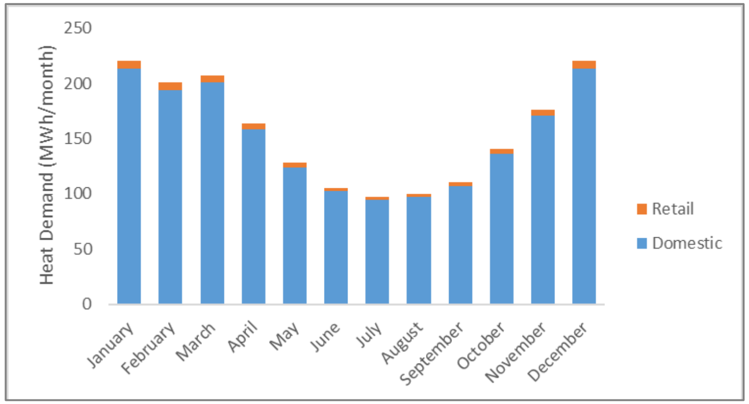


Figure A13 Former BBC Studio annual heat demand profile

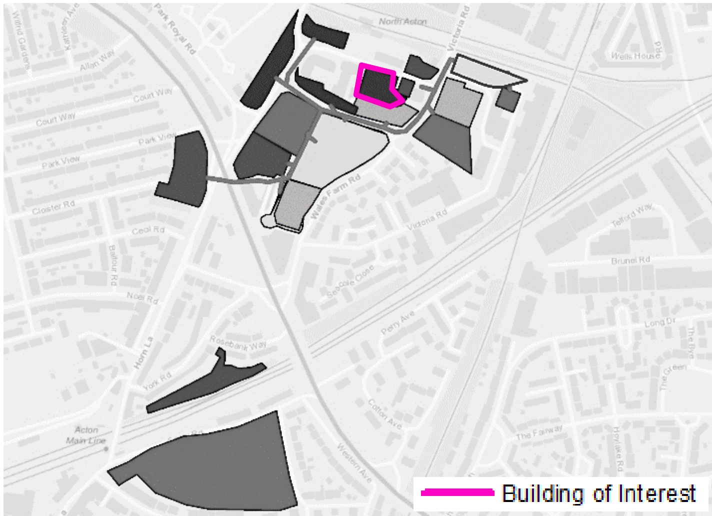


Figure A14 Former BBC Studio location

Developer		Indigo Planning
Level of Engagement		Low
Contract		Bulk sale
Avoided Costs	2020	£0
	2032	£481,094
Avoided Emissions		37%

Table A14 Key development details

Site H. Lyra Court

Potential for connection **Low**

Planned Development

Lyra Court development is one of the existing buildings. Its primary use will be domestic student accommodation, with 382 m^2 of retail space. The current energy strategy is a CHP with a 150 kWe CHP unit and 70m^2 of solar PV.

Heat Load

The total heat demand is 459,800 kWh/year, 5% of the total heat load of the developments Identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a low level of engagement in the process.

Advantages

By connecting to a district heating scheme Lyra Court could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation	Existing Building															

Table A15 Design and construction timeline

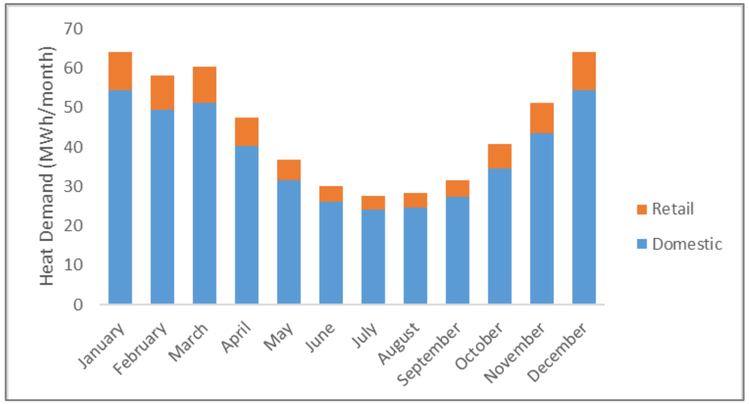


Figure A15 Lyra Court annual heat demand profile

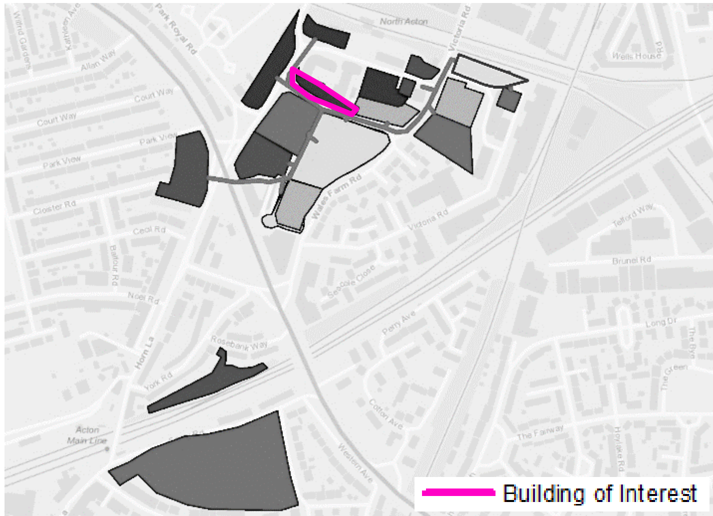


Figure A16 Lyra Court location

Developer		N/A
Level of Engagement		None
Contract		Bulk sale with on sale
Avoided Costs	2020	£0
	2032	£251,979
Avoided Emissions		39%

Table A16 Key development details

Site I. Victoria Square

Potential for connection **Low**

Planned Development

The Victoria Square development is one of the existing buildings. Its primary use will be domestic, with 673 m^2 of retail space. The current energy strategy is a CHP with a 60kWth / 40 kWe CHP unit, a 10m3 thermal store and 129m^2 of solar PV.

Heat Load

The total heat demand is 727,800 kWh/year, 3% of the total heat load of the developments identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a low level of engagement in the process.

Advantages

By connecting to a district heating scheme Victoria Square could significantly reduce its carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

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RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation	Existing Building															

Table A17 Design and construction timeline

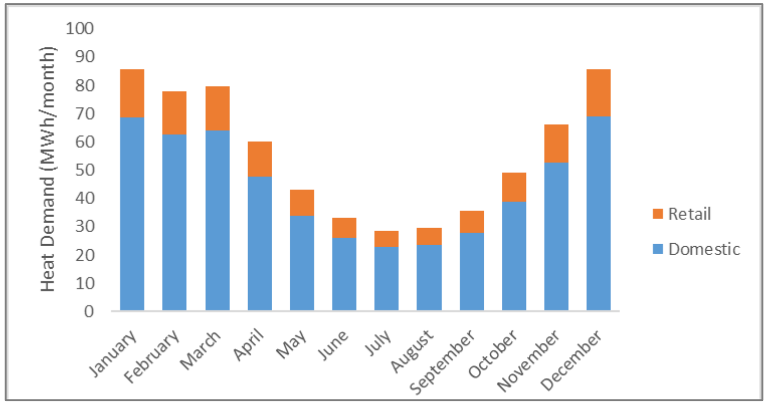


Figure A17 Victoria Square annual heat demand profile

Developer		Savills
Level of Engagement		High
Contract		Bulk sale with on sale
Avoided Costs	2020	£0
	2032	£271,226
Avoided Emissions		39%

Table A18 Key development details

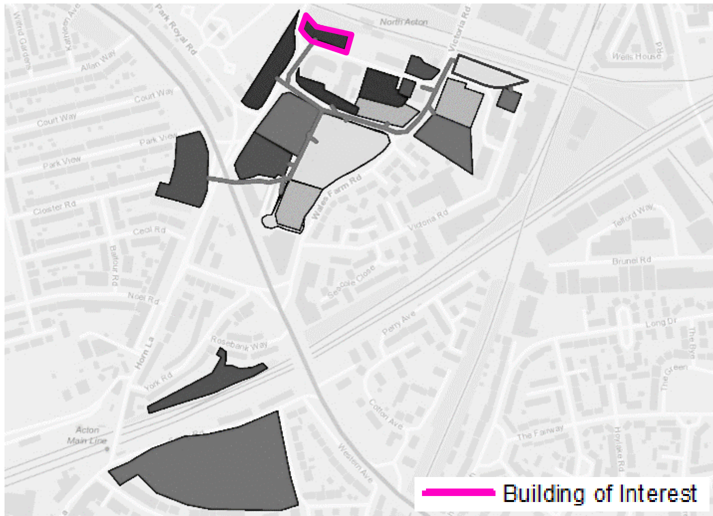


Figure A18 Victoria Square location

Site J. NEC House

Potential for connection **Low**

Planned Development

The NEC House development is one of the existing buildings. Its primary use will be domestic student accommodation, with 930 m^2 of retail space and 1,675 m^2 of office space . The current energy strategy is a CHP with a 203kWth / 140 kWe CHP unit for heating and hot water.

Heat Load

The total heat demand is 1,990,000 kWh/year, 8% of the total heat load of the developments identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a low level of engagement in the process.

Advantages

By connecting to a district heating scheme NEC House could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation	Existing Building															

Table A19 Design and construction timeline

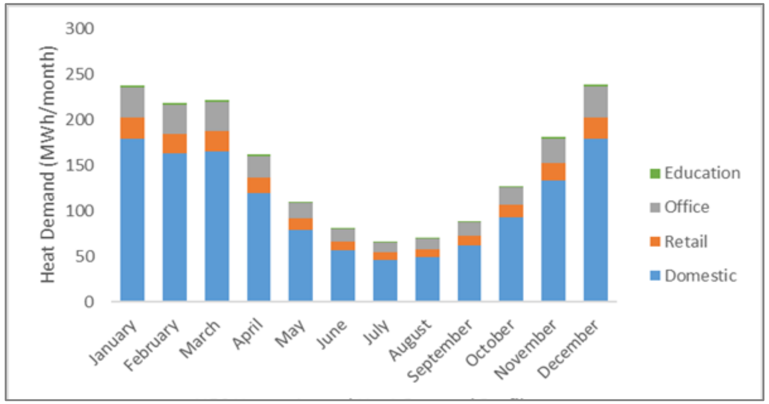


Figure A19 JNEC House annual heat demand profile

Developer		DC Consultancy
Level of Engagement		Low
Contract		Bulk sale
Avoided Costs	2020	£0
	2032	£451,569
Avoided Emissions		37%

Table A20 Key development details

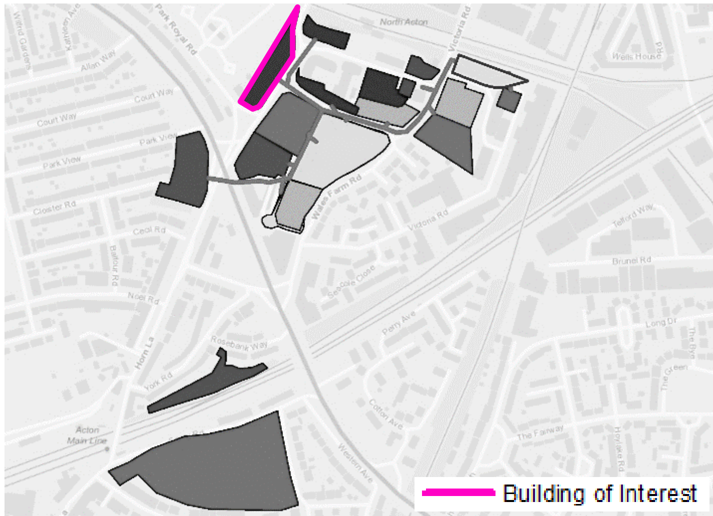


Figure A20 NEC House location

Site K. Gypsy Corner

Potential for connection **Low**

Planned Development

The development at Gypsy Corner is due to be completed in January 2020. The development is comprised of two blocks, one of domestic residential, the other is a 100 bedroom hotel. The current energy strategy is a CHP system to preheat the domestic hot water service, with Solar PV panels to be installed on the roof of the hotel.

Heat Load

The total heat demand is 2,237,000 kWh/year, 9% of the total heat load of the developments identified in the area. It located c.600m from the proposed energy centre and there is 1 major road crossing that could complicate connection.

Potential Constraints

The developers have had a high level of engagement in the process and have expressed interest in joining a heat network.

Advantages

By connecting to a district heating scheme Gypsy Corner could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A21 Design and construction timeline

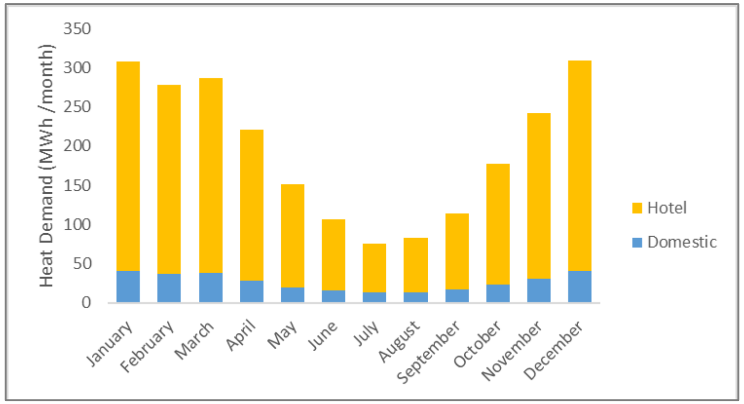


Figure A21 Gypsy Corner annual heat demand profile

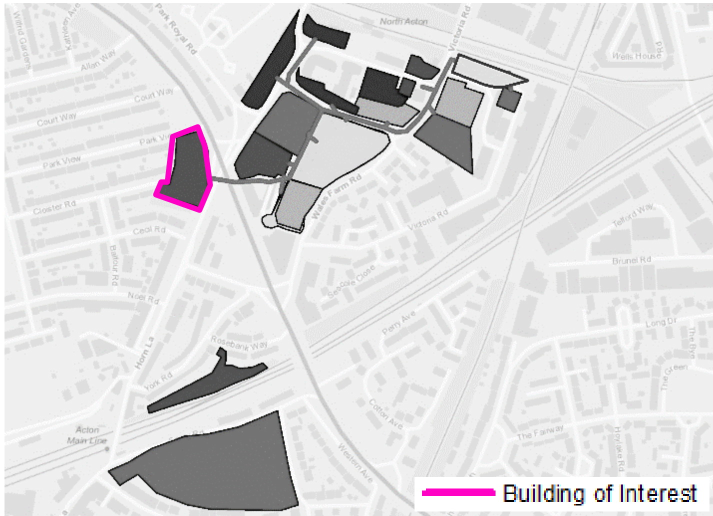


Figure A22 Gypsy Corner location

Developer		Simply Planning
Level of Engagement		High
Contract		Bulk sale
Avoided Costs	2020	£0
	2032	£515,165
Avoided Emissions		37%

Table A22 Key development details

Site L. Land to the Rear of Western Court and Rosebank

Potential for connection **Very Low**

Planned Development

The development on the land to the rear of Western Court and Rose bank is due to be completed in January 2019. The currently no energy strategy available however the buildings have been future proofed to allow for connection to a district heat network.

Heat Load

The development is primarily domestic with 77m^2 of office space available. The total heat demand is 138,000 kWh/year, 1% of the total heat load of the developments identified in the area.

Potential Constraints

It is located c.800m from the proposed energy centre and there are major road crossing that could complicate connection. The developers have had a low level of engagement in the process.

Advantages

By connecting to a district heating scheme the land to the rear of Western Court and Rosebank could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A23 Design and construction timeline

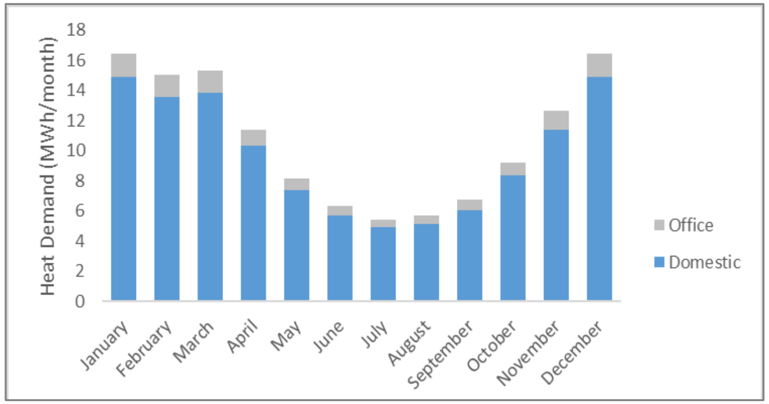


Figure A23 Land to the rear of Western Court and Rosebank annual heat demand profile

Developer		Maddox Associates
Level of Engagement		Low
Contract		Bulk sale with on sale
Avoided Costs	2020	£0
	2032	£185,913
Avoided Emissions		39%

Table A24 Key development details

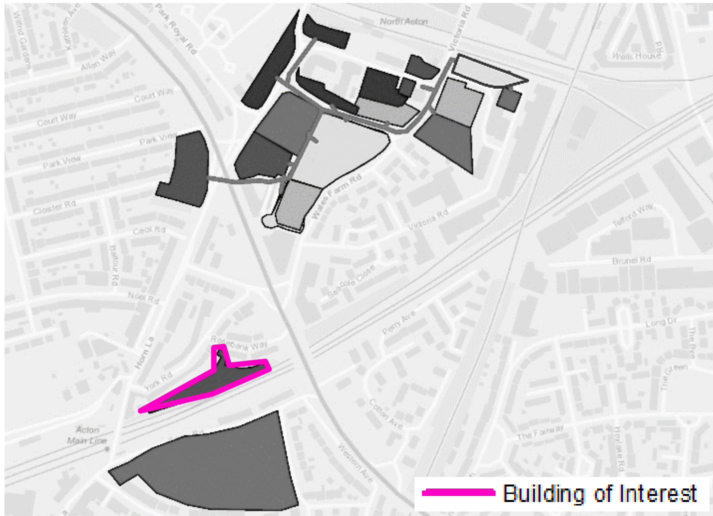


Figure A24 Land to the Rear of Western Court and Rosebank location

Site M. 2 Portal Way

Potential for connection **Medium**

Planned Development

The development at 2 Portal Way is due to be completed in January 2019. Its primary use will be domestic. The current energy strategy is an in house CHP, details of which to be confirmed.

Heat Load

The total heat demand is 1,252,000 kWh/year, 5% of the total heat load of the developments identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a low level of engagement in the process.

Advantages

By connecting to a district heating scheme 2 Portal Way could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A25 Design and construction timeline

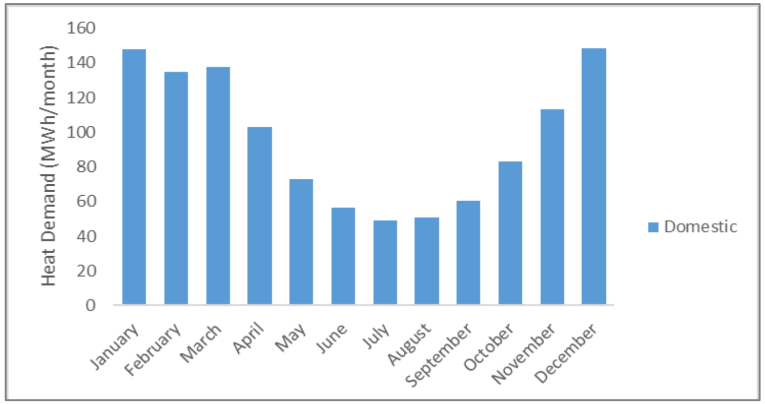


Figure A25 2 Portal Way annual heat demand profile

Developer		Maddox Associates
Level of Engagement		Low
Contract		Bulk sale
Avoided Costs	2020	£426,590
	2032	
Avoided Emissions		37%

Table A26 Key development details

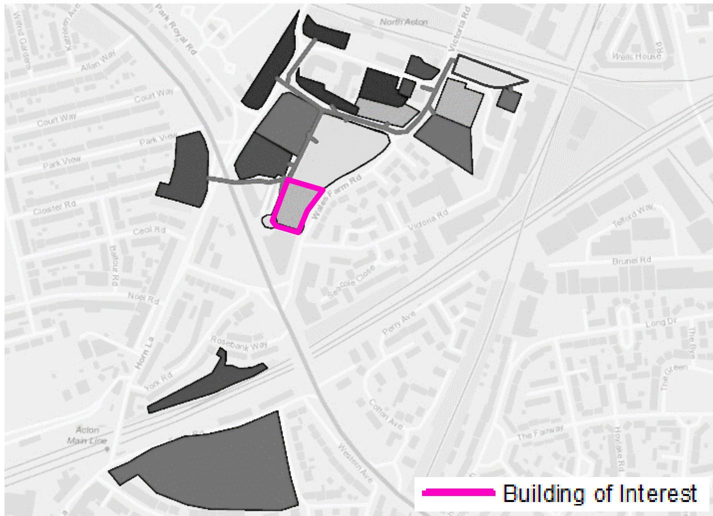


Figure A26 2 Portal Way location

Site N. 5 Portal Way

Potential for connection **Medium**

Planned Development

The development at 5 Portal Way is due to be completed in January 2019. Its primary use will for offices. The is no energy strategy currently available.

Heat Load

The total heat demand is 631,600 kWh/year, 2% of the total heat load of the developments identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection. The developers have had a low level of engagement in the process.

Advantages

By connecting to a district heating scheme 5 Portal Way could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A27 Design and construction timeline

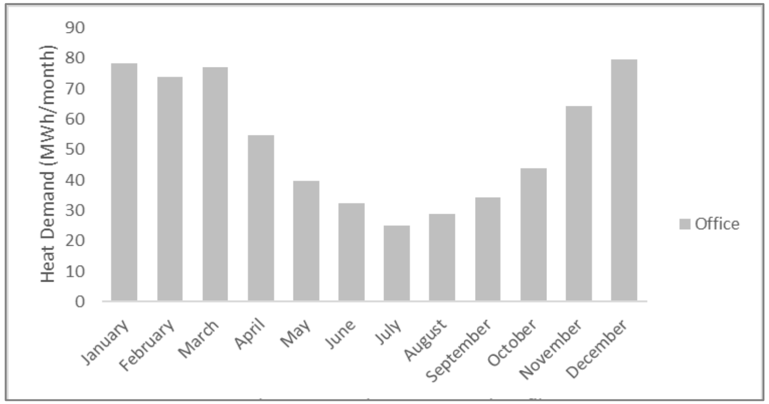


Figure A27 5 Portal Way annual heat demand profile

Developer		Child Grandon Lewis
Level of Engagement		Low
Contract		Bulk sale with on sale
Avoided Costs	2020	£0
	2032	£286,241
Avoided Emissions		39%

Table A28 Key development details

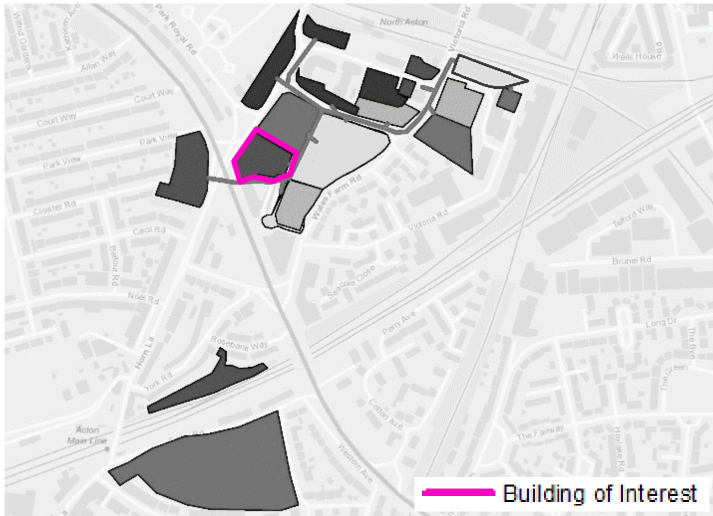


Figure A28 5 Portal Way location

Site O. Carphone Warehouse

Potential for connection **Low**

Planned Development

The Carphone Warehouse site has a planning application associated with it and this has formed the basis of the assessment. However the landowner has confirmed there are no plans at the time of reporting to redevelop the site. The current tenant, Carphone Warehouse, has a lease for the next ten years.

Heat Load

The total heat demand is 3,665,000 kWh/year, 14% of the total heat load of the developments identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection.

Advantages

The avoided costs of not building their own energy centre are significant and the projected reduction in carbon emissions is 36%.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation	Existing Building – plans for redevelopment not known.															

Table A29 Design and construction timeline

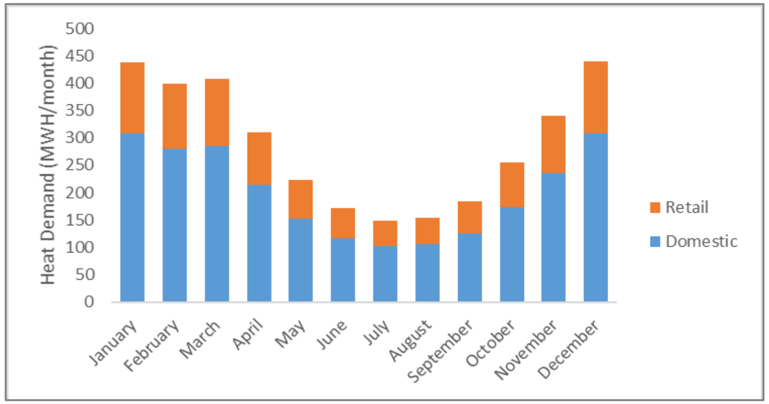


Figure A29 Carphone Warehouse annual heat demand profile

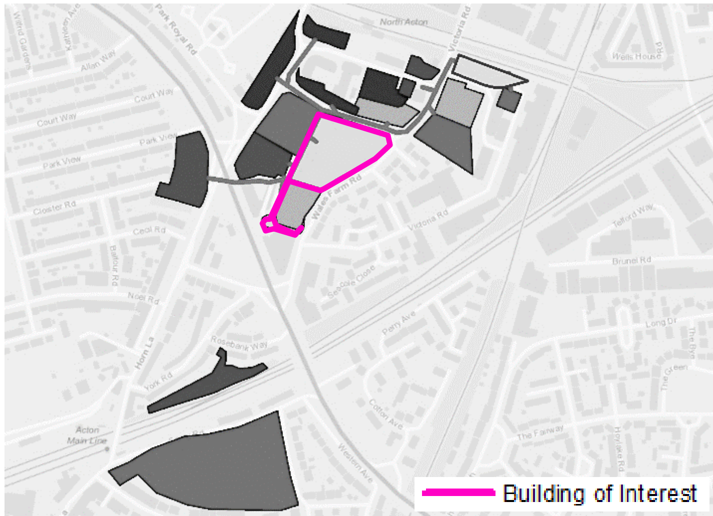


Figure A30 Carphone Warehouse location

Developer		Imperial College
Level of Engagement		High
Contract		Bulk sale with on sale
Avoided Costs	2020	£649,358
	2032	
Avoided Emissions		36%

Table A30 Key development details

Site P. 6 Portal Way

Potential for connection **Medium**

Planned Development

The development at 6 Portal Way is due to be completed in September 2020. Its primary use will for offices. The current energy strategy is to house a CHP unit with 200kWth /124kWe capacity and a 30m^3 thermal store to cover approximately 72% of the developments annual heat load.

Heat Load

The total heat demand is 493,000 kWh/year, 2% of the total heat load of the developments identified in the area.

Potential Constraints

It is located near the proposed energy centre and there are no major rail or road crossing that would prevent connection.

Advantages

By connecting to a district heating scheme the 6 Portal Way could significantly reduce it carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A31 Design and construction timeline

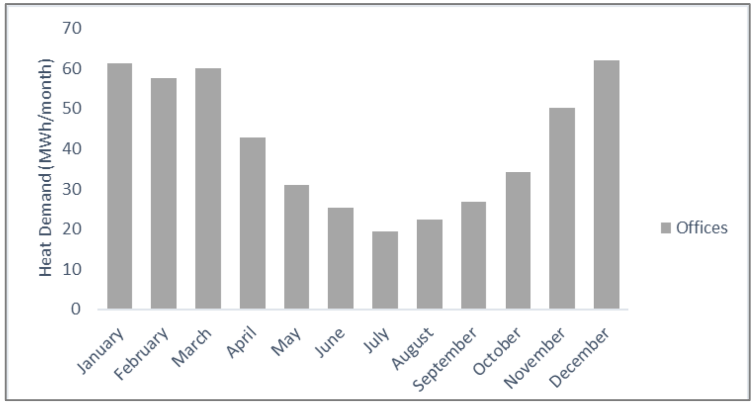


Figure A31 6 Portal Way annual heat demand profile

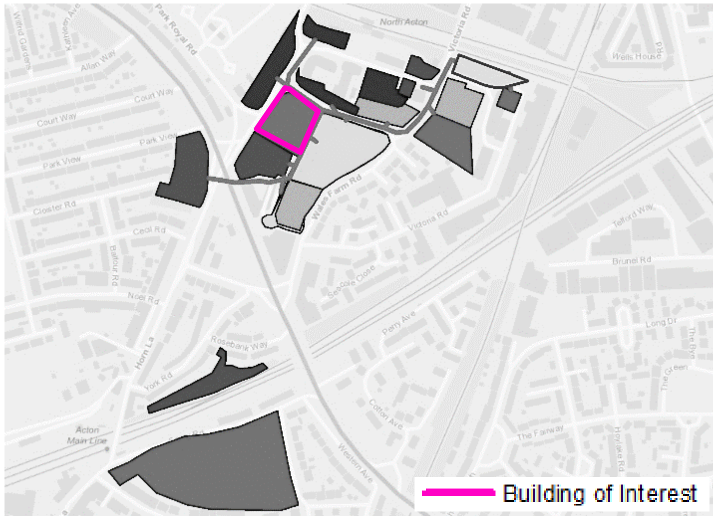


Figure A32 6 Portal Way location

Developer		Child Graddon Lewis
Level of Engagement		Low
Contract		Bulk sale with on sale
Avoided Costs	2020	£350,767
	2032	
Avoided Emissions		37%

Table A32 Key development details

Site Q. Friary Park Estate

Potential for connection **Very Low**

Planned Development

The Friary Park Estate development is due to be completed in January 2020. The development is 6000m^2 of residential domestic. The current energy strategy is a CHP with domestic boilers for some properties supported by Solar PV panels.

Heat Load

The total heat demand is 2,412,000 kWh/year, 9% of the total heat load of the developments identified in the area.

Potential Constraints

It is located c.1km from the proposed energy centre and there are major road and rail crossing that could complicate connection. The developers have had a low level of engagement in the process and have previously conducted a feasibility study on join a network with results showing that the location of the site will make the connection unfeasible.

Advantages

By connecting to a district heating scheme Friary Park Estate could significantly reduce its carbon emissions as well as avoiding costs associated with building a self serving energy centre in house.

RIBA Stage	2018				2019				2020				2021			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1. Preparation and Brief																
2. Concept Design																
3. Developed Design																
4. Technical Design																
5. Construction																
6. Handover and Close out																
7. Occupation																

Table A33 Design and construction timeline

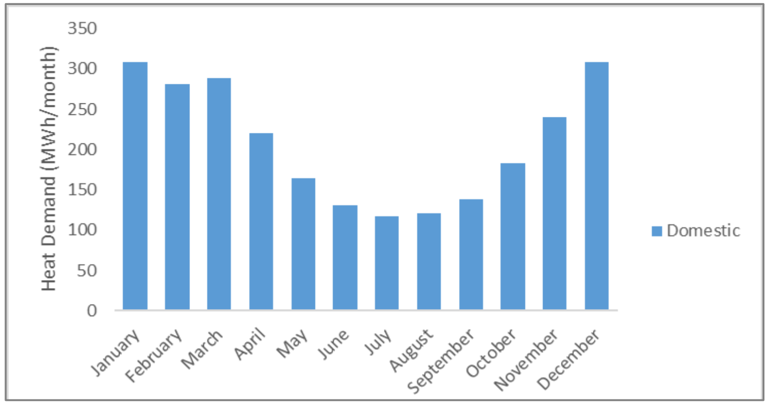


Figure A33 Friary Park Estate annual heat demand profile

Developer		Barton Willmore
Level of Engagement		Low
Contract		Bulk sale with on sale
Avoided Costs	2020	£536,445
	2032	
Avoided Emissions		39%

Table A34 Key development details

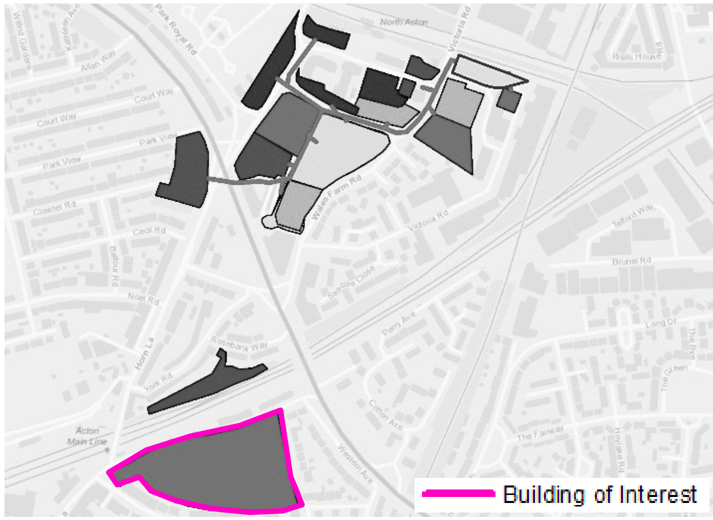


Figure A34 Friary Park Estate location

Appendix B – Risk Register

Demand Risk Register

Table B1 Demand risk register

Title	Risk	Mitigation	Level
Accuracy of data	Not having accurate data will mean that benchmarks and assumptions have to be made which have a higher risk of being inaccurate and could lead to incorrect recommendations. Could lead to reducing the viability and business case for the Heat Network.	Arup have contacted the responsible parties for developments (as provided by OPDC) in the study area and requested data and chased this in all cases. Where we have not received sufficient data (or it is not available due to the status of the development) we have used industry benchmarks to estimate. A sensitivity analysis has been undertaken for the level of demand.	
Connections to scheme not materialising	The promoter for the heat network may not be able to negotiate the connection of loads that are not under their direct control.	The study will undertake sensitivity to understand the effect on the network of not connecting loads A meeting with developers has been held, to confirm and maintain interest levels and to increase awareness of the scheme.	
Phasing/timing of connections	Network takes a long time to develop and opportunity window for connecting key developments is missed e.g. new developments finishing prior to the heat network completion date put in their own solution that is not immediately compatible with heat network.	Study is developing a timeline to plan, secure funding and procure network, based on different commercial solutions. The timing of network delivery will determine whether the earliest developments can connect to the network before they are built. Economic modelling will reflect these options.	
Stakeholder engagement not forthcoming	Engagement with stakeholders, particularly developers and ESCOs does not illicit meaningful response and could lead to reducing the viability and business case for the Heat Network due to their lack of interaction.	Meetings with ESCOs and a meeting with Developers have been held. Project steering group includes Ealing and GLA. Presentation to Senior Management Team is planned for January the 22nd.	
ESCO procurement timeframe	ESCO procurement timeframes taking too long too allow it to be a feasible model for North Acton	Arup is modelling different scenarios depending on the first year of DH operation. This analysis will give figures about changes in costs, revenues and feasibility due to the delayed start of DH	
Increased cost of connection to existing buildings	Complications with interfacing heating systems in developments with established design for plant room increases the capital cost of connection, reducing the viability and business case for the Heat Network.	Record information from developers on particular constraints of existing buildings. Record if available the location of proposed building plant rooms / energy centres to confirm position on site relative to proposed DH route. Visual inspections from public highway will also provide some indication of connection complexity.	

Supply Risk Register

Option 1. CHP-Led

Table B2 Supply risk register

Title	Risk	Mitigation	Level
Securing energy centre location	The capital cost of purchasing land and building own energy centre is high.	Different options of colocation in the larger developments have been considered.	
Lifetime saving of CO_2	Successful decarbonising of the UK electricity grid may compromise the carbon emissions savings achievable via gas fired CHP.	The future potential for switching gas CHP technology for an alternative option should be considered, including the viability of a heat supply connection to the wider OPDC network with alternative low carbon resources.	

Supply Risk Register
Options 2 and 3 CHP plus AQHP

Table B2 Supply risk register

Title	Risk	Mitigation	Level
Securing energy centre location	The capital cost of purchasing land and building own energy centre is high.	Different options of colocation in the larger developments have been considered.	
Lifetime saving of CO_2	Successful decarbonising of the UK electricity grid may compromise the carbon emissions savings achievable via gas fired CHP.	An aquifer heat pump has been included as base load to reduce the carbon emission in long term.	
Aquifer availability	The aquifer depth and availability is uncertain	Desk studies have been undertaken analysing data from boreholes in the vicinity, costs for drilling test have been included in the capex	
Aquifer power	The power extracted from the aquifer can be less than what expected	A scenario with half power of the max expected from the aquifer has been included in the study	

Supply Risk Register

Option 4 Heat pump only (no gas)

Table B2 Supply risk register

Title	Risk	Mitigation	Level
Securing energy centre location	The capital cost of purchasing land and building own energy centre is high.	Different options of colocation in the larger developments have been considered.	
Supply Technology	Capital cost for the equipment can be really high	Different technology options have been tested. Electric boilers have been added for peak load to mitigate capital costs of heat ump.	
Size of thermal store	The thermal store for the zero carbon scenario can be bigger than what used in the CHP driven scenarios	Due to land availability the size has been limited to a size comparable with traditional storage size	
Savings of CO_2	Different carbon factors used for planning permission can show this scenario as worse than others using gas	A comparison of carbon emission using different carbon factors has been done and included in the report	

Routing Risk Register

Table B3 Routing risk register

Title	Risk	Mitigation	Level
Developer design	The cut of date for decision about a DH solution will depends on developers plans and can affect the phasing of the scheme	Details of design cut-off dates were not provided by developers in the information provided to date.	
Developer system design temperature	High temperature system will affect the district heating temperature, reducing the COP of heat pumps and increasing thermal losses	Early developers will be contacted to confirm if system temperatures are available. If necessary, different configurations will be analysed considering the connection of those buildings happening in 10-15 years. Additionally, different scheme efficiencies will be considered.	
Coordination with existing buried Infrastructure	Insufficient space may be present within existing roads and utility corridors to incorporate new distribution pipework.	Further details to be sought on key existing buried (and surface-level) infrastructure with potential to impact upon proposed heat network routing, including an engineer route walk.	
Network crossing major obstacles	Works will be subject to strict programme due to the size and importance of local infrastructure. This could add large cost to construction of pipe network.	Railways and major obstacles have been identified on map. Costing has allowed for the challenging setting for pipe dig and installation. Site visit provided additional information on feasibility constraints. Following site visit a further cost review will be completed to confirm allowances for irregularities (e.g. tunnel under rail)	
Heat store construction close to railway land	Heat store in zero carbon scenario is an earthwork structure. Constraints on construction near railway lines may prevent it from being built on the energy centre site	Enquiry to Network Rail / TfL would help address this question. OPDC to provide contact details if available.	
Innovative scheme	Zero carbon scenario could seem too innovative to developers and ESCos	Different configurations have been investigated, including conventional CHP with higher temperature networks. First ESCO consultation gave a positive response to scheme innovation.	
Distribution Pipework diameters	Increase in required diameters of distribution pipework results in need for larger trenches, impacting upon space requirements and cost.	Hydraulic modelling work will be undertaken to confirm pipe size requirements.	

Appendix C – Additional Technical Information

Supply Assessment Methodology

Gas-fired CHP

Combined heat and power (CHP) systems capture the heat released during the power generation process. A well designed system, which matches plant capacity to a maintained level of heat demand, can result in higher system efficiencies than using gas boilers combined with grid electricity.

Gas Boilers

Gas boilers are a well-developed and resilient technology that have been applied in many cases as a district heating supply source. Proper matching of plant capacity to heat demand is similarly important to ensure efficient operation. Another key consideration is that of local air quality requirements,

Heat Pumps

Heat pumps are a reliable and proven technology, which operate using a vapour-compression cycle. Operation is similar to that of a domestic refrigerator turning a unit of high-grade electrical energy into multiple units of low-grade heat energy. They are therefore typically driven through electricity via a connection to the electricity network. Heat pumps are most suited to heating and cooling systems that require relatively moderate temperatures. However, low grade heat produced by heat pumps can be boosted by other energy supply technologies if higher grade heat is required (e.g. boilers). Heat pumps do not release pollutants, There are several low grade heat resources available in the North Acton site that have been evaluated.

Aquifer Heat Pump (AQHP)

An open-loop system could be installed in boreholes that allows water from the Aquifer to be brought to the surface. If abstraction rates of approximately 20l/s were achieved per borehole then the expected thermal energy output of this resource could be 1.2MW. Extraction rates will be uncertain until boreholes are sunk, but this is a potentially deliverable source of heating and cooling that has been exploited elsewhere in London. Necessary licences would need to be obtained and renewed.

Ground Source Heat Pumps (GSHPs)

GSHP arrangements work by upgrading low grade heat recovered from groundwater. At depths below approximately 6m, ground temperatures are stable throughout the year. The ground can act as both a store and supply of heat.

Air Source Heat Pumps (ASHPs)

Though more typically suitable for individual building solutions, the use of large-scale ASHPs has been considered for the carbon performance achievable in then context of a decarbonising grid mix.

Figure C1 Combined Heat and Power*

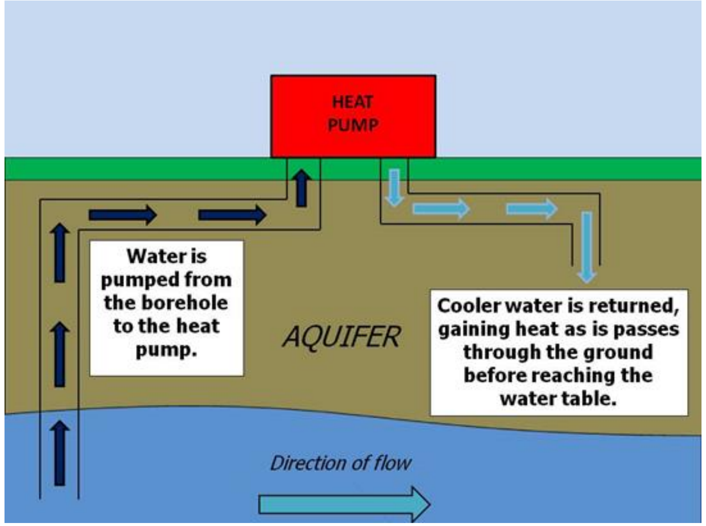


Figure C2 Aquifer Schematic*

*www.planet-biogas-usa.com/chp/speechfoodie.com/water-source-heat-pump-loop-diagram

Low-temperature Heat Recovery

Within this category of technology, options such as rejected heat from buildings, electrical substations and sewer systems have been considered.

All are based on the recovery of low-grade heat best suited for according use within low temperature networks and systems.

Sewage Heat Pump

Another option of low grade heat recovery is by harnessing the waste heat in the sewer system. This technology consists of a series of curved metal heat exchangers each of approximately 1m in length. The maximum total length that can currently be installed is 200m with the main constraint on this being pumping and hydraulic considerations. Each 200m length is expected to produce 200-500kW of heat.

Data Centre Heat Recovery

The high electrical loadings of data centres mean they reject a significant amount of heat. This low grade rejected heat can be used as a source of medium heat for heat pumping to serve an area wide network.

Canal Heat Pump

One option of low grade heat that has been explored is the Grand Union canal. The water can be taken from the canal and the heat the extracted from it, via a water side heat pump. In order to comply with regulations, the water would then be returned to the canal at a lower temperature. Research by AECOM has suggested that the canal could potentially provide 1-3MW of heat. However, the location of the canal favours the connection of other heat loads which are closer and would not require c.1km of piping needed to reach North Acton. For this reason, it is not analysed in any of the scenarios modelled.

Geothermal

Deep geothermal heat is typically accessed via boreholes or wells at depths of 500m or greater which can access heat at temperatures between 50 – 80°C. There is no known site for geothermal technology in the North Acton area.

Fuel Cells

Fuel cells convert the chemical energy in a fuel directly into electrical current and heat without combustion. However this technology is still in development and not deemed proven enough for a scheme of this scale

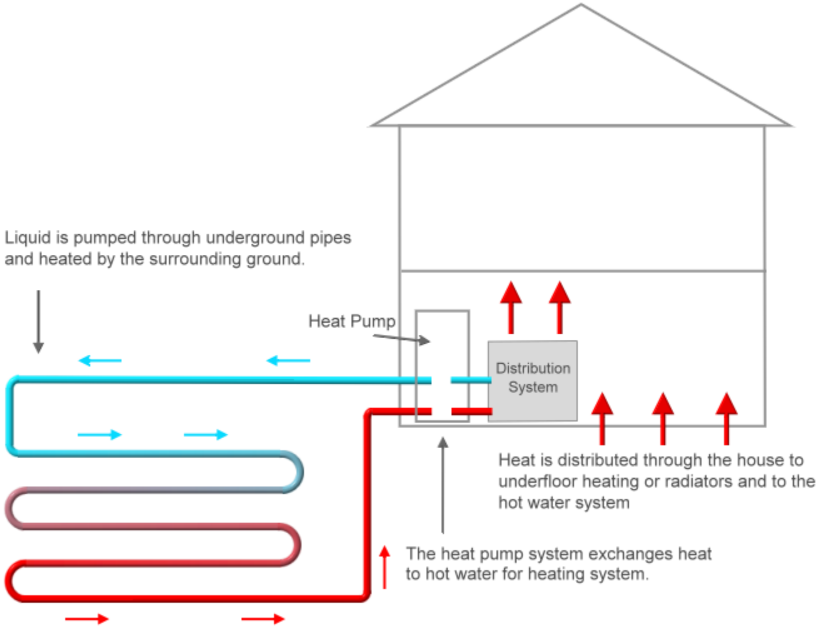


Figure C3 Ground source heat pump schematic*

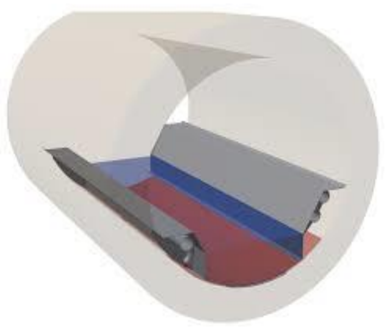


Figure C4 Canal heat recovery system***

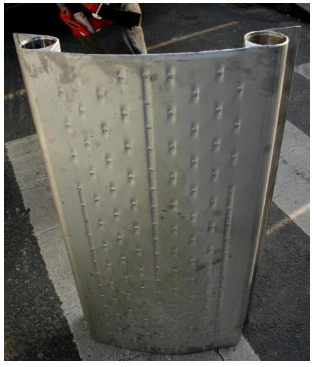


Figure C5 Sewer heat pump heat exchanger**

*https://greenbusinesswatch.co.uk/guides/ground-source-heat-pumps
**http://www.aqualogyuk.co.uk/markets/water-utilities
***https://www.kasag.com/en/product/renewable-energies-systems-plants-heat-exchanger-heat-from-wastewater-heat-exchanger-solutions-wasterwater-canal/

Energy Centre Location

On the 22nd of November 2017 Arup conducted a site visit to establish the appropriateness of energy site location and ascertain any additional constraints to the pipe route.

Energy centre location identified by AECOM

The only way to access the original triangular site is via the side of the railway. However, this was not possible on the day due to security and fences.

The location identified by AECOM has a total area of 14,000 m^2 and could easily allow for an energy centre of about 650 m^2. This location has various constraints in terms of access, and the structure of the railway bridge does not allow enough space for routing pipes.

New energy centre location

In the course of the site visit the new energy centre location was identified. Even though it is smaller than the original site (total area of about 3,400 m^2), it could still accommodate an energy centre of about 650 m^2. This new location has less constraints in terms of access.

Conclusion

The conclusion reached was that the new site (on the corner of Chase road and Victoria) road represents the most suitable location, given the relative ease of access and additionally its proximity to the developments of interest intended to comprise the emerging DE scheme and to be served via a direct electrical connection.

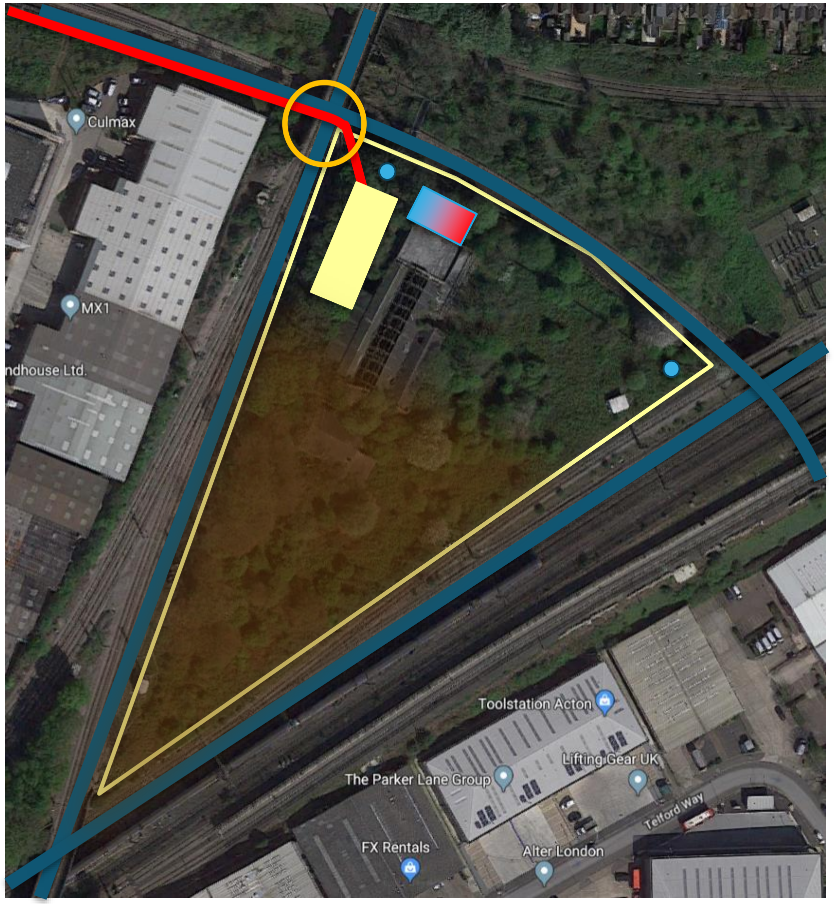
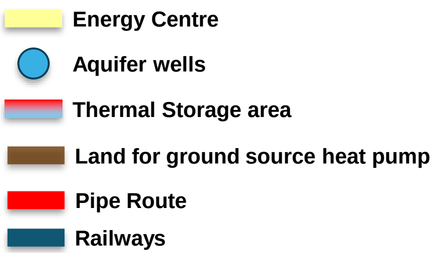


Figure C6 Energy centre location identified by AECOM



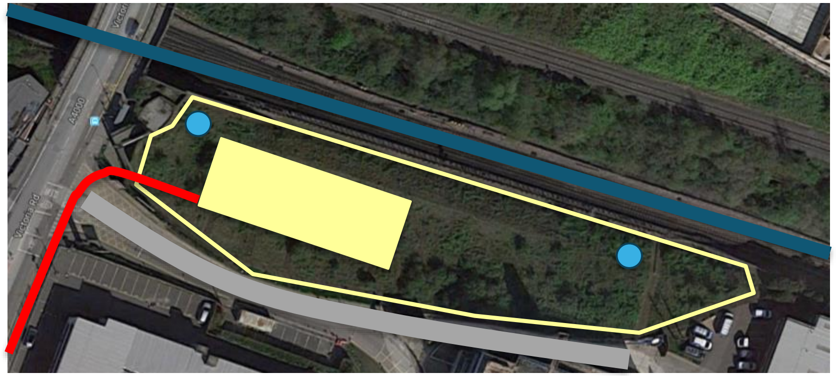


Figure C7 New energy centre location

Table C1 Assessment of Energy Centre location options

	Triangular Site between North Acton and Wormwood Scrubs Park	Site on the Corner of Chase and Victoria Road
Size Constraints	The available area is significant (consisting of c.20,000m^2) and is split over two plots by a key surface railway line.	The available area of this site is 3,400m, it lies adjacent to a key surface railway line.
Planning Permission Considerations	The necessary air quality and visual impact considerations associated with siting the energy centre here would need to be considered as part of the wider building Planning assessment.	The necessary air quality and visual impact considerations associated with siting the energy centre here would need to be considered as part of the wider building Planning assessment.
Access	The site is surrounded by railway lines, representing significant barriers and obstacles for access, both for the construction of the energy centre and for future operation and maintenance procedures.	The site is located immediately next to the developments of interest. The surrounding area has ongoing construction. Further information would be required to assure access.
Visual Impact	This site is surrounded by railway lines and the visual impact of a new energy centre is not likely to be high.	Whilst any new building on this site would involve visual impacts for the surrounding areas, this is not anticipated to be a constraint due the nature and typology of the surrounding buildings.
Ground Works Requirements	Proximity to rail network and bridge foundations need to be considered for ground works.	Proximity to rail network and bridge foundations need to be considered for ground works.
Proximity to Heat Loads (& sources)	This site is in close proximity to the heat loads, the furthest development considered for connection in c.600m. Both sites are located in the North West of the North Acton area which is beneficial for future connection to a wider Old Oak network.	The site is immediately next to some of the heat loads of interest the furthest development of interest is c.450m. Both sites are located in the North West of the North Acton area which is beneficial for future connection to a wider Old Oak network.
Key Risks	The key risk associated with the site is the lack of apparent accessibility to the site.	The key risk of this site is its proximity to the railway line as this may cause constraints in the planning and construction phases.
Conclusions	Whilst this site is arguably the best as it offers the most space for expansion and has no current plans for development. The lack of access due to the railway lines preclude the potential to accommodate a new energy centre.	This site is deemed most suitable location to accommodate a new energy centre.

Demand Assessment of Electrical Loads

The generation of electricity alongside heat would provide a further revenue stream to the scheme, utilising one of the following options:

- Sale of electricity exported to local distribution network
- Direct sale of electricity (via a private wire arrangement) to identified customer(s)
- The consumption of generated electricity, thereby displacing cost of import

Given the wide variety of building/site operators involved with the proposed connections, plus the contractual complications of setting up private wire arrangements with each, the private wire option has been considered only for Imperial College (which involves also Perfume Factory and Carphone Warehouse) as big customer.

In the supply scenario with the Aquifer Heat pump, all electricity used by the heat pump is produced by the CHP in order to maximize efficiency and revenues.

Total Load

The total benchmarked annual electricity consumption, associated with the buildings, has been determined as around 9,2 GWh/year.

The electricity profile is almost constant across the entirety of the year and is mostly influenced by non domestic loads.

Table C2 Electrical load data for select buildings

Building Name	Annual Electrical Load	Data Source
Units	kWh/year	-
Perfume Factory	2,267,775	Benchmarked
Imperial College	1,580,148	
Carphone Warehouse	706,350	
6 Portal Way	695,899	
The Portal	190,275	
Lyra Court	75,662	
Former BBC Studio	205,921	
Holbrook House	92,690	
Monarch House	558,121	
Gypsy Horn Lane	768,240	
Victoria Square	123,135	
NEC House	574,705	
2 Portal Way	34,762	
Friary Park Estate	420,000	
142-154 Victoria Road	38,730	
5 Portal Way	891,118	
Land to the Rear of Western Court and Rosebank	32,942	

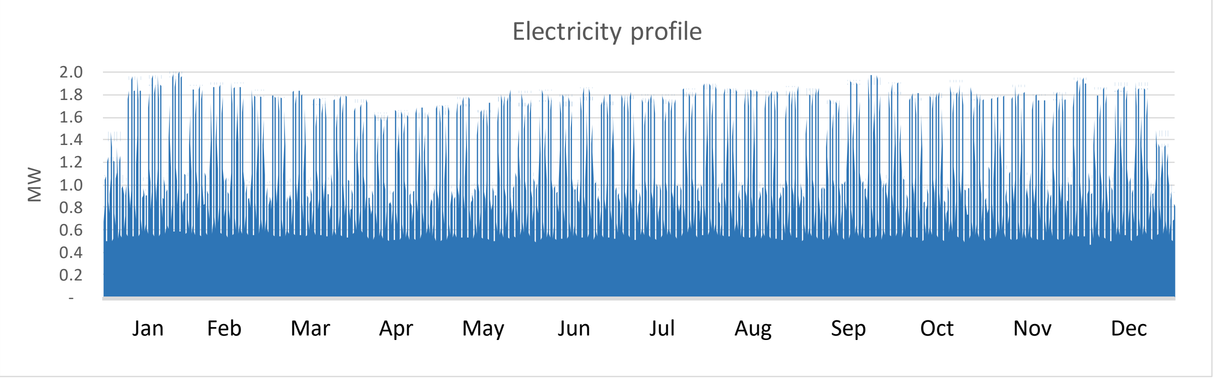


Figure C8 Daily electricity load profile across the year

Management of the London Aquifer Basin

The aquifer is a large reservoir trapped in porous rock (e.g. chalk) deep underground at a depth of c.100m. This water, typically at 14°C, can be utilised as a water-sourced heat pump to elevate temperature in a secondary circuit up to temperatures suitable for an area-wide heat network. In order to maintain aquifer water levels. The water must be rejected back into the reservoir after the heat exchange has taken place.

Ground water levels in the London aquifer need careful management to remain sustainable and in recent years the water level has been decreasing due to increased abstraction rates leaving some of the chalk unsaturated. The depth of chalk varies significantly across the London basin. Variation in burial depth described earlier is an important control of the hydraulic properties of the Chalk in the London Basin.

In the southwest part of the London Basin where depth to Chalk is often in excess of 100 m from surface, the Chalk has much lower transmissivity, whilst under the valleys of the rivers Thames and Lee, where the Chalk is at shallow depth, or at surface, high transmissivity corridors are present. The levels also respond more to changes in local abstraction intensity than the overall balance between abstraction regime is also dynamic and changes year by year depending on the actual, rather than the licensed volume of abstraction, which means groundwater levels will never actually stabilise.

The principle of the licensing strategy is to maintain groundwater levels below an upper level needed to protect underground structures, and above a lower level, which prevents the Chalk aquifer from being dewatered to an unacceptable level.

As part of the licensing provisions, all new schemes should not discharge water at temperatures higher than 25°C or be more than 10° different (higher or lower) to that measured at the point of abstraction.

Table C3 London Aquifer data

Time stamp	Dip[m]	State of value	Groundwater level[mAOD]	State of absolute value	Comments
28/01/2015 11:00	52.05	G	-36.93	G	
13/01/2016 09:00	---	M	---	M	Not drilled
31/03/2017 11:55	48.01	G	-32.89	G	null
20/04/2017 09:50	48.45	G	-33.33	G	null
26/05/2017 10:15	47.97	G	-32.85	G	null
28/06/2017 10:20	47.38	G	-32.26	G	null
31/07/2017 09:57	48.02	G	-32.9	G	null
10/08/2017 11:44	48.07	G	-32.95	G	null
22/09/2017 13:30	47.98	G	-32.86	G	null
13/10/2017 12:33	48.07	G	-32.95	G	null
16/11/2017 13:30	47.98	G	-32.86	G	null

The Water table geology map method enables areas of different water availability status to be updated annually. Local assessments are used to confirm if water is deemed to be available for licensing from the confined Chalk. These assessments take into account the local ground water availability outcome maps, as seen in Figure C9. Alongside some additional guidelines and considerations such as the general long – term trend of the ground water in the area and other proposals in the vicinity. The North Acton developments are situated in an water available area, and the closest active well is TQ28/226.The water level at the borehole in 2017 is around -33mAOD. This is consistent with nearby observations and the general trend in the area is that the water table is rising. Data suggests that the piezometric head is within LONDON Clay and the lower aquifer is confined.

The number of proposals and investigations are significantly larger than the number of schemes that come to fruition. From inception to operations the open loop GSHP can take several years. Therefore this must be taken into consideration when considered when planning and assessing the feasibility of the scheme and the viability of this resource. Drill testing would be required in order to confirm the depth and flow rate available at the site. These unknown parameters will affect the costing and over all heat generation capacity of the Aquifer.

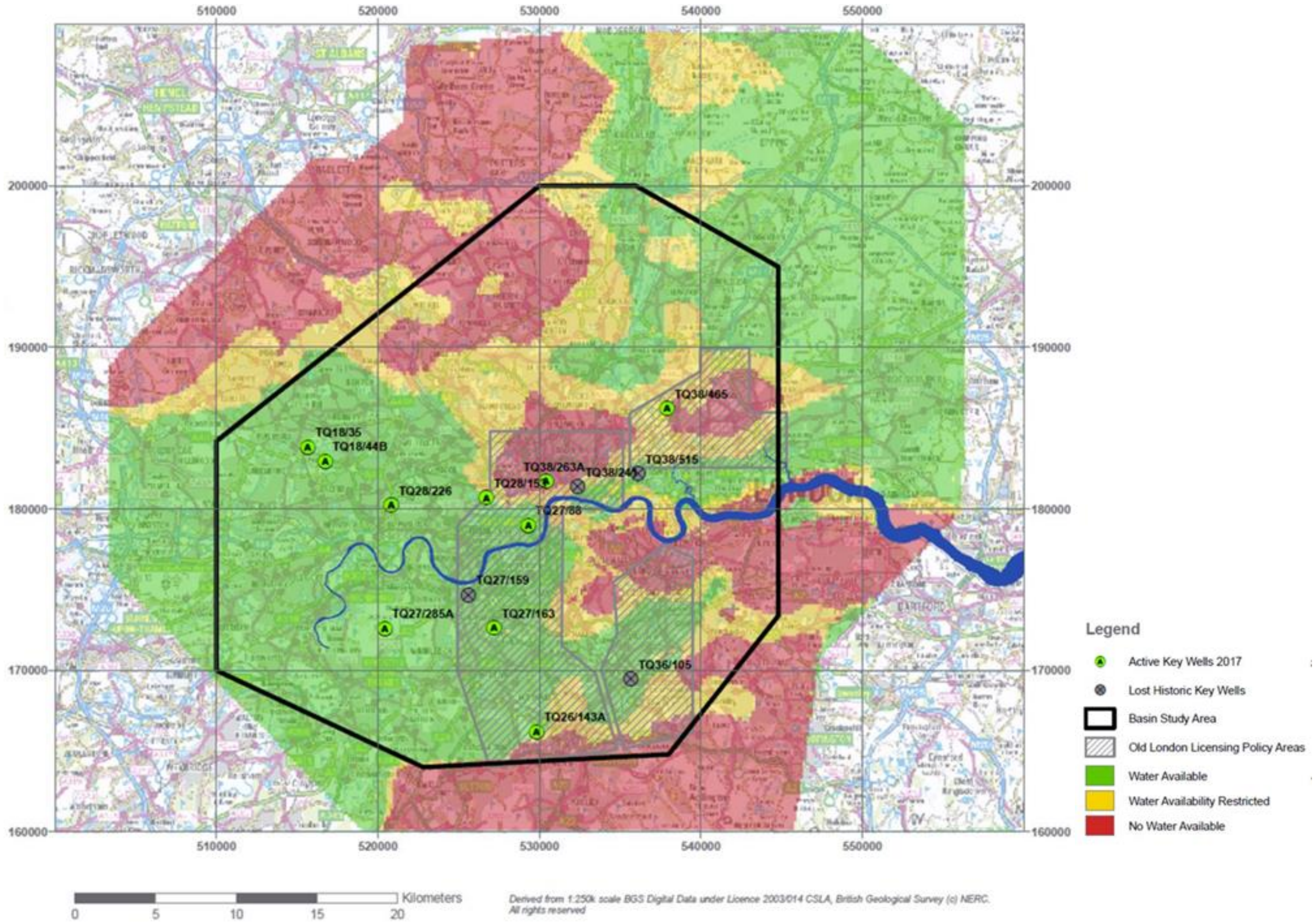


Figure C9 London Aquifer borehole locations

Appendix D – Modelling assumptions

Model Assumptions

Scenario Testing

	Active Scenario		1	2	3	4	5	6	7
Scenario Number	1								
Scenario Name	2020 Completion + AQHP		2020 Completion + AQHP	2020 Completion + AQHP + 2032 existing buildings	2020 Completion + CHP (only)	2020 Completion + CHP (only) + 2032 existing bldings connection	2020 Completion + Small AQHP	2020 Completion + Small AQHP + late connection existing bldings	2032 Completion + AQHP
First Scenario Run	1								
	to								
Last Scenario Run	7								

Time

		Unit	1	2	3	4	5	6	7	Comment
1st model column start date	01 Jan 2019	date	01 Jan 2019	01 Jan 2019	01 Jan 2019	01 Jan 2019	01 Jan 2019	01 Jan 2019	01 Jan 2031	Earliest Completion date
Months per model period	12	months	12	12	12	12	12	12	12	
Opening balance sheet date	01 Jan 2019	date	01 Jan 2019	01 Jan 2019	01 Jan 2019	01 Jan 2019	01 Jan 2019	01 Jan 2019	01 Jan 2031	
Length of forecast period	40	years	40	40	40	40	40	40	40	
First modelling column financial year number	2019	year #	2019	2019	2019	2019	2019	2019	2031	
Financial year end month number	12	month #	12	12	12	12	12	12	12	
Forecast heat-on date	31 Jan 2020	date	31 Jan 2020	31 Jan 2020	31 Jan 2020	31 Jan 2020	31 Jan 2020	31 Jan 2020	31 Jan 2031	
RHI payment term	20	years	20	20	20	20	20	20	0	Current Non-Dom RHI contract period

Technical Inputs

Demand Side

Input Load Names	LoAC connected?				1	2	3	4	5	6	7	Comment
Perfume Factory	1	flag		01/01/2021	1	1	1	1	1	1	1	Information from Developers & scenario testing
Imperial College	1	flag		01/01/2020	1	1	1	1	1	1	1	Information from Developers & scenario testing
Carphone Warehouse / 1 Portal Way	1	flag		01/01/2027	1	1	1	1	1	1	1	Information from Developers & scenario testing
6 Portal Way	1	flag		01/01/2020	1	1	1	1	1	1	1	Information from Developers & scenario testing
The Portal	1	flag		01/01/2021	1	1	1	1	1	1	1	Information from Developers & scenario testing
Lyra Court	1	flag	existing		1	1	1	1	1	1	1	Information from Developers & scenario testing
Former BBC Studio	1	flag	existing		1	1	1	1	1	1	1	Information from Developers & scenario testing
Holbrook House	1	flag		01/01/2019	1	1	1	1	1	1	1	Information from Developers & scenario testing
Monarch House	1	flag		01/01/2020	1	1	1	1	1	1	1	Information from Developers & scenario testing
Gypsy Horn Lane	1	flag		01/01/2019	1	1	1	1	1	1	1	Information from Developers & scenario testing
Victoria Square	1	flag	existing		1	1	1	1	1	1	1	Information from Developers & scenario testing
NEC House	1	flag	existing		1	1	1	1	1	1	1	Information from Developers & scenario testing
2 Portal Way	1	flag		01/01/2021	1	1	1	1	1	1	1	Information from Developers & scenario testing
Friary Park Estate	0	flag		01/01/2020	0	0	0	0	0	0	0	Information from Developers & scenario testing
142-154 Victoria Road	1	flag		01/01/2019	1	1	1	1	1	1	1	Information from Developers & scenario testing
5 Portal Way	1	flag		01/01/2019	1	1	1	1	1	1	1	Information from Developers & scenario testing
Land to the Rear of Western Court Rosebank	0	flag		01/01/2019	0	0	0	0	0	0	0	Information from Developers & scenario testing
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
	0	flag			0	0	0	0	0	0	0	
Number of connections	15	no.										

Building Typologies	Primary Typology		1	2	3	4	5	6	7	Comment
Perfume Factory	Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
Imperial College	Education	label	Education	Education	Education	Education	Education	Education	Education	Not used in the model - only for context
Carphone Warehouse / 1 Portal Way	Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
6 Portal Way	Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
The Portal	Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
Lyra Court	Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
Former BBC Studio	Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context

Holbrook House		Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
Monarch House		Retail	label	Retail	Retail	Retail	Retail	Retail	Retail	Retail	Not used in the model - only for context
Gypsy Horn Lane		Retail	label	Retail	Retail	Retail	Retail	Retail	Retail	Retail	Not used in the model - only for context
Victoria Square		Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
NEC House		Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
2 Portal Way		Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
Friary Park Estate		Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
142-154 Victoria Road		Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
5 Portal Way		Office	label	Office	Office	Office	Office	Office	Office	Office	Not used in the model - only for context
Land to the Rear of Western Court Rosebank		Domestic	label	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Domestic	Not used in the model - only for context
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
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	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								

Existing or New

		Existing / New									
Perfume Factory		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
Imperial College		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
Carphone Warehouse / 1 Portal Way		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
6 Portal Way		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
The Portal		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
Lyra Court		Existing	label	Existing	Existing	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
Former BBC Studio		Existing	label	Existing	Existing	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
Holbrook House		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
Monarch House		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
Gypsy Horn Lane		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
Victoria Square		Existing	label	Existing	Existing	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
NEC House		Existing	label	Existing	Existing	Existing	Existing	Existing	Existing	Existing	Not used in the model - only for context
2 Portal Way		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
Friary Park Estate		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
142-154 Victoria Road		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
5 Portal Way		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
Land to the Rear of Western Court Rosebank		New	label	New	New	New	New	New	New	New	Not used in the model - only for context
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								
	0	0	label								

Private Wire Network

Perfume Factory Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
Imperial College Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
Carphone Warehouse / 1 Portal Way Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
6 Portal Way Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
The Portal Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
Lyra Court Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
Former BBC Studio Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
Holbrook House Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
Monarch House Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
Gypsy Horn Lane Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
Victoria Square Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
NEC House Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
2 Portal Way Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
Friary Park Estate Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
142-154 Victoria Road Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
5 Portal Way Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
Land to the Rear of Western Court Rosebank Private Wire	0	flag	0	0	0	0	0	0	0	Not included as an option
Private Wire	0	flag								
Private Wire	0	flag								
Private Wire	0	flag								
Private Wire	0	flag								
Private Wire	0	flag								
Private Wire	0	flag								

Private Wire	0	flag									
Private Wire	0	flag									
Private Wire	0	flag									
Private Wire	0	flag									
Private Wire	0	flag									
Private Wire	0	flag									
Private Wire	0	flag									
Private Wire	0	flag									
Number of PW connections	0	no.									

Connection Dates

Perfume Factory Connection Date	01 Jan 2021	date	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2032	information from developers, if already constructed
Imperial College Connection Date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2032	information from developers, if already constructed
Carphone Warehouse / 1 Portal Way Connection Date	01 Jan 2027	date	01 Jan 2027	01 Jan 2027	01 Jan 2027	01 Jan 2027	01 Jan 2027	01 Jan 2027	01 Jan 2027	01 Jan 2032	information from developers, if already constructed
6 Portal Way Connection Date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Sep 2020	01 Jan 2020	01 Sep 2020	01 Jan 2020	01 Sep 2020	01 Jan 2032	information from developers, if already constructed
The Portal Connection Date	01 Jan 2021	date	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2032	information from developers, if already constructed
Lyra Court Connection Date	01 Jan 2020	date	existing	01 Jan 2020	01 Jan 2032	01 Jan 2020	01 Jan 2032	01 Jan 2020	01 Jan 2032	01 Jan 2032	information from developers, if already constructed
Former BBC Studio Connection Date	01 Jan 2020	date	existing	01 Jan 2020	01 Jan 2032	01 Jan 2020	01 Jan 2032	01 Jan 2020	01 Jan 2032	01 Jan 2032	information from developers, if already constructed
Holbrook House Connection Date	01 Jan 2020	date	01 Jan 2019	01 Jan 2020	02 Jan 2020	01 Jan 2020	02 Jan 2020	01 Jan 2020	02 Jan 2020	01 Jan 2032	information from developers, if already constructed
Monarch House Connection Date	01 Jan 2020	date	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2032	information from developers, if already constructed
Gypsy Horn Lane Connection Date	01 Jan 2020	date	01 Jan 2019	01 Jan 2020	02 Jan 2020	01 Jan 2020	02 Jan 2020	01 Jan 2020	02 Jan 2020	01 Jan 2032	information from developers, if already constructed
Victoria Square Connection Date	01 Jan 2020	date	existing	01 Jan 2020	01 Jan 2032	01 Jan 2020	01 Jan 2032	01 Jan 2020	01 Jan 2032	01 Jan 2032	information from developers, if already constructed
NEC House Connection Date	01 Jan 2020	date	existing	01 Jan 2020	01 Jan 2032	01 Jan 2020	01 Jan 2032	01 Jan 2020	01 Jan 2032	01 Jan 2032	information from developers, if already constructed
2 Portal Way Connection Date	01 Jan 2021	date	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2021	01 Jan 2032	information from developers, if already constructed
Friary Park Estate Connection Date	01 Jan 2020	date	not included	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2020	01 Jan 2032	information from developers, if already constructed
142-154 Victoria Road Connection Date	01 Jan 2020	date	01 Jan 2019	01 Jan 2020	02 Jan 2020	01 Jan 2020	02 Jan 2020	01 Jan 2020	02 Jan 2020	01 Jan 2032	information from developers, if already constructed
5 Portal Way Connection Date	01 Jan 2020	date		01 Jan 2020	02 Jan 2020	01 Jan 2020	02 Jan 2020	01 Jan 2020	02 Jan 2020	01 Jan 2032	information from developers, if already constructed
Land to the Rear of Western Court Rosebank Connection Date	-	date	not included								information from developers, if already constructed
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	
Connection Date	-	date		-	-	-	-	-	-	-	

Heat Loads

Perfume Factory Heat Load	1,922,507	kWh	1,922,507	1,922,507	1,922,507	1,922,507	1,922,507	1,922,507	1,922,507	From Network Profiling tool - 2017-12-13_ISSUE
Imperial College Heat Load	3,131,667	kWh	3,131,667	3,131,667	3,131,667	3,131,667	3,131,667	3,131,667	3,131,667	From Network Profiling tool - 2017-12-13_ISSUE
Carphone Warehouse / 1 Portal Way Heat Load	3,989,578	kWh	3,989,578	3,989,578	3,989,578	3,989,578	3,989,578	3,989,578	3,989,578	From Network Profiling tool - 2017-12-13_ISSUE
6 Portal Way Heat Load	567,281	kWh	567,281	567,281	567,281	567,281	567,281	567,281	567,281	From Network Profiling tool - 2017-12-13_ISSUE
The Portal Heat Load	1,414,921	kWh	1,414,921	1,414,921	1,414,921	1,414,921	1,414,921	1,414,921	1,414,921	From Network Profiling tool - 2017-12-13_ISSUE
Lyra Court Heat Load	622,305	kWh	622,305	622,305	622,305	622,305	622,305	622,305	622,305	From Network Profiling tool - 2017-12-13_ISSUE
Former BBC Studio Heat Load	2,153,132	kWh	2,153,132	2,153,132	2,153,132	2,153,132	2,153,132	2,153,132	2,153,132	From Network Profiling tool - 2017-12-13_ISSUE
Holbrook House Heat Load	1,515,480	kWh	1,515,480	1,515,480	1,515,480	1,515,480	1,515,480	1,515,480	1,515,480	From Network Profiling tool - 2017-12-13_ISSUE
Monarch House Heat Load	1,732,966	kWh	1,732,966	1,732,966	1,732,966	1,732,966	1,732,966	1,732,966	1,732,966	From Network Profiling tool - 2017-12-13_ISSUE
Gypsy Horn Lane Heat Load	2,551,954	kWh	2,551,954	2,551,954	2,551,954	2,551,954	2,551,954	2,551,954	2,551,954	From Network Profiling tool - 2017-12-13_ISSUE
Victoria Square Heat Load	786,044	kWh	786,044	786,044	786,044	786,044	786,044	786,044	786,044	From Network Profiling tool - 2017-12-13_ISSUE
NEC House Heat Load	2,046,494	kWh	2,046,494	2,046,494	2,046,494	2,046,494	2,046,494	2,046,494	2,046,494	From Network Profiling tool - 2017-12-13_ISSUE
2 Portal Way Heat Load	1,331,260	kWh	1,331,260	1,331,260	1,331,260	1,331,260	1,331,260	1,331,260	1,331,260	From Network Profiling tool - 2017-12-13_ISSUE
Friary Park Estate Heat Load	2,875,841	kWh	2,875,841	2,875,841	2,875,841	2,875,841	2,875,841	2,875,841	2,875,841	From Network Profiling tool - 2017-12-13_ISSUE
142-154 Victoria Road Heat Load	269,135	kWh	269,135	269,135	269,135	269,135	269,135	269,135	269,135	From Network Profiling tool - 2017-12-13_ISSUE
5 Portal Way Heat Load	726,419	kWh	726,419	726,419	726,419	726,419	726,419	726,419	726,419	From Network Profiling tool - 2017-12-13_ISSUE
Land to the Rear of Western Court Rosebank Heat Load	148,035	kWh	148,035	148,035	148,035	148,035	148,035	148,035	148,035	From Network Profiling tool - 2017-12-13_ISSUE
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								
Heat Load	-	kWh								

Peak Demands

Perfume Factory Peak Demand	1,018	kW	1,018	1,018	1,018	1,018	1,018	1,018	1,018	From Network Profiling tool - 2017-12-13_ISSUE
Imperial College Peak Demand	1,500	kW	1,500	1,500	1,500	1,500	1,500	1,500	1,500	From Network Profiling tool - 2017-12-13_ISSUE
Carphone Warehouse / 1 Portal Way Peak Demand	1,803	kW	1,803	1,803	1,803	1,803	1,803	1,803	1,803	From Network Profiling tool - 2017-12-13_ISSUE
6 Portal Way Peak Demand	283	kW	283	283	283	283	283	283	283	From Network Profiling tool - 2017-12-13_ISSUE
The Portal Peak Demand	794	kW	794	794	794	794	794	794	794	From Network Profiling tool - 2017-12-13_ISSUE

Lyra Court Peak Demand	393	kW	393	393	393	393	393	393	393	From Network Profiling tool - 2017-12-13_ISSUE
Former BBC Studio Peak Demand	1,098	kW	1,098	1,098	1,098	1,098	1,098	1,098	1,098	From Network Profiling tool - 2017-12-13_ISSUE
Holbrook House Peak Demand	868	kW	868	868	868	868	868	868	868	From Network Profiling tool - 2017-12-13_ISSUE
Monarch House Peak Demand	589	kW	589	589	589	589	589	589	589	From Network Profiling tool - 2017-12-13_ISSUE
Gypsy Horn Lane Peak Demand	1,002	kW	1,002	1,002	1,002	1,002	1,002	1,002	1,002	From Network Profiling tool - 2017-12-13_ISSUE
Victoria Square Peak Demand	470	kW	470	470	470	470	470	470	470	From Network Profiling tool - 2017-12-13_ISSUE
NEC House Peak Demand	1,068	kW	1,068	1,068	1,068	1,068	1,068	1,068	1,068	From Network Profiling tool - 2017-12-13_ISSUE
2 Portal Way Peak Demand	779	kW	779	779	779	779	779	779	779	From Network Profiling tool - 2017-12-13_ISSUE
Friary Park Estate Peak Demand	1,469	kW	1,469	1,469	1,469	1,469	1,469	1,469	1,469	From Network Profiling tool - 2017-12-13_ISSUE
142-154 Victoria Road Peak Demand	217	kW	217	217	217	217	217	217	217	From Network Profiling tool - 2017-12-13_ISSUE
5 Portal Way Peak Demand	363	kW	363	363	363	363	363	363	363	From Network Profiling tool - 2017-12-13_ISSUE
Land to the Rear of Western Court Rosebank Peak Demand	147	kW	147	147	147	147	147	147	147	From Network Profiling tool - 2017-12-13_ISSUE
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								
Peak Demand	-	kW								

Electricity Loads

Perfume Factory Electricity Load	-	kWh								Not included in this study
Imperial College Electricity Load	-	kWh								
Carphone Warehouse / 1 Portal Way Electricity Load	-	kWh								
6 Portal Way Electricity Load	-	kWh								
The Portal Electricity Load	-	kWh								
Lyra Court Electricity Load	-	kWh								
Former BBC Studio Electricity Load	-	kWh								
Holbrook House Electricity Load		kWh								
Monarch House Electricity Load	-	kWh								
Gypsy Horn Lane Electricity Load		kWh								
Victoria Square Electricity Load	-	kWh								
NEC House Electricity Load	-	kWh								
2 Portal Way Electricity Load	-	kWh								
Friary Park Estate Electricity Load	-	kWh								
142-154 Victoria Road Electricity Load	-	kWh								
5 Portal Way Electricity Load	-	kWh								
Land to the Rear of Western Court Rosebank Electricity Load	-	kWh								
Electricity Load	-	kWh								
Electricity Load	-	kWh								
Electricity Load	-	kWh								
Electricity Load	-	kWh								
Electricity Load		kWh								
Electricity Load	-	kWh								
Electricity Load		kWh								
Electricity Load	-	kWh								
Electricity Load		kWh								
Electricity Load	-	kWh								
Electricity Load		kWh								
Electricity Load	-	kWh								
Electricity Load		kWh								
Electricity Load	-	kWh								

Number of Dwellings

Perfume Factory Number of Dwellings	-	dwellings	0	0	0	0	0	0	0	Not used for calculations, but does provide context i
Imperial College Number of Dwellings	-	dwellings	0	0	0	0	0	0	0	Not used for calculations, but does provide context i
Carphone Warehouse / 1 Portal Way Number of Dwellings	765	dwellings	765	765	765	765	765	765	765	Not used for calculations, but does provide context i
6 Portal Way Number of Dwellings	578	dwellings	578	578	578	578	578	578	578	Not used for calculations, but does provide context i
The Portal Number of Dwellings	355	dwellings	355	355	355	355	355	355	355	Not used for calculations, but does provide context i
Lyra Court Number of Dwellings	-	dwellings	0	0	0	0	0	0	0	Not used for calculations, but does provide context i
Former BBC Studio Number of Dwellings	-	dwellings	0	0	0	0	0	0	0	Not used for calculations, but does provide context i
Holbrook House Number of Dwellings	-	dwellings	0	0	0	0	0	0	0	Not used for calculations, but does provide context i
Monarch House Number of Dwellings	133	dwellings	133	133	133	133	133	133	133	Not used for calculations, but does provide context i
Gypsy Horn Lane Number of Dwellings	149	dwellings	149	149	149	149	149	149	149	Not used for calculations, but does provide context i
Victoria Square Number of Dwellings	171	dwellings	171	171	171	171	171	171	171	Not used for calculations, but does provide context i
NEC House Number of Dwellings	-	dwellings	0	0	0	0	0	0	0	Not used for calculations, but does provide context i
2 Portal Way Number of Dwellings	368	dwellings	368	368	368	368	368	368	368	Not used for calculations, but does provide context i
Friary Park Estate Number of Dwellings	709	dwellings	709	709	709	709	709	709	709	Not used for calculations, but does provide context i
142-154 Victoria Road Number of Dwellings	64	dwellings	64	64	64	64	64	64	64	Not used for calculations, but does provide context i
5 Portal Way Number of Dwellings	-	dwellings								Not used for calculations, but does provide context i
Land to the Rear of Western Court Rosebank Number of Dwellings	37	dwellings	37	37	37	37	37	37	37	Not used for calculations, but does provide context i
Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								

Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								
Number of Dwellings	-	dwellings								
Non-Domestic Floor Area										
Perfume Factory Non-domestic Floor Area	1,650	m2	1,650	1,650	1,650	1,650	1,650	1,650	1,650	Last updated - 22/10/2017 - From Network Profiling
Imperial College Non-domestic Floor Area	6,214	m2	6,214	6,214	6,214	6,214	6,214	6,214	6,214	Last updated - 22/10/2017 - From Network Profiling
Carphone Warehouse / 1 Portal Way Non-domestic Floor Area	5,134	m2	5,134	5,134	5,134	5,134	5,134	5,134	5,134	Last updated - 22/10/2017 - From Network Profiling
6 Portal Way Non-domestic Floor Area	3,079	m2	3,079	3,079	3,079	3,079	3,079	3,079	3,079	Last updated - 22/10/2017 - From Network Profiling
The Portal Non-domestic Floor Area	549	m2	549	549	549	549	549	549	549	Last updated - 22/10/2017 - From Network Profiling
Lyra Court Non-domestic Floor Area	382	m2	382	382	382	382	382	382	382	Last updated - 22/10/2017 - From Network Profiling
Former BBC Studio Non-domestic Floor Area	286	m2	286	286	286	286	286	286	286	Last updated - 22/10/2017 - From Network Profiling
Holbrook House Non-domestic Floor Area	74	m2	74	74	74	74	74	74	74	Last updated - 22/10/2017 - From Network Profiling
Monarch House Non-domestic Floor Area	133	m2	133	133	133	133	133	133	133	Last updated - 22/10/2017 - From Network Profiling
Gypsy Horn Lane Non-domestic Floor Area	102	m2	102	102	102	102	102	102	102	Last updated - 22/10/2017 - From Network Profiling
Victoria Square Non-domestic Floor Area	660	m2	660	660	660	660	660	660	660	Last updated - 22/10/2017 - From Network Profiling
NEC House Non-domestic Floor Area	2,735	m2	2,735	2,735	2,735	2,735	2,735	2,735	2,735	Last updated - 22/10/2017 - From Network Profiling
2 Portal Way Non-domestic Floor Area	-	m2	-	-	-	-	-	-	-	Last updated - 22/10/2017 - From Network Profiling
Friary Park Estate Non-domestic Floor Area	-	m2	-	-	-	-	-	-	-	Last updated - 22/10/2017 - From Network Profiling
142-154 Victoria Road Non-domestic Floor Area	158	m2	158	158	158	158	158	158	158	Last updated - 22/10/2017 - From Network Profiling
5 Portal Way Non-domestic Floor Area	3,943	m2	3,943	3,943	3,943	3,943	3,943	3,943	3,943	Last updated - 22/10/2017 - From Network Profiling
Land to the Rear of Western Court Rosebank Non-domestic Floor Area	77	m2	77	77	77	77	77	77	77	Last updated - 22/10/2017 - From Network Profiling
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Non-domestic Floor Area	-	m2								
Space Take	-	m2								20/10/2017
Supply Side										
Emissions Factors										
SAP 2016 3-year gas factor	208	gCO2e/kWh	208	208	208	208	208	208	208	Marginal SAP 2016
SAP 2016 3-year grid factor	398	gCO2e/kWh	398	398	398	398	398	398	398	Marginal SAP 2016
SAP 2012 3-year gas factor	216	gCO2e/kWh	216	216	216	216	216	216	216	Marginal SAP 2012
SAP 2012 3-year grid factor	519	gCO2e/kWh	519	519	519	519	519	519	519	Marginal SAP 2012
Conversion Efficiencies										
Counterfactual CHP Electrical Efficiency	36.00%	% HHV	36.00%	36.00%	36.00%	36.00%	36.00%	36.00%	36.00%	Veolia Data Sheet - 12/2017
Counterfactual CHP Thermal Efficiency	40.00%	% HHV	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	40.00%	Veolia Data Sheet - 12/2017
CHP Electrical Efficiency	39.00%	% HHV	39.00%	39.00%	39.00%	39.00%	39.00%	39.00%	39.00%	Veolia Data Sheet - 12/2017
CHP Thermal Efficiency	42.00%	% HHV	42.00%	42.00%	42.00%	42.00%	42.00%	42.00%	42.00%	Veolia Data Sheet - 12/2017
Gas Boiler Efficiency	90.00%	% HHV	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	90.00%	DECC DH Guidance Document
Sewage Heat Pump COP	390.00%	COP	3.90	3.90	3.90	3.90	3.90	3.90	3.90	Based on case study - Reference
Aquifer Heat Pump COP	3.50	COP	3.50	3.50	3.50	3.50	3.50	3.50	3.50	Guido Instruction - 18/12/2017
Ground Source Heat Pump COP	4.00	COP	4.00	4.00	4.00	4.00	4.00	4.00	4.00	https://www.kensaheatpumps.com/the-technology/
Air Source Heat Pump COP	2.00	COP	2.00	2.00	2.00	2.00	2.00	2.00	2.00	https://www.gov.uk/government/uploads/system/u
Asset Lifetimes										
CHP Lifetime	15	years	15	15	15	15	15	15	15	Arup Assumption
Sewage Heat Pump Lifetime	15	years	15	15	15	15	15	15	15	Arup Assumption
Aquifer Heat Pump Lifetime	15	years	15	15	15	15	15	15	15	Arup Assumption
Gas Boiler Lifetime	20	years	20	20	20	20	20	20	20	Arup Assumption
HIU and Meter Lifetime	15	years	15	15	15	15	15	15	15	Arup Assumption
Network Side										
Private Wire Length										
Private Wire Network Length	-	m								
Financial Inputs										
Financial Indices										
RPI Inflation Rate	0%	%	0%	0%	0%	0%	0%	0%	0%	Beyond Scope, included for customer to test

Gas Price Inflation Rate	0%	%	0%	0%	0%	0%	0%	0%	0%	Beyond Scope, included for customer to test
Biomass Price Inflation Rate	0%	%	0%	0%	0%	0%	0%	0%	0%	Beyond Scope, included for customer to test
Electricity Price Inflation Rate	0%	%	0%	0%	0%	0%	0%	0%	0%	Beyond Scope, included for customer to test
Heat Price Inflation	0%	%	0%	0%	0%	0%	0%	0%	0%	Beyond Scope, included for customer to test
Council Discount Rate	6%	%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	IRR required for a local authority
Company Discount Rate	12%	%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	12.0%	IRR required for private investment
Revenues										
Heat Pricing Variable Charge										
Heat Price Discount	10%	%	10%	10%	10%	10%	10%	10%	10%	Industry wide assumption to incentivise connection
Perfume Factory	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
Imperial College	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
Carphone Warehouse / 1 Portal Way	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
6 Portal Way	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
The Portal	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
Lyra Court	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
Former BBC Studio	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
Holbrook House	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
Monarch House	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
Gypsy Horn Lane	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
Victoria Square	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
NEC House	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
2 Portal Way	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
Friary Park Estate	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
142-154 Victoria Road	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
5 Portal Way	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
Land to the Rear of Western Court Rosebank	0.034	£/kWh	0.038	0.038	0.038	0.038	0.038	0.038	0.051	Assumptions - calculated in separate spreadsheet
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
0	-	£/kWh								
Heat Pricing Fixed Charge (Annualised REPEX Cost)										
Perfume Factory	33	£/kW	33	33	33	33	33	33	33	Assumptions_2018-02-14 - calculated in separate spr
Imperial College	19	£/kW	19	19	19	19	19	19	19	Assumptions_2018-02-14 - calculated in separate spr
Carphone Warehouse / 1 Portal Way	22	£/kW	22	22	22	22	22	22	22	Assumptions_2018-02-14 - calculated in separate spr
6 Portal Way	78	£/kW	78	78	78	78	78	78	78	Assumptions_2018-02-14 - calculated in separate spr
The Portal	33	£/kW	33	33	33	33	33	33	33	Assumptions_2018-02-14 - calculated in separate spr
Lyra Court	41	£/kW	41	41	41	41	41	41	41	Assumptions_2018-02-14 - calculated in separate spr
Former BBC Studio	27	£/kW	27	27	27	27	27	27	27	Assumptions_2018-02-14 - calculated in separate spr
Holbrook House	30	£/kW	30	30	30	30	30	30	30	Assumptions_2018-02-14 - calculated in separate spr
Monarch House	19	£/kW	19	19	19	19	19	19	19	Assumptions_2018-02-14 - calculated in separate spr
Gypsy Horn Lane	32	£/kW	32	32	32	32	32	32	32	Assumptions_2018-02-14 - calculated in separate spr
Victoria Square	33	£/kW	33	33	33	33	33	33	33	Assumptions_2018-02-14 - calculated in separate spr
NEC House	26	£/kW	26	26	26	26	26	26	26	Assumptions_2018-02-14 - calculated in separate spr
2 Portal Way	34	£/kW	34	34	34	34	34	34	34	Assumptions_2018-02-14 - calculated in separate spr
Friary Park Estate	22	£/kW	22	22	22	22	22	22	22	Assumptions_2018-02-14 - calculated in separate spr
142-154 Victoria Road	62	£/kW	62	62	62	62	62	62	62	Assumptions_2018-02-14 - calculated in separate spr
5 Portal Way	50	£/kW	50	50	50	50	50	50	50	Assumptions_2018-02-14 - calculated in separate spr
Land to the Rear of Western Court Rosebank	73	£/kW	73	73	73	73	73	73	73	Assumptions_2018-02-14 - calculated in separate spr
0	-	£/kW								
0	-	£/kW								
0	-	£/kW								
0	-	£/unit								
0	-	£/kW								
0	-	£/unit								
0	-	£/kW								
0	-	£/unit								
0	-	£/unit								
0	-	£/kW								
0	-	£/unit								
0	-	£/kW								
0	-	£/unit								
0	-	£/kW								

Connection Charge												
Discount applied to connection charge	10%	%			10%	10%	10%	10%	10%	10%	10%	Industry wide assumption to incentivise connection
Perfume Factory	509	£/kW		01 January 2021	565	565	565	565	565	565	488	Assumptions_2018-02-14 - calculated in separate spı
Imperial College	303	£/kW		01 January 2020	336	336	336	336	336	336	287	Assumptions_2018-02-14 - calculated in separate spı
Carphone Warehouse / 1 Portal Way	348	£/kW		01 January 2027	386	386	386	386	386	386	330	Assumptions_2018-02-14 - calculated in separate spı
6 Portal Way	1,197	£/kW		01 January 2020	1,330	1,330	1,330	1,330	1,330	1,330	1,175	Assumptions_2018-02-14 - calculated in separate spı
The Portal	519	£/kW		01 January 2021	577	577	577	577	577	577	499	Assumptions_2018-02-14 - calculated in separate spı
Lyra Court	-	£/kW	existing		-	609	-	609	-	609	609	Assumptions_2018-02-14 - calculated in separate spı
Former BBC Studio	-	£/kW	existing		-	405	-	405	-	405	405	Assumptions_2018-02-14 - calculated in separate spı
Holbrook House	467	£/kW		01 January 2019	519	519	519	519	519	519	451	Assumptions_2018-02-14 - calculated in separate spı
Monarch House	306	£/kW		01 January 2020	340	340	340	340	340	340	286	Assumptions_2018-02-14 - calculated in separate spı
Gypsy Horn Lane	497	£/kW		01 January 2019	552	552	552	552	552	552	476	Assumptions_2018-02-14 - calculated in separate spı
Victoria Square	-	£/kW	existing		-	492	-	492	-	492	492	Assumptions_2018-02-14 - calculated in separate spı
NEC House	-	£/kW	existing		-	391	-	391	-	391	391	Assumptions_2018-02-14 - calculated in separate spı
2 Portal Way	529	£/kW		01 January 2021	588	588	588	588	588	588	509	Assumptions_2018-02-14 - calculated in separate spı
Friary Park Estate	353	£/kW	not included		392	392	392	392	392	392	336	Assumptions_2018-02-14 - calculated in separate spı
142-154 Victoria Road	1,058	£/kW		01 January 2019	1,175	1,175	1,175	1,175	1,175	1,175	934	Assumptions_2018-02-14 - calculated in separate spı
5 Portal Way	763	£/kW			847	847	847	847	847	847	743	Assumptions_2018-02-14 - calculated in separate spı
Land to the Rear of Western Court Rosebank	1,219	£/kW	not included		1,355	1,355	1,355	1,355	1,355	1,355	1,091	Assumptions_2018-02-14 - calculated in separate spı
0	-	£/kW										
0	-	£/kW										
0	-	£/kW										
0	-	£ / unit										
0	-	£/kW										
0	-	£ / unit										
0	-	£/kW										
0	-	£ / unit										
0	-	£ / unit										
0	-	£/kW										
0	-	£ / unit										
0	-	£/kW										
0	-	£ / unit										
0	-	£/kW										
Demand Response Revenues												
TRIAD Revenues												
Proportion of peak over 3 periods	-	out of 3			0	0	0	0	0	0	0	Counterfactual will cancel out any benefit
STOR Revenues												
Annual runtime as STOR	-	hours			0	0	0	0	0	0	0	Counterfactual will cancel out any benefit
Additional Revenues												
RHI Revenues												
WSHP / GSHP Tier 1 Operation Limit	1,314	hours			1314	1314	1314	1314	1314	1314	1314	https://www.ofgem.gov.uk/environmental-program
Teir 1 Price	0.0909	£			0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	https://www.ofgem.gov.uk/environmental-program
Teir 2 Price	0.0271	£			0.0271	0.0271	0.0271	0.0271	0.0271	0.0271	0.0271	https://www.ofgem.gov.uk/environmental-program
ASHP - no teirs for operation	0.0261	£			0.0261	0.0261	0.0261	0.0261	0.0261	0.0261	0.0261	https://www.ofgem.gov.uk/environmental-program
Fuel Costs												
Gas Price	0.020	£/kWh			0.020	0.020	0.020	0.020	0.020	0.020	0.020	Non Dom Small Customer DECC - updated Oct 2017
Heat Pump Electricity Price (Bought from CHP)	0.046	£/kWh			0.046	0.046	0.046	0.046	0.046	0.046	0.098	CHP sized to provide HP with all electricity requireme
Wholesale Electricity Price	0.046	£/kWh			0.046	0.046	0.046	0.046	0.046	0.046	0.046	Annex M - BEIS - emissions and energy projections 20
Private wire electricity price	0.094	£/kWh			0.094	0.094	0.094	0.094	0.094	0.094	0.094	Assumed the same as commercial purchase price for
EfW Heat Price	-	£/kWh										Not used in this version
Operational Costs												
Main Plant and Energy Centre Maintenance												
CHP Maintenance Cost	0.010	£ / kWhe			0.010	0.010	0.010	0.010	0.010	0.010	0.010	Veolia Spreadsheet - 11/2017
Sewage Heat Pump Maintenance Costs	0.005	£ / kWhe			0.005	0.005	0.005	0.005	0.005	0.005	0.005	Quote from manufacturer saying 5% of CAPEX. Calcu
Aquifer Heat Pump Maintenance Costs	0.005	£ / kWhe			0.005	0.005	0.005	0.005	0.005	0.005	0.005	Quote from manufacturer saying 5% of CAPEX. Calcu
Ground Source Heat Pump Maintenance Costs	0.005	£ / kWhe			0.005	0.005	0.005	0.005	0.005	0.005	0.005	Quote from manufacturer saying 5% of CAPEX. Calcu
Air Source Heat Pump Maintenance Costs	0.005	£ / kWhe			0.005	0.005	0.005	0.005	0.005	0.005	0.005	Quote from manufacturer saying 5% of CAPEX. Calcu
Proporion of Heat Pump energy from CHP	-	%			-	-	-	-	-	-	-	Not currently used
Gas Boiler Maintenance Cost	0.0025	£ / kWh			0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	Arup Estimation
Energy Centre Maintenance	30,000	£ / year			30,000	30,000	30,000	30,000	30,000	30,000	30,000	Quote from Paul from 3 different suppliers
Substation and Network Maintenance Cost												
Substation & Network maintenance cost	7.350	£ / kW			7.35	7.35	7.35	7.35	7.35	7.35	7.35	

Other Operational Costs											
Business Rates	-	£ / kWh		-	-	-	-	-	-	-	
Bad Debt	0%	% of revenue		0%	0%	0%	0%	0%	0%	0%	Not in Scope - Client input
Insurances	0.0%	% of capex		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	Not in Scope - Client input
Capital Costs											
Plant Costs											
Gas Boiler Capital Cost	36	£/kW		36	36	36	36	36	36	36	Spons
CHP Capital Cost	650	£/kWth		650	650	650	650	650	650	650	Quote received by Arup
Sewage Heat Pump Capital Cost	600	£/kWth		600	600	600	600	600	600	600	Quote received by Arup
Aquifer Heat Pump Capital Cost	600	£/kWth		600	600	600	600	600	600	600	Quote received by Arup
Ground Source Heat Pump Capital Cost	500	£/kWth		500	500	500	500	500	500	500	Quote received by Arup
Air Source Heat Pump Capital Cost	600	£/kWth		600	600	600	600	600	600	600	page 109 - http://www.poyry.co.uk/sites/local.poyry
Thermal Storage	100	£/m3		100	100	100	100	100	100	100	page 109 - http://www.poyry.co.uk/sites/local.poyry
HIU Costs											
HIU Costs	-	£ / unit		-	-	-	-	-	-	-	
Energy Centre Cost											
Energy Centre Cost	1,300,000	£		1,300,000	1,300,000	1,300,000	1,300,000	1,300,000	1,300,000	1,300,000	Uses Fixed numbers from Paul G to emulate what th
Energy Centre Gas Boiler Capital Cost	25	£/kW	875	25	25	25	25	25	25	25	Not linked in yet, have used fixed values in the energ
Energy Centre CHP Capital Cost	225	£/kWth	1,070	225	225	225	225	225	225	225	Not linked in yet, have used fixed values in the energ
Energy Cetre Sewage Heat Pump Capital Cost	500	£/kWth		500	500	500	500	500	500	500	Not linked in yet, have used fixed values in the energ
Energy Centre Aquifer Heat Pump Capital Cost	470	£/kWth		470	470	470	470	550	550	550	Guido quote, see assumptions build up file for detail:
Energy Centre Ground Source Heat Pump Capital Cost	300	£/kWth		300	300	300	300	300	300	300	Not linked in yet, have used fixed values in the energ
Energy Centre Air Source Heat Pump Capital Cost	150	£/kWth		150	150	150	150	150	150	150	Not linked in yet, have used fixed values in the energ
Space Cost	528	£/m2		528	528	528	528	528	528	528	http://www.instantoffices.com/en/gb/serviced-offic
Gas Connection Cost											
Gas Connection Cost	400,000	£		400,000	400,000	400,000	400,000	400,000	400,000	400,000	Arup Approximation based on previous quotes & exp
Private Wire Costs											
MV Distribution Cable 500kVA	-	£/m									
Terminations, cable ties etc	-	£/connection									
Step down transformer	-	£/connection									
MV Circuit Breakers	-	£/connection									
Electricity Connection Costs											
Connection costs for electricity export	500,000	£		500,000	500,000	500,000	500,000	500,000	500,000		Arup Approximation based on previous quotes & exp
Connection Costs	*This is the substation and HIU cost (not pipe)*										
Perfume Factory	25,450	£		25,450	25,450	25,450	25,450	25,450	25,450	25,450	Calculations behind model assumptions - 22/12/201
Imperial College	28,750	£		28,750	28,750	28,750	28,750	28,750	28,750	28,750	Calculations behind model assumptions - 22/12/201
Carphone Warehouse / 1 Portal Way	34,558	£		34,558	34,558	34,558	34,558	34,558	34,558	34,558	Calculations behind model assumptions - 22/12/201
6 Portal Way	28,300	£		28,300	28,300	28,300	28,300	28,300	28,300	28,300	Calculations behind model assumptions - 22/12/201
The Portal	23,820	£		23,820	23,820	23,820	23,820	23,820	23,820	23,820	Calculations behind model assumptions - 22/12/201
Lyra Court	39,300	£		39,300	39,300	39,300	39,300	39,300	39,300	39,300	Calculations behind model assumptions - 22/12/201
Former BBC Studio	27,450	£		27,450	27,450	27,450	27,450	27,450	27,450	27,450	Calculations behind model assumptions - 22/12/201
Holbrook House	21,700	£		21,700	21,700	21,700	21,700	21,700	21,700	21,700	Calculations behind model assumptions - 22/12/201
Monarch House	17,670	£		17,670	17,670	17,670	17,670	17,670	17,670	17,670	Calculations behind model assumptions - 22/12/201
Gypsy Horn Lane	25,050	£		25,050	25,050	25,050	25,050	25,050	25,050	25,050	Calculations behind model assumptions - 22/12/201
Victoria Square	47,000	£		47,000	47,000	47,000	47,000	47,000	47,000	47,000	Calculations behind model assumptions - 22/12/201
NEC House	26,700	£		26,700	26,700	26,700	26,700	26,700	26,700	26,700	Calculations behind model assumptions - 22/12/201
2 Portal Way	23,370	£		23,370	23,370	23,370	23,370	23,370	23,370	23,370	Calculations behind model assumptions - 22/12/201
Friary Park Estate	28,156	£		28,156	28,156	28,156	28,156	28,156	28,156	28,156	Calculations behind model assumptions - 22/12/201
142-154 Victoria Road	21,700	£		21,700	21,700	21,700	21,700	21,700	21,700	21,700	Calculations behind model assumptions - 22/12/201
5 Portal Way	36,300	£		36,300	36,300	36,300	36,300	36,300	36,300	36,300	Calculations behind model assumptions - 22/12/201
Land to the Rear of Western Court Rosebank	-	£									Calculations behind model assumptions - 22/12/201
0	-	£									
0	-	£									
0	-	£									
0	-	£									
0	-	£									
0	-	£									
0	-	£									
0	-	£									
0	-	£									
0	-	£									
0	-	£									
0	-	£									
0	-	£									
0	-	£									
Substation Cost	20,000	£		20,000	20,000	20,000	20,000	20,000	20,000	20,000	

Proportion of Substation Cost replaced	30%	%	30%	30%	30%	30%	30%	30%	30%	
Domestic Service Costs										
Perfume Factory	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
Imperial College	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
Carphone Warehouse / 1 Portal Way	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
6 Portal Way	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
The Portal	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
Lyra Court	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
Former BBC Studio	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
Holbrook House	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
Monarch House	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
Gypsy Horn Lane	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
Victoria Square	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
NEC House	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
2 Portal Way	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
Friary Park Estate	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
142-154 Victoria Road	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
5 Portal Way	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
Land to the Rear of Western Court Rosebank	-	£/dwelling	-	-	-	-	-	-	-	Would have in counterfactual
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
0	-	£/dwelling								
Project Costs										
Testing and Commissioning	1.5%	% of CAPEX	1.5%	2%	2%	2%	2%	2%	1.5%	
Builders Work	3.0%	% of CAPEX	3%	3%	3%	3%	3%	3%	3%	
Preliminaries	15.0%	% of CAPEX	15%	15%	15%	15%	15%	15%	15%	
Overheads and Profit	5.0%	% of CAPEX	5%	5%	5%	5%	5%	5%	5%	
Professional Fees	12.0%	% of CAPEX	12%	12%	12%	12%	12%	12%	12%	12% of Professional fees & 10% for optimism bias
Optimism bias (applied after the above)	20.0%	% of CAPEX	20%	20%	20%	20%	20%	20%	20%	5% design risk, 5% client change risk, 5% constructio
Network Contingency	20%	% of Network CAPEX	20%	20%	20%	20%	20%	20%	20%	Applied to Network CAPEX. Based on specific conting
Other Contingencies	0%	% of CAPEX (except network CAPEX)	0%	0%	0%	0%	0%	0%	0%	Applied to total CAPEX minus network CAPEX
Tax Costs										
Tax Contingency	0%	% of Annual Total Costs	0%	0%	0%	0%	0%	0%	0%	Applied to total CAPEX minus network CAPEX
Number of hours in a year	8,760	Hours	8,760.00	8,760.00	8,760.00	8,760.00	8,760.00	8,760.00	8,760.00	
Counterfactual Details										
Proportion of heat from gas boilers	60%	%	60%	60%	60%	60%	60%	60%	60%	
Proportion of heat from CHP	40%	%	40%	40%	40%	40%	40%	40%	40%	
Proportion of CHP going to private wire	0%	%	0%	0%	0%	0%	0%	0%	0%	

END OF SHEET

Counter factual calculations for basecase scenario

Connection Cost

Building Stand Alone Operation Assumptions	Value	Unit	Comment
Building Stand Alone Solution Assumed CHP Size (%)	15%	% of kWp	Based on the energy strategies for the buildings with planning permission in the area, use actual where known
Boiler Sizing	130%	% of kWp	Allow for redundancy
ASHP Size (%)	3%	% of kWp	Based on the energy strategies for the buildings with planning permission in the area
Discount Applied	0%	%	Incentive for buildings to connect
Whole Site Peak Heat Demand	13,296	kW	From Benchmarking Tool
Whole Site Peak Heat Demand	13.296	MW	From Benchmarking Tool
Proportion of heat from CHP	40%	%	Arup Estimation
Proportion of heat from Boiler	60%	%	Arup Estimation
Private Wire Assumptions			
Network CHP proportion of electricity used for PW	40%	%	Assumes that connects to Perfume factory and is able to negotiate other connections in subsequent years as more buildings connected
Building Stand Alone CHP proportion of electricity used for PW	50%	%	Guido Confirmed this

Marginal Cost of Energy Assumptions

	Value	Unit	Comment
WSHP / GSHP Tier 1 RHI Rate	0.090	£ / kWh	Ofgem - 11/2017
WSHP / GSHP Tier 2 RHI Rate	0.027	£ / kWh	Ofgem - 11/2018
ASHP Single RHI Rate	0.026	£ / kWh	Ofgem - 11/2019
Gas Price	0.027	£/kWh	Non Dom Small Customer DECC - updated Oct 2017 by Guido Bollino - ECCC_assumptions_draft_10_2017.xlsx
Retail Electricity	0.11	£/kWh	Non Dom Small Customer DECC - updated Oct 2017 by Guido Bollino - ECCC_assumptions_draft_10_2017.xlsx
Wholesale Electricity Price	0.046	£/kWh	Annex M - BEIS - emissions and energy projections 2019 value (2017 source)
Private wire electricity price	0.11	£/kWh	10% discount of the non dom
Sewage Heat Pump COP	3.90	COP	Sharpe Paper sent by OPDC
Aquifer Heat Pump COP	3.50	COP	Guido - 18/12/2017
Ground Source Heat Pump COP	4.00	COP	https://www.kensaheatpumps.com/the-technology/compliance/coefficient-of-peformance-cop/
Air Source Heat Pump COP	2.00	COP	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/255762/summary_detailed_monitoring_2_flats_exhaust_air_source_heat_pumps.pdf
Boiler Efficiency	90%	%	
100 kW CHP Electrical Efficiency	34%	%	V-0100MA-070-NG-50-500 - HV efficiency - (Veolia 100kW CHP)
100kW CHP Heating Efficiency	44%	%	V-0100MA-070-NG-50-500 - HV efficiency - (Veolia 100kW CHP)
100kW CHP elecitricty to heat generation ratio	0.77	ratio	
600 kW CHP Electrical Efficiency	39%	%	V-0100MA-070-NG-50-500 - HV efficiency - (Veolia 100kW CHP)
600kW CHP Heating Efficiency	42%	%	V-0100MA-070-NG-50-500 - HV efficiency - (Veolia 100kW CHP)
600kW CHP elecitricty to heat generation ratio	0.9	ratio	
Discount Offered to Developers on heat price			
REPEX			
Equiptment lifetime	15	years	Assumed lifetime of all plant to approximate repex costs
Proportion of Ancillary Costs included	50%		Arup Assumption
Approximate Operation			
SSHP	2,500	hours	Taken from Energy Pro 20/11/2017
AQSHP	6,000	hours	Taken from Energy Pro 20/11/2017
GSHP	6,000	hours	Taken from Energy Pro 20/11/2017
ASHP	1,400	hours	Taken from Energy Pro 20/11/2017

CAPEX	Value	Unit	Comment
ASHP	600,000	£/MW	Poyry Report - Michael NW Office email
GSHP	600,000	£/MW	Arup build up as in cost assumptions tab based on experience from previous projects
SSHP	600,000	£/MW	Arup build up as in cost assumptions tab
AQSHP	600,000	£/MW	Arup build up as in cost assumptions tab
Boiler Capital Costs	36,000	£/MW	Arup build up as in cost assumptions tab
Boiler Capital Cost (£/kW)	36	£/kW	Arup build up as in cost assumptions tab
Boiler Auxillary Cost (£/kW)	25	£/kW	Arup build up as in cost assumptions tab
CHP Direct Costs			
50 kW CHP CAPEX	1,600	£/kW	VEOLIA CHP Pricing sheet
100 kW CHP CAPEX	1,150	£/kW	VEOLIA CHP Pricing sheet

200 kW CHP CAPEX	720	£/kW	VEOLIA CHP Pricing sheet
600 kW CHP CAPEX	505	£/kW	VEOLIA CHP Pricing sheet
CHP Electrical Efficiencies			
50 kW CHP CAPEX	31.8%	%	VEOLIA CHP Pricing sheet
100 kW CHP CAPEX	34.2%	%	VEOLIA CHP Pricing sheet
200 kW CHP CAPEX	34.6%	%	VEOLIA CHP Pricing sheet
600 kW CHP CAPEX	39.4%	%	VEOLIA CHP Pricing sheet
CHP Heating Efficiencies			
50 kW CHP CAPEX	52.0%	%	VEOLIA CHP Pricing sheet
100 kW CHP CAPEX	44.4%	%	VEOLIA CHP Pricing sheet
200 kW CHP CAPEX	44.3%	%	VEOLIA CHP Pricing sheet
600 kW CHP CAPEX	41.9%	%	VEOLIA CHP Pricing sheet
Auxillary Costs (£/kW)			
ASHP Auxillay Cost (£/kW)	-	£/kW	Assumed to be included in the Capital cost - assumed this is inlcuded in the Poyry report
Average CHP Auxillary Costs	225	£/kW	Arup Costs Built Up for Ancillary Equipment + installation + DHN distribution pumps - see costing assumptions tab for more details
50kW CHP Auxillary Costs	560	£/kW	VEOLIA CHP Pricing sheet
100kW CHP Auxillary Costs	403	£/kW	VEOLIA CHP Pricing sheet
200kW CHP Auxillary Costs	252	£/kW	VEOLIA CHP Pricing sheet
600kW CHP Auxillary Costs	177	£/kW	VEOLIA CHP Pricing sheet
Operation & Maintenance			
Heat Pump Operation & Maintenance	0.005	£/kWh	Quote from manufacturer saying 5% of CAPEX. Calculation of scenario with 1.2MW indicated 0.0036, therefore 0.005p/kWh seen as conservative
50kW CHP Operation & Maintenance cost	0.040	£/kWh	VEOLIA CHP Pricing sheet
100kW CHP Operation & Maintenance cost	0.020	£/kWh	VEOLIA CHP Pricing sheet
200kW CHP Operation & Maintenance cost	0.014	£/kWh	VEOLIA CHP Pricing sheet
600kW CHP Operation & Maintenance cost	0.010	£/kWh	VEOLIA CHP Pricing sheet
Boiler Operation & Maintenance cost	0.003	£/kWh	
Prelims Costs			
Preliminaries	15%	% of CAPEX	
less than £200k - 20% - prelims	20.0%	%	Arup Experience
Between 200k-500k - 15% - pelims	15.0%	%	Arup Experience
>£500k	10.0%	%	Arup Experience
Testing commissioning			
Testing and Commissioning	2.0%	% of CAPEX	
less than £200k - 3% - T&C	3.0%	%	Arup Experience
Between 200k-500k - 2%	2.0%	%	Arup Experience
>£500k	1.5%	%	Arup Experience
Builders work			
Builders Work	3%	% of CAPEX	
less than £200k	4.0%	%	Arup Experience
Between 200k-500k	3.0%	%	Arup Experience
>£500k	2.0%	%	Arup Experience
Design Fees			
Contractors design fees	4%		Arup Experience
Client Professional Fees	12%	% of CAPEX	Arup Experience
Risk			
Design risk	2.5%	% of CAPEX	Arup Experience - +/- accuracy
client change risk	2.5%	% of CAPEX	Arup Experience - +/- accuracy
construction risk	2.5%	% of CAPEX	Arup Experience - +/- accuracy
client any other risk	2.5%	% of CAPEX	Arup Experience - +/- accuracy
Overheads & Profit			
Overheads and Profit	5%	% of CAPEX	Arup Experience
Total Project Costs	47%		Arup Experience
Connection Cost			
HX kW costings			

60	120	£/kW	Arup quote from historic project		
100	100	£/kW	Arup quote from historic project		
500	30	£/kW	Arup quote from historic project		
800	25	£/kW	Arup quote from historic project		
1200	20	£/kW	Arup quote from historic project		

Carbon

Emissions Factors

SAP 2012 3-year gas factor	216	gCO_2e/kWh	https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf - page 225		
SAP 2012 3-year grid factor	519	gCO_2e/kWh	https://www.bre.co.uk/filelibrary/SAP/2012/SAP-2012_9-92.pdf - page 225		

Emission Factors over time

Financial year ending				2019	2020
Marginal Emissions Factors for onsite usage		gCO_2e/kWh	BEIS	394	387
Marginal Emissions Factors for export		gCO_2e/kWh	BEIS	349	332

Heat Price Calculation

Discount Offered to Developers on heat price	10%	%	

OPDC

North Acton District Heating Network

Additional Information

ISSUE |

Job number 258341-00

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ARUP

Document Verification

ARUP

Job title	North Acton District Heating Network	**Job number**	258341-00
Document title	Additional Information	**File reference**	
Document ref			

Revision	**Date**	**Filename**	Additional Information_2018_03_28_ISSUE.docx		
ISSUE	28 Mar 2018	**Description**	Additional Information OPDC		
			Prepared by	Checked by	Approved by
		Name	Catrina Cassie	Guido Bollino	Stephen Cook
		Signature	CC	GB	
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
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		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

1 Introduction

Arup was appointed by the Old Oak and Park Royal Development Corporation (OPDC) to undertake a feasibility study for a decentralised energy (DE) network for the development in the North Acton area. The results, findings and recommendations of this study are set out in the "North Acton District Energy Network - Final Report" issued on the 22nd March 2018.

This report provides additional information relevant to the study, which was not appropriate to be included in the main report. The information contained in this report is as follows:

- Kick-start Network Option
- Aquifer testing info and costs
- Developers engagement documentation
- Minutes from meeting with ESCOs and Developers
- Weekly Emerging Findings sent during the project duration
- The Interim Technical Note
- The Interim Commercial Note

This report should be read in conjunction with the main report.

2 Kick-start Network Option

The North Acton study concluded that a low carbon heat network could be developed in North Acton but it faces a number of technical uncertainties and commercial challenges. In response, OPDC asked Arup to undertake a further brief investigation of a small network serving 2-3 buildings and using the best low carbon heat source as the main supply for such a network. The purpose of the investigation was to establish whether such a network might have the potential to serve as a viable starting point from which a larger network might be able to grow.

This investigation identified a potential network connecting the following three development sites that have shown greater interest or willingness to connect to a future district heating scheme:

- Imperial College
- The Portal
- Perfume Factory

In summary, the total demand of such a network is 7,321 MWh, and the peak demand is around 3.6 MW. This level of demand could be supplied by heat pumps (aquifer and air source) along with top up boilers.

2.1 Demand Assessment of Kick-start Network

The developments included within this network option have been selected based on the timing of development and the evidence of a willingness to connect to a network (on acceptable terms). They are all in planning phases or early construction phases. Details of the developments are shown in Table 1.

Table 1 Development details

Development site	Status	Start on site	Completion	Typology and Size	Annual heat load (MWh)
Perfume Factory	Planning application submitted	Q3 2019	Q1 2021	534 flats and 10,800m^2 non-residential	3,600
Imperial College	Started on site	Q2 2018	Q1 2020	6oo student flats, 83 residential flats, 6,200m^2 non-residential	2,400
The Portal	GLA stage 2 referral	Q4 2018	Q 2021	355 flats and 5234m^2 of retail space	1,321

2.1.1 Perfume Factory

The Perfume Factory is due be completed in January 2021. Its primary use will be domestic, with some space for retail, office and educational use. The current energy strategy is to house a CHP in the basement to serve both the Perfume Factory and Imperial College.

2.1.2 Imperial College

The Imperial College development is due to be completed in January 2020. Its primary use will be domestic, with some space for offices on the ground floor. The current energy strategy is to use the CHP in the basement of Perfume Factory wich will serve both the Perfume Factory and Imperial College.

2.1.3 The Portal

The Portal development is due to be completed in January 2021. Its primary use will be domestic providing 355 new homes, with 5,134 m^2 of retail space. The current energy strategy is house a communal gas boiler and solar PV to serve the buildings energy needs.

By connecting to a district heating scheme each development could significantly reduce its carbon emissions as well as achieve some level of avoided costs associated with building an on-site energy centre and stand-alone heat network.

The co-location of the energy centre has been considered and discussed with each of the individual developers. However, due to special constraints or planning stages, co-location has been discounted. The aquifer heat pump will be housed in the area identified for the energy centre by the side of the railway in close proximity to the developments. This is the preferred site identified in the main study report. The proposed route map is shown in Figure 1.

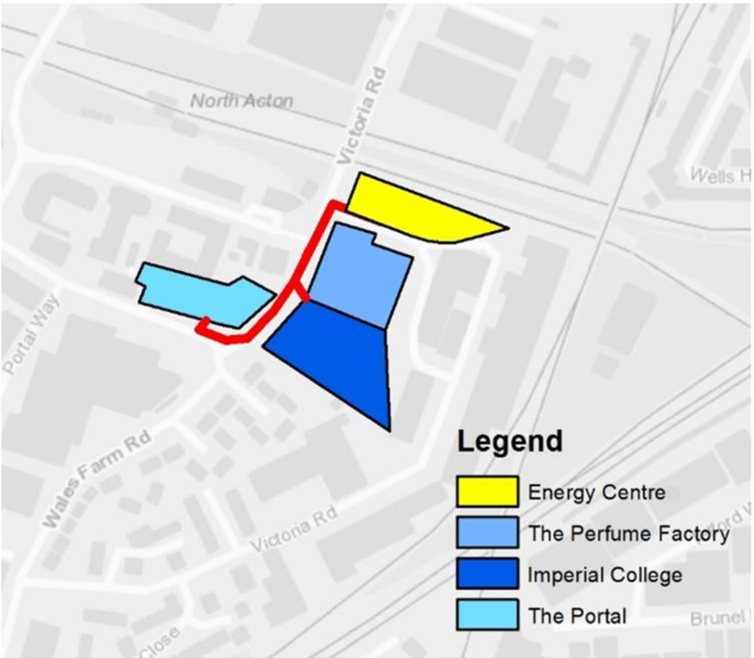


Figure 1 Kick-start network proposal

2.2 Supply Assessment of Kick-start Network

The supply options have been assessed on their environmental and economic performance as well as their practicality. Based on the supply assessment, the supply mix options proposed for this network are as follows:

- Large aquifer heat pump (AQHP) scenario: 1.2MW AQHP with top up boilers
- Small AQHP and air source heat pump (ASHP) scenario: 0.6MW AQHP and 0.6 MW ASHP and top up boilers

Both options are low carbon in comparison to CHP options. In the small AQHP and ASHP scenario, the AQHP sizing has been reduced by 50% (compared to the large AQHP scenario) to reflect associated risks in terms of estimated yield available from the AQHP. Extraction rates of the aquifer heat pump will be uncertain until test boreholes are sunk (see section 3 for a specification for a borehole test).

2.3 Results

The results of the two scenarios are shown below in Table 2. These highlight the overall economic and carbon results. In summary, neither of the options modelled achieves a projected internal rate of return (IRR) sufficient to meet typical thresholds for investment (6% for public, 12% for private). The gap funding requirement shown in the table represents the additional funding which would be needed to bring each scenario to the project IRR of 6% or 12% respectively. The carbon performances of the scenarios vary depending on the carbon factor used (SAP 2016 and BEIS projections). The second scenario, which uses a smaller aquifer heat pump and air source heat pumps, shows a worse performance in terms of carbon because of the lower efficiency of air source heat pumps and the need of a greater contribution from boilers in the coldest days. The IRR of this second scenario is lower, mainly because of larger electrical consumption and the difference in revenues from RHI (lower subsidies for air source heat pumps). Therefore, this scheme would require more gap funding in order to be commercially viable.

Table 2 Comparison of scenarios

Scenario	CAPEX (£m)	IRR (%)		Gap funding (40yr)		2016 SAP Average Carbon Intensity (CO_2g/kWth)	2016 SAP Lifetime Emission Savings (tCO_2)	BEIS Average Carbon Intensity (CO_2g/kWth)	BEIS Lifetime Emission Savings (tCO_2)
		25yr	40yr	To achieve IRR of 6%	To achieve IRR of 12%				
What are the effects of making the network smaller?									
Kick-start Network & Large AQHP	£ 5,088,000	3.7%	4.0%	£ 606,200	£ 1,704,700	146	13,300	24.7	52,600
Kick-start Network & Small AQHP & ASHP	£ 4,743,000	0.2%	0.0%	£ 1,390,400	£ 2,081,000	174	6,800	37.7	49,400

This kick-start scheme will start with three developments which showed interest in the scheme. However, it could potentially expand in the future if other developments sought to join once the network is built and it represents a more concrete and realistic option. One of the main issues of the North Acton Scheme was the appetite of developers to connect to the network, due to their advanced planning or design stage and the uncertainties related to the network completion. Starting from a smaller scheme, which involves a small cluster of developments, can partially solve this issue and can reduce some other project risks (identified in the risk register of the report), in particular:

- Accuracy of data is higher due to close involvement of the three developers
- Phasing and times of connection issues are avoided since all three developments have completion dates between 2020 to 2021
- Negotiation for connection can be easier since the developers have already expressed a willingness to connect to a network
- Simpler network routing

However, other key risks would not be reduced, including:

- ESCos' appetite to deliver the project may be lower due to the small size of the network.

- Gap funding remains a necessary prerequisite to procurement of an ESCo, based on modelled financial results
- Acquisition of the energy centre site depends on landowner (Network Rail) negotiations. Co-location within a development site was not supported during developer engagement.
- The potential yield from the aquifer will be uncertain before drilling and pumping tests.

3 Aquifer Performance Testing

3.1 Introduction

The main study report highlighted that the potential yield from the aquifer is a key supply risk. An intrusive borehole test was identified as the appropriate way to reduce the uncertainty. In response, OPDC asked Arup to prepare an outline scope and specification for a suitable site investigation.

3.2 Summary of known conditions

The North Acton developments are situated in a water available area, and the closest active well is TQ28/226. The water level at the borehole in 2017 is around -33mAOD. This is consistent with nearby observations and the general trend in the area is that the water level is rising. Data suggest that the piezometric head is within London Clay and the lower aquifer is confined.

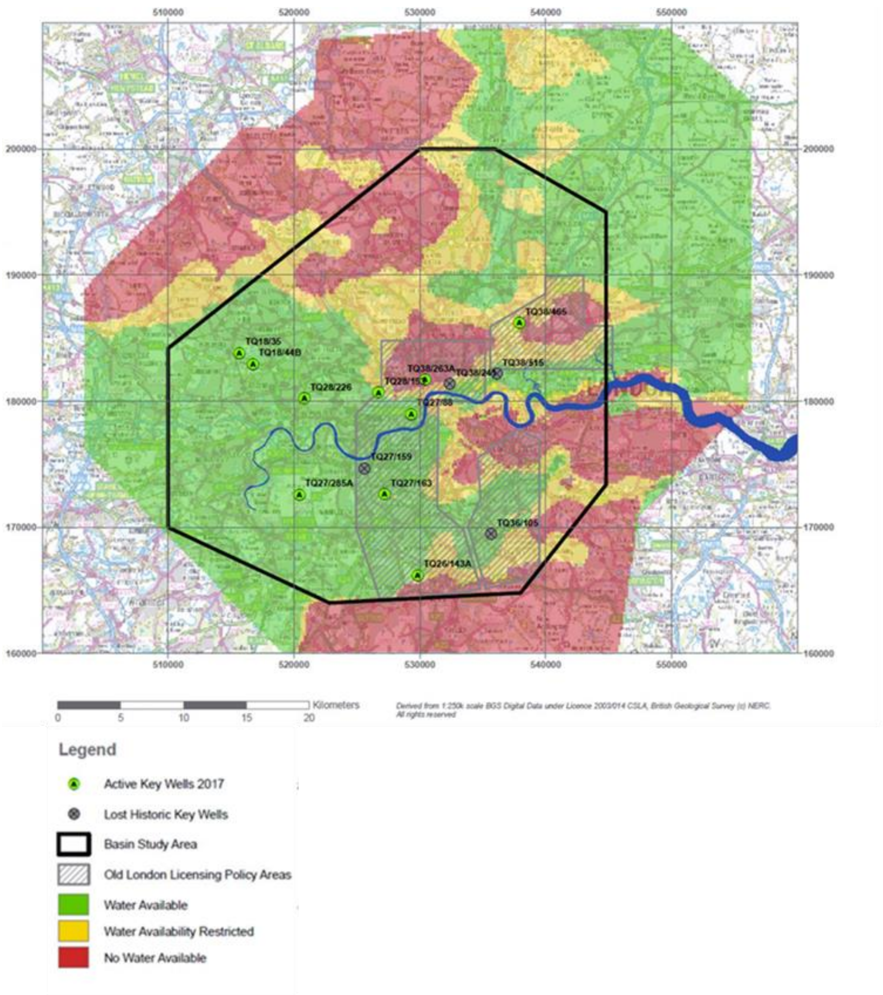


Figure 2 London Aquifer borehole locations

Table 3 Data from borehole TQ28/226

Time stamp	Dip[m]	State of value	Groundwater level[mAOD]	State of absolute value	Comments
28/01/2015 11:00	52.05	G	-36.93	G	
13/01/2016 09:00	---	M	---	M	Not drilled
31/03/2017 11:55	48.01	G	-32.89	G	null
20/04/2017 09:50	48.45	G	-33.33	G	null
26/05/2017 10:15	47.97	G	-32.85	G	null
28/06/2017 10:20	47.38	G	-32.26	G	null
31/07/2017 09:57	48.02	G	-32.9	G	null
10/08/2017 11:44	48.07	G	-32.95	G	null
22/09/2017 13:30	47.98	G	-32.86	G	null
13/10/2017 12:33	48.07	G	-32.95	G	null
16/11/2017 13:30	47.98	G	-32.86	G	null

Drill testing would be required in order to confirm the depth and flow rate available at the site. These unknown parameters will affect the costing and over all heat generation capacity of the aquifer. A preliminary discussion with the Environmental Agency (EA) on the open-loop and the consent for investigation from the EA are required before the drilling.

3.3 Drilling specification

The primary purpose of the trial is to determine the yield obtainable from the borehole pair, operating in simultaneous abstraction and recharge mode and with the flow in either direction.

3.3.1 Borehole Drilling and Casing

Drilling muds, additives and foams used shall be degradable and approved for use in potable water wells. Bentonite shall not be used as a drilling mud for drilling through the Chalk. Water introduced into the well shall be potable water from the public supply.

3.3.2 Initial Development and Geophysical Logging

Following completion of drilling, the borehole shall be initially developed using the following methods:

- High pressure water jetting in the open hole section to remove any disturbed chalk residue.
- Airlift pumping of the borehole to remove any sediment. Flow rate shall be measured during this phase to allow crude estimation of the unacidised yield.

- Following initial development, the borehole shall be geophysically logged using sondes.

3.3.3 Acidisation

Following initial development and geophysical logging a detailed plan for acidisation of the boreholes should be produced. The primary objectives of the acidisation process shall be to inject acid at specific levels in the boreholes where water inflow and/or open joints and fissures have been identified during geophysical logging. Particular care must be taken not to damage the seal at the base of the casing.

3.3.4 Clearance Pumping

After acidisation, the boreholes shall be cleared of acidised water by pumping. The discharge water shall be pumped to a storage tank where, if necessary, it shall be neutralised with lime, before being tankered off-site to an appropriate licensed disposal facility.

3.4 Pumping tests

3.4.1 General

The pump test procedures shall be in accordance with ISO14686 "Hydrometeric determinations – Pumping tests for water wells", and shall be in accordance with the specific requirements of the Environment Agency (EA).

The boreholes shall be pump tested in accordance with the requirements of the Environment Agency, including the monitoring of any external boreholes.

3.4.2 Step Test

The step test shall consist of four steps of 100 minutes duration each, with the flow rate for each step greater than the last. The flow rate and the drawdown in the well shall be monitored. Monitoring intervals shall be as specified in BS 14686:2003. The water levels in the un-pumped well shall be measured prior to starting each test and at the end of each step. Field meters shall be used to monitor pH, Specific Conductivity and water temperature. A water sample shall be taken at the end of each step test and shall be tested for the short list of chemical parameters given below. At the end of the final step a water sample shall be taken and tested for the Full List of Chemical Parameters. Recovery of groundwater levels (following cessation of pumping) shall be monitored at the intervals specified in BS14686:2003 for a minimum of 12 hours.

3.4.3 Constant Rate Pumping Tests

Constant rate pumping tests shall be carried out in both boreholes. Test 1 shall be for a period of 72 hours and test 2 for a minimum of 24 hours. A minimum of 95% recovery shall be allowed between the two tests.

3.4.4 Abstraction and Injection Tests

Two abstraction and injection tests shall be performed, with the flow direction reversed between the two tests. Afterward, the pumping is to be switched and water levels are to recover for 24 hours or 95% recovery to the rest water levels. The water injected into the receiving borehole shall not be allowed to cascade or jet in such a way that it becomes aerated. A positive head will be maintained in the injection pipe by means of a throttle, nozzle or other arrangement so that the water is injected below the water level in the recharge borehole.

3.4.5 Discharge of Pumped Water (during pumping tests)

It is anticipated that discharge water will be disposed to the sewer, except in the combined abstraction and injection tests. All necessary permissions for disposal of the water must be obtained.

3.4.6 Records and Reporting

Following completion of the pumping tests, a pumping test report must be produced in hard copy and electronic format. The test data shall be provided in Microsoft Excel format worksheets. The pumping test report shall include:

- Dates and times of all monitoring and pumping phases;
- Details of datums (description and reduced level) used to record groundwater levels;
- Groundwater level data;
- Flow rate data;

During the site works on site hard copies of the test results must be maintained, which shall be available for inspection during working hours.

3.4.7 Water Quality Testing

Two water samples shall be collected during each constant rate test and sent to an approved laboratory for analysis.

3.5 Costs

Costs for drilling and testing one borehole are estimated to be around **£ 100,000** and for two boreholes from **£ 150,000 to £ 200,000**. If test at the first well shows non-promising of well yield, the second well may not proceed, while, if test will confirm the availability of water and the flowrate usable, the boreholes drilled can be used for supplying the aquifer heat pump without additional costs. If the flowrate of a doublet of boreholes is lower than the expectations but still usable for an aquifer heat pump, a second doublet can be added 50 metres from the first one (in perpendicular to the aquifer gradient direction). In this case, the cost of the four boreholes is estimated to be around **£ 300,000** in total.

4 Developer Engagement

4.1 Summary of Developer Engagement

Building	1st mail 10/10/17	2nd email 13/10/17	1st call 17/10/17	3rd email 17/11/17	4th email 29/11/17	Developers meeting 21/11/12	5th email 13/12/2017	Letter to Developers 13/12/17	6th email 17/01/18	Developer Meeting 17/01/18	Skype meeting 23/01/18	Call to discuss co-location of energy centre 23/01/18
Gypsy Horn Lane												
Imperial College												
Friary Park Estate												
Monarch House												
2 Portal Way												
Carphone Warehouse / 1 Portal Way												
Perfume Factory												
Holbrook House												
The Portal												
5 Portal Way												
6 Portal Way												
142-154 Victoria Road												
NEC House												
Former BBC Studio												
Land to the Rear of Western Court Rosebank												
Victoria Square												
Lyra Court												

Responded
Not necessary
No response or decline

4.2 Sample of Email Communications

To: owen.pike@sw.co.uk
Subject: Lyra Court Energy

Dear Owen Pike,

Arup has recently been commissioned by Old Oak and Park Royal Development Corporation (OPDC) to undertake a heat network feasibility study in North Acton.

Our aim is to establish whether it is feasible to create a centralised heat network to connect existing and new developments in the area including the Perfume Factory. We are also investigating a variety of commercial models for how the network could be delivered.

At this stage we would like to confirm the energy demands of the buildings and potential developments in the area. Could you please review the following information for the Perfume Factory and confirm whether there are any significant updates you could share with us?

1. Floor Area: 184 unit student accommodation / 6,724.2 m^2 382 m^2 (Use class A1, A2, A3, A5, B1, D1)

2. Proposed heating and cooling solutions: 50kWe/ 76kWth CHP unit to provide heat and hot water at the student accommodation (60% of the annual DHW and 30% of the annual heating demand)

   45m^2 and 35m^2 installed on Blocks F and G with total capacity 10.7kWp, respectively, and ASHP for space heating & cooling to the commercial areas

If you could respond by the end of this week I would be very grateful.

Please don't hesitate to give me a call if you would like to talk through any of the questions above or need more information about the study.

Kind regards,

Annie Gibbons
Senior Consultant | Energy, Cities and Climate Change
BEng MSc
Arup
13 Fitzroy Street London W1T 4BQ United Kingdom

Figure 3 Example of 1st email sent 10/10/2017

To: paulhoughton@downing.com
Subject: Holbrook House Energy

Dear Paul,

Following my email earlier in the week enquiring about the development at Holbrook House. Are you able to confirm the following information that will help us create an accurate picture of the energy demand in the area?

1. Floor Area: 424 bed spaces, 12,457 m^2 of student accommodation and small retail unit on the ground floor
   12,454 m2 of student accommodation and small retail unit on the ground floor
2. Proposed heating and cooling solutions: Onsite CHP unit with 201kWe capacity; Solar PV

Please don't hesitate to give me a call if you would like to talk through any of the questions above or need more information about the study.

Kind regards,

Annie Gibbons
Senior Consultant | Energy, Cities and Climate Change
BEng MSc
Arup
13 Fitzroy Street London W1T 4BQ United Kingdom

Figure 4 Example of 2nd email sent 13/10/2017

To: j.wilson@imperial.ac.uk
Subject: Carphone Warehouse Energy

Dear Jenny,

As I'm sure you are now aware ARUP have been commissioned to conduct a feasibility study for a district heating system for North Acton area, In order to improve our study it would be useful for us to know some details about the current / planned heating systems in your development. If possible, would be able to provide the following information:

- The current / planned temperature of the heating system. (High, medium, low);
- If high, is there potential in your development to change to a medium or low temperature system;
- The latest date that your development would be able to make a decision about connecting to a district heating network.

Please do not hesitate to contact me if there is anything you would like to discuss further.

Kind Regards,

Guido Bollino
Senior Engineer | Energy and Climate Change Consulting

Arup
13 Fitzroy Street London W1T 4BQ United Kingdom

Figure 5 Example of 3rd email sent 17/11/2017

From:	Catrina Cassie
Sent:	29 November 2017 12:19
To:	'justin.kenworthy@bartonwillmore.co.uk'
Subject:	North Acton Decentralised Energy Network
Attachments:	2017-11-21_North_Acton_developers_presentation.pdf

Dear Justin,

Following the developers meeting last week, with regards to the North Acton Decentralised Energy Network, that you were unfortunately unable to attend we would like to invite you to propose an alternative time to meet and discuss the technical and commercial benefits of connecting to an Energy Network. Attached are the presentation slides from the meeting for your interest.

If you would like to discuss this further or have any questions please do not hesitate to call.

Kind Regards,

Catrina Cassie
Graduate Energy Consultant

Arup
8 Fitzroy Street London W1T 4BQ United Kingdom

Figure 6 Example of 4th email sent 29/11/2017

To:	sbode@oselarch.co.uk
Subject:	North Acton Decentralised Energy Network

Dear Simon,

I am writing on behalf of Arup who have been commissioned by Old Oak and Park Royal Development Corporation (OPDC) to undertake a heat network feasibility study in North Acton. This will establish whether it is feasible to create a centralised heat network serving the area and provide an opportunity for buildings and developments to access cheaper energy, reduce carbon and release space for others. We would like to confirm the date at which you can no longer make modifications to yours plan, your current heating system and the operating temperatures of this system.

If you would like more information on the scheme, please do not hesitate to call and we can arrange a meeting to discuss the technical and commercial benefits of the scheme.

Kind Regards,

Guido Bollino
Senior Engineer | Energy and Climate Change Consulting

Arup
13 Fitzroy Street London W1T 4BQ United Kingdom

Figure 7 Example of 5th email sent 13/12/2017

From:	Catrina Cassie
Sent:	17 January 2018 14:47
To:	'ralph@maddoxassociates.co.uk'
Cc:	Guido Bollino
Subject:	North Acton Heat Network
Attachments:	18_01_16_RIBA -Plan of Work_ISSUE.xlsx

Dear Ralph,

I am writing to you to enquire further about the planned timeline of the development at 2 Portal Way in North Acton. I have attached a spreadsheet that outlines the key stages of the RIBA plan of work, if you could please give an indication of the dates that you would expect these actions to be completed this would help us make a more informed and comprehensive study. If you would prefer to talk over the phone I am more than happy to assist in filling out the spreadsheet. In addition I should say that only indicative dates are required and that this is solely for the purposes of the feasibility study.

Many Thanks,

Catrina Cassie
Graduate Energy Consultant
MEng

Arup
8 Fitzroy Street London W1T 4BQ United Kingdom

Figure 8 Example of 6th mail sent 17/01/2018

4.3 Invitation to Developers Meeting

Subject: North Acton DCE - Meeting with Developers

When: 21 November 2017 15:00-17:00 (UTC+00:00) Dublin, Edinburgh, Lisbon, London.

Where: 8 Fitzroy Street, Arup Offices, London

Dear All,

As notified in the invitation letter from OPDC, we are pleased to invite you to the meeting for the North Acton Decentralised Energy Network, on Tuesday the 21st of November from 3pm-5pm. This will be held in our office at:

8 Fitzroy Street London

W1T 4BQ

United Kingdom

Please let us know if you will be able to attend. We look forward to meeting you.
Kind Regards,

Guido Bollino

Senior Engineer | Energy and Climate Change Consulting Arup

13 Fitzroy Street London W1T 4BQ United Kingdom

4.4 Letter to Developers

OPDC
OLD OAK AND PARK ROYAL DEVELOPMENT CORPORATION

City Hall
The Queen's Walk
More London Riverside
London
SE1 2AA

Oliver Milne
Victoria Square
By email only to: omilne@savills.com
13/12/2017

Dear Oliver,

North Acton Decentralised Energy – Follow up letter

We recently wrote to you in relation to the North Acton heat network feasibility study currently being undertaken by Arup, our appointed advisors. That letter invited you to attend a meeting to discuss the potential for a centralised heat network to connect existing and new developments in the area.

At the meeting, we presented a variety of advantages of connecting to a heat network, including:

- Centralised energy centre which will save space in development sites
- Meeting planning requirements for low carbon energy systems
- A full-service heat supply system with lower heating bills and peace of mind for customers
- The removal of the need for flue chimneys
- The minimization of local plant maintenance
- A resilient heat supply
- Reduced Section 106 carbon offset payments

I have attached a copy of the meeting presentation slides for your information, and would like to offer you a further opportunity to engage with the study either through a meeting or telephone call.

If you would like to understand more about the scheme, please contact us or a member of the Arup team (details listed below). We look forward to hearing from you in the near future.

Guido Bollino, Senior Engineer
E: guido.bollino@arup.com
T: +44 20 7755 5128

Catrina Cassie, Graduate Energy Consultant
E: catrina.cassie@arup.com
T: +44 20 7755 3956

Yours sincerely,

Peter O'Dowd
Technical Director & Infrastructure Lead
Old Oak & Park Royal Development Corporation
Peter.odowd@opdc.london.gov.uk

David Moore
Director of Regeneration and Planning
London Borough of Ealing
MooreD@ealing.gov.uk

5 Minutes

5.1 Meeting with E.ON

Project title		**Job number**	
Meeting name and number	Meeting with E.ON	**File reference**	
Location		**Time and date**	1st Dec 2017
Purpose of meeting			
Present			
Apologies			
Circulation	Those present		

Action

1. OPDC

- Peter O'Dowd introduces OPDC
- OPDC can start the project and ESCos can then adopt it

2. AECOM

- Introduces the study conducted on OPDC area
- Low temperature network possible with developers' involvement possible in north area but really difficult in North Acton

3. E.ON

- Heat losses can often be more than what calculated
- E.ON will prefer low temperature network due to heat losses
- CHP is still the preferred technology choice.
- They agree for intermediate solution like CHP plus heat pumps
- E.ON recognise that the timeline for CHP use in future network is uncertain
- They prefer DBOM model

- The adoption model can generate problems due to the standard used for construction
- E.ON also interested in being a Multi Utility Service Company (MUSCo)
- Minimum time for an ESCo contract is 6 months but it can go up to 12 months
- Contracts with commercial developments can include max energy and timing of heat supply in order to reduce the peak power and pipes' diameter
- North Acton site can be problematic due to the delivery time of developments versus the time for completion of a network
- E.ON support the use of temporary solutions
- North Acton is likely to be contractually complicated due to the number of developers
- Given that complexity, the commitment and contribution of OPDC is necessary for a scheme to go ahead in North Acton
- E.ON agree to send comments on the AECOM report on 13th December (not part of North Acton study)

5.2 Meeting with Metropolitan

Project title		**Job number**	
Meeting name and number	Meeting with Metropolitan	**File reference**	
Location		**Time and date**	8th November
Purpose of meeting			
Present			
Apologies			
Circulation	Those present		

On Wednesday 8th November AECOM hosted a meeting with Arup, OPDC and Metropolitan Infrastructure Limited, to discuss about ESCo opportunities. The outcome of this discussion was that Metropolitan is open to different commercial option for the district heating:

- Public sector led - DBOM
- ESCo consection model - DBFO
- Utility adopted model
- Franchising model

A crucial point remains the developers' intention to connect and the supply temperature.

Metropolitan also suggested that they can be partner for all services (electricity, water, wastewater, gas, FTTH) and mentioned the King's Cross project in which they are involved in a joint venture with Argent.

5.3 Meeting with Engie

Project title		**Job number**	
Meeting name and number	Meeting with Engie	**File reference**	
Location		**Time and date**	17th November
Purpose of meeting			
Present			
Apologies			
Circulation	Those present		

- Embassy Quarter / Nine Elms experience:
  - Contractual negotiations have taken more than 18 months, but confidence is now high and Engie is working with developers to manage interim delivery of heat
  - Temporary boilers in place for earlier delivery
  - Does this model work? Engie can't invest speculatively
  - Wandsworth has underwritten some infrastructure investment but all has been piecemeal
- Keep it commercially simple - saves time
- Pipeco model - owner needs to take demand risk
- How to get developers to comply with standards
- Condenser loop option - not tried before
- Innovative tariff models, eg temperature based. Not done that. Depends on how bad the buildings are, and if applied the ESCo would need control over space.

Engie indicated that Part L is expected to be reformed to require space heating temps at max 50/30 deg C and DHW at no more than 60 deg C with cylinder and 50 deg C with instantaneous heat. This would in the future affect the design of DH

6 Weekly Emerging Findings

6.1 Update 20-10-2017

Emerging Findings – Rolling Summary Report
Update 20-10-2017

Work stream:
North Acton DHN Feasibility Study

Lead:
Stephen Cook – Arup
Alaina Tolhurst - OPDC

1. Objective:

This study is to establish a technically feasible solution and commercial structure for a heat network in the North Acton development cluster.

2. Constraints/Policy requirements:

No update

3. Data Collection Phase – Emerging findings

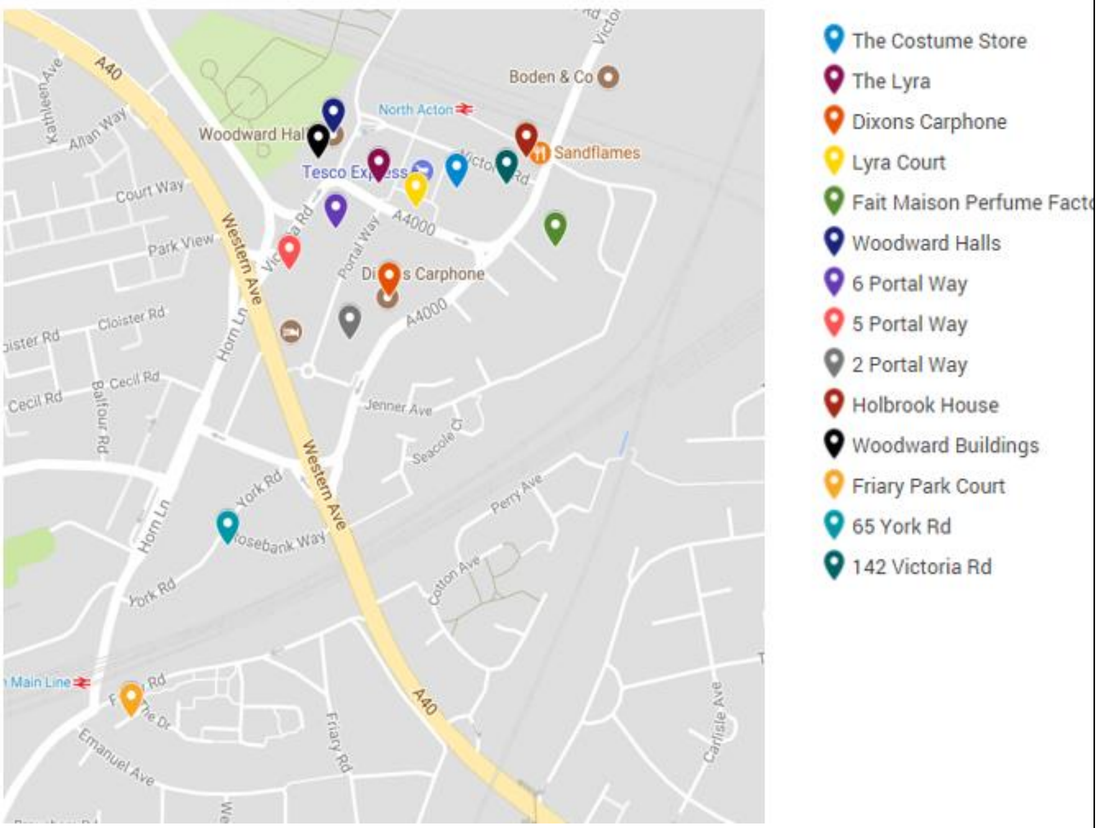
Arup has conducted a review and validation of the data available for developments that were identified in the original AECOM report for North Acton. We have made (or attempted) contact with all the developers identified in order to validate their scale and, where possible, predicted energy demands.

The table below summarises the total predicted heat load of each development based on the best data available. It represents the (basic) data that will be used going forward in the techno-economic feasibility model.

Building	Heating Loads (kWh/year)	Source
Perfume Factory	1,617,000	Energy Strategy provided by developer
Imperial College	2,419,000	Energy Strategy provided by developer
Carphone Warehouse/ 1 Portal Way	3,665,000	Electricity and gas consumption data
6 Portal Way	2,460,000	Data Confirmed by developer
The Portal	1,321,000	Data Confirmed by developer
Lyra Court - Portal Way	460,000	Data sourced from Ealing Planning
Former BBC Costume Store	1,553,000	Energy Strategy provided by developer
Holbrook House	721,000	Energy Strategy provided by developer
Monarch House	1,959,000	Energy Strategy provided by developer
328 Horn Lane (Gyspy Corner Site)	2,379,000	Data sourced from Ealing Planning
Victoria Square - Land at Junction of Chase Road & Victoria Road	718,000	Energy Strategy provided by developer
NEC House - 1 Victoria Road	1,517,000	Energy Strategy sourced from Ealing planning
2 Portal Way	1,252,000	Data sourced from Ealing Planning

5 Portal Way	632,000	Data Confirmed by developer
Friary Park Estate	2,412,000	Data Confirmed by developer
142-154 Victoria Road	250,000	Data sourced from Ealing Planning
Land To The Rear Of Western Court Rosebank Way And 9-65 York Road Acton W3 6TT	138,000	Data sourced from Ealing Planning

The assumed locations of the future developments and existing buildings is indicated in the map. Although GIS data was provided for the area (from AECOM study) this was for the freeholds of



buildings in the area and was not complete, therefore some inferences have been made from other sources. We will provide a separate GIS generated map of this information.

The table below divides the developments into phases based on scheduled dates of completion.

Phase 1 - Buildings already completed
Phase 2 - Buildings due to be completed by the end of 2019
Phase 3- Buildings due to be completed between 2020 and 2027

Phase 1	**Phase 2**	**Phase 3**
Lyra Court	142-154 Victoria Road	2 Portal Way
Former BBC Studio	5 Portal Way	Friary Park Estate
Victoria Square	Land to the Rear of Western Court Rosebank	Monarch House
NEC House	Gypsy Horn Lane	Perfume Factory

	Holbrook House	Imperial College
		Carphone Warehouse / 1 Portal Way
		6 Portal Way
		The Portal

4. Emerging Options to be considered:

Using the energy demands from the collected data, the Arup team has begun to model different options for the network. Two core scenarios have been used to set up the model and obtain initial outputs. These scenarios include all the heat demands (all of the developments at the site) and apply supply technologies of combined heat and power (CHP) and Sewage Heat Pumps. These scenarios can be seen in the table below.

	Supply			Demand (GWh/yr)		
Scenario	CHP	Sewer Heat Recovery	EfW	Phase 1 (existing)	Phase 2 (short term developments)	Phase 3 (long term developments)
1	Yes	Not included	Not included	4.2	4.1	17.1
2	Yes	Yes	Not included	4.2	4.1	17.1

Scenario 1 - the basic network and most likely to form the baseline comparator
Scenario 2 - Sewer Heat Recovery as prioritised heat load supported by CHP base load with boilers used as peaking supply.

Additional supply technologies of energy from waste and aquifer heat pump will be modelled next week.

Initial results

The two core scenarios described above were tested using a combination of Energy Pro (see layouts in the appendix) and Arup's techno-economic model. The results are very high level and indicative and have a number of assumptions that may need adjusting as further modelling is conducted. These results give an early indication of the cost of a network compared to a counterfactual of localised gas boilers.

	Costs	**Carbon**
Scenario 1 - Central CHP plant	High initial CAPEX but long-term savings due to electricity revenues	110 Mt
Scenario 2 - Central Sewage Source Heat Pump and CHP	Very High initial CAPEX but long-term savings due RHI and electricity revenues	130 Mt

5. Risks that will affect delivery of the objectives:

See separate risk register

6. Recommended approach:

No update

7. Next Steps

Arup will continue to model scenarios next week (in the table below) and will produce NPV and IRR results to compare. Work to update model inputs and assumptions will include:

- Network routing assessment
- Establishing avoided costs for developers
- Energy Centre location and layout

	Supply			Demand (GWh/yr)		
Scenario	CHP	Sewer Heat Recovery	EfW	Phase 1	Phase 2	Phase 3
3	1	1	1	4.2	4.1	17.1
4	1	1	1	4.2	4.1	N/A
5	1	1	1	4.2	N/A	N/A
6	1	1	0	Load shedding for optimising		
7	1	1	0	Load shedding for optimising		
8	1	0	0	Load shedding for optimising		

6.2 Update 27-10-2017

Emerging Findings – Rolling Summary Report
Update 27-10-2017

Work stream: North Acton DHN Feasibility Study	**Lead**: Stephen Cook – Arup; Alaina Tolhurst - OPDC

8. Objective:

To test the feasibility of a decentralised energy (DCE) network in the North Acton area, as the initial phase of an Old Oak area-wide DEC network. The work shall include assessment of heat demand and supply, and ascertain appropriate buy-in from developers to enable the development of a business case to create a North Acton DCE network, if appropriate.

9. Constraints/Policy requirements:

- London Plan will require regulated CO2 emissions to be reduced by 35% on site. All homes will need to reduce regulated emissions to zero through on site savings or payments to offset funds from 2016. Non-domestic expected to need to do similar from 2019.
- London Plan promotes connection to district heating or creation of district heating networks. Current baseline developer approach to meeting standards is meeting Part L through efficiency measures alone, connecting to communal heating served by gas CHP, and installing roof top PV to meet 35% reduction and offsetting remaining emissions through an offset fund where this has been set up by the planning authority.
- The next consultation draft London Plan is expected to promote a revision to the Mayor's Energy Hierarchy, promoting the use of low grade heat sources ahead of gas-fuelled Combined Heat and Power (CHP). This revision is already proposed in the Regulation 19 draft Local Plan which is currently out for consultation.

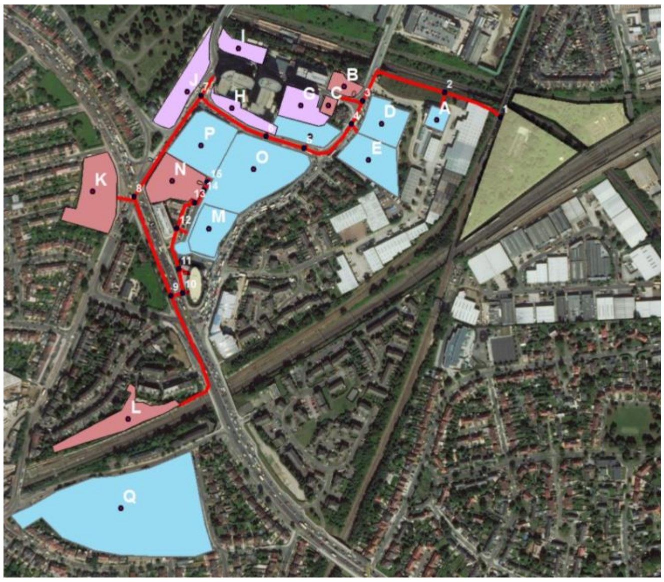
- The current draft OPDC local plan promotes district energy solutions at Old Oak common in line with GLA London Plan policy.

10. Data Collection Phase – Emerging findings

Data collection is now complete. Some uncertainties remain and benchmarks have been used - this cannot be avoided due to some buildings still being in early design and planning stages.

Updates have been made to the map, which have corrected the locations of the buildings in line with information provided by Ealing Council (which had formerly been based on the AECOM report). Arup has also identified a potential network route. The triangular plot between North Acton and Wormwood Scrubs park has been identified as a key potential opportunity for siting an energy centre.

Phase 1 – Lilac



Phase 2 – Red
Phase 3 – Blue
Route – Red
Energy Centre – Yellow with black outline

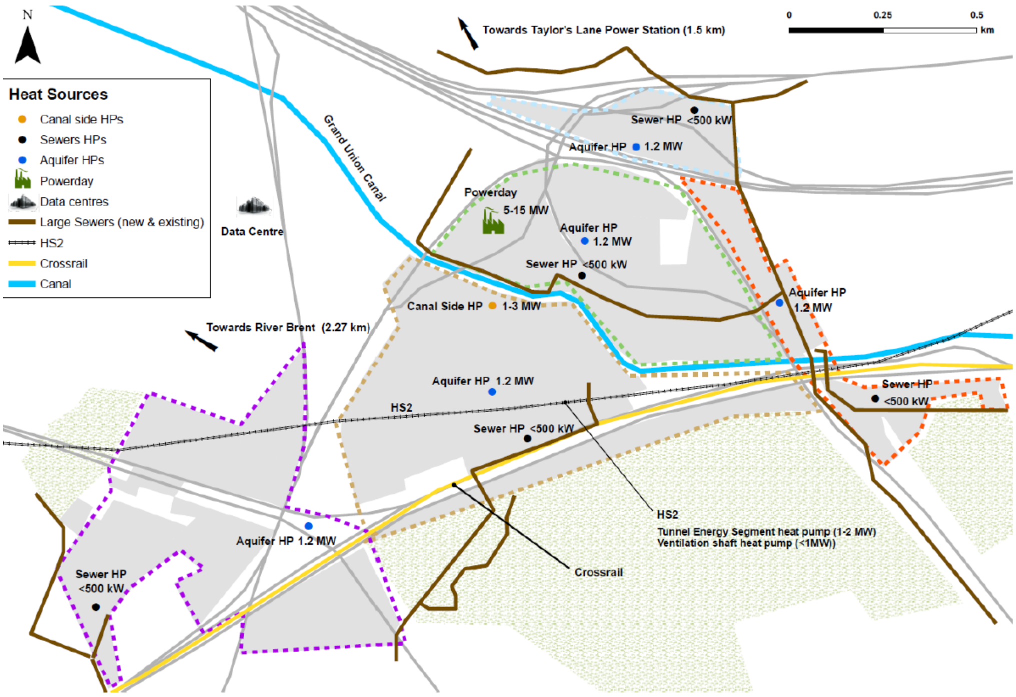
A	Monarch House
B	Holbrook House
C	142-154 Victoria Road
D	Perfume Factory
E	Imperial College
F	The Portal
G	Former BBC Costume Store
H	Lyra Court
I	Victoria Square
J	NEC House
K	Gypsy Corner
L	Land to the rear of Western Court Rose Bank
M	2 Portal Way
N	5 Portal Way
O	Carphone Warehouse
P	6 Portal Way
Q	Friary Park Estate

The indicative network route has been plotted following main roads to minimise cost and disruption during construction and maintenance. The secondary network is positioned approximately to supply groups of buildings, based on geographical and phasing considerations. The approximate total length of primary pipe for the indicative route is c. 1,250m.

The location of Friary Park estate between the railway line and the A40 make it challenging to connect to this network. The developer of this site has also (separately) conducted a feasibility test into possible connections to a district heating network without a positive outcome.

The location of the proposed energy centres has been taken into consideration when proposing the indicative network route. The route encompasses the separate energy centres/sources so that potentially sewer heat recovery, CHP and Aquifer can be used in combination to optimise the heat supply for the network.

The feasibility of utilising a canal side heat pump as a heat supply for the North Acton site has been evaluated. As can be seen in the map below, the distance between the canal side heat pump and the developments in North Acton is c. 1km. For a canal side heat pump with a small temperature difference this could potentially be an issue as the pipe diameter would need to be large in order to have the capacity for the increased flow rate required. Moreover, there are other heat loads being developed in the immediate surrounding area (to the canal and the data centre) which will have sufficient demand to absorb heat supply, making a connection to North Acton unfavourable at this stage of network development.



11. Emerging Options to be considered:

The final scenarios we are testing are outlined in the table below. The configurations have been chosen due to the position of the two main low carbon sources: sewage and aquifer. The CoP of any heat pump connected to these heat sources depends on the temperature of the heat network, that, in turn, depends on the heating technologies used in the buildings. We propose to engage with developers about the heating technology installed (or planned), in order to be more accurate in the network temperature calculations.

In the scenarios evaluated, CHP and boilers can be used to top up the power and also to top up the temperature of the network, depending on the configurations.

	Supply						Total Demand	Comment
Scenario	CHP	Backup boilers	Sewer Heat Recovery	Aquifer Heat recovery	Canal Heat Recovery	Data Centre Heat Recovery		
1	0	1	1	0	0	0	17.1 GWh/yr	Sewer heat recovery with boilers used as peaking plants
2	0	1	1	1	0	0	17.1 GWh/yr	Aquifer HP for base load, sewer HP second priority based on sewer temperature

								with boilers used as peaking plants
3	1	1	1	1	0	0	17.1 GWh/yr	CHP as a base load and for electricity production for HP, aquifer HP second priority and sewer third, based on sewer temperature. Boilers used as peaking plants. This is the scenario we will use to test the performance of development phases.

The scenarios described above were tested using a combination of Energy Pro (see examples in the appendix) and Arup's techno-economic model.

12. Risks that will affect delivery of the objectives:

See separate risk register

13. Recommended approach:

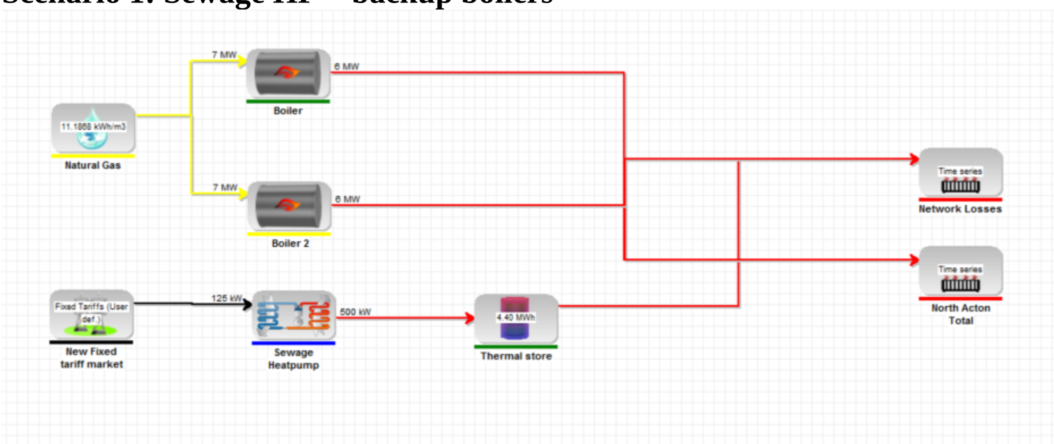
As mentioned, canal heat recovery and data centre heat recovery has been considered and discarded as viable options for the moment. These two energy sources could be considered for a future wider area integrated district heating grid.

14. Next Steps

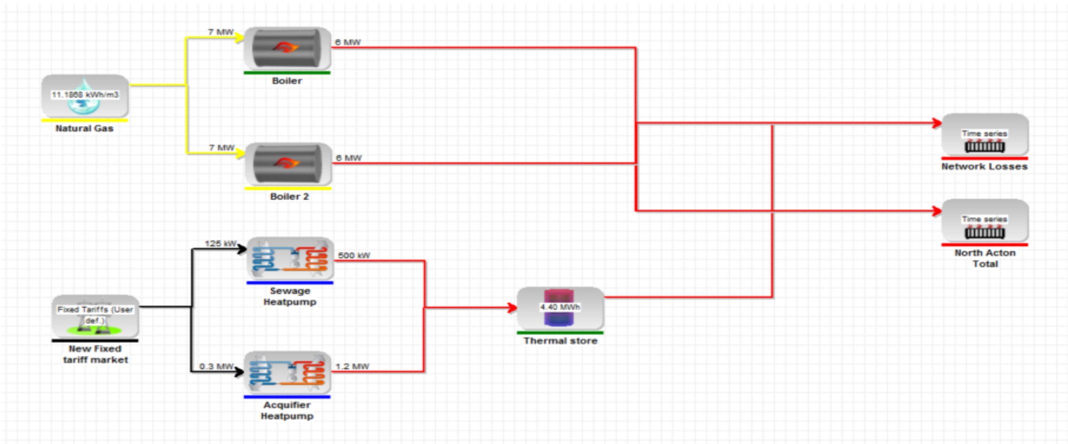
Arup will continue to model scenarios and will produce NPV and IRR results to compare in a draft technical report.

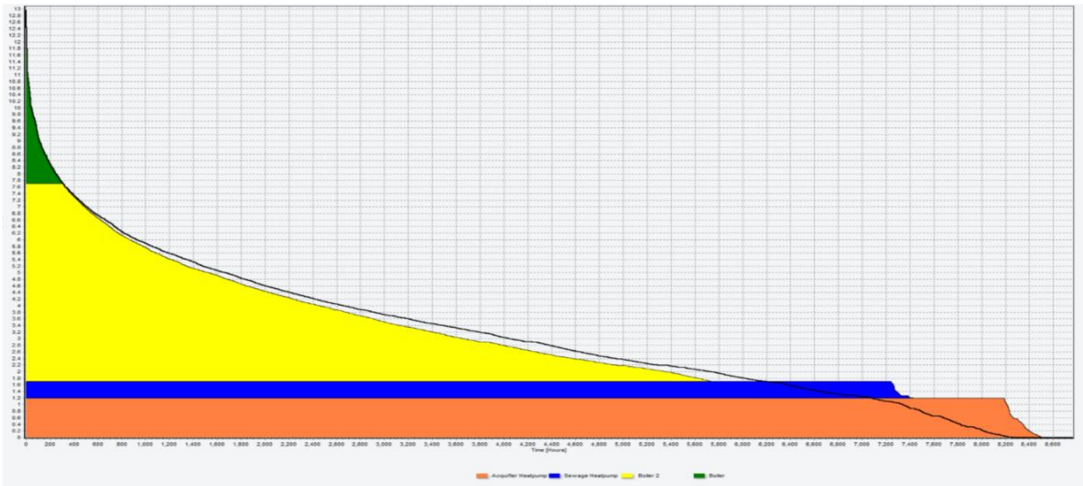
Appendix – Energy Pro Modelling

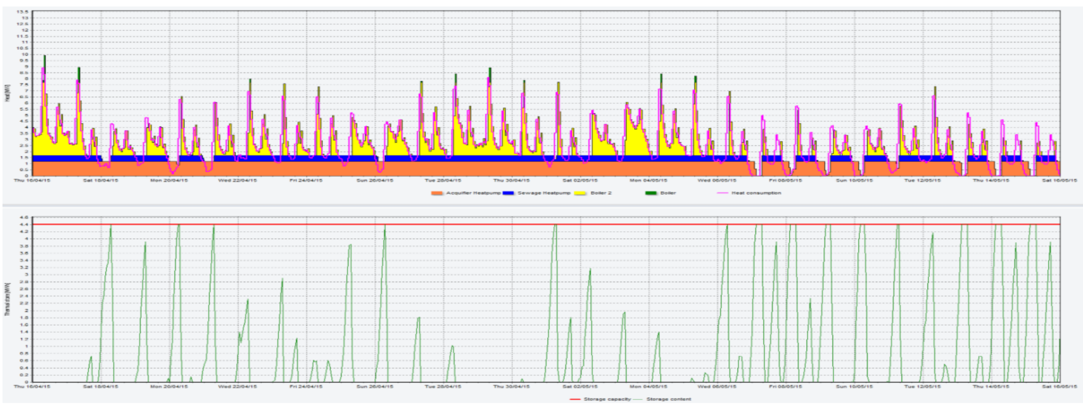
Scenario 1: Sewage HP + backup boilers



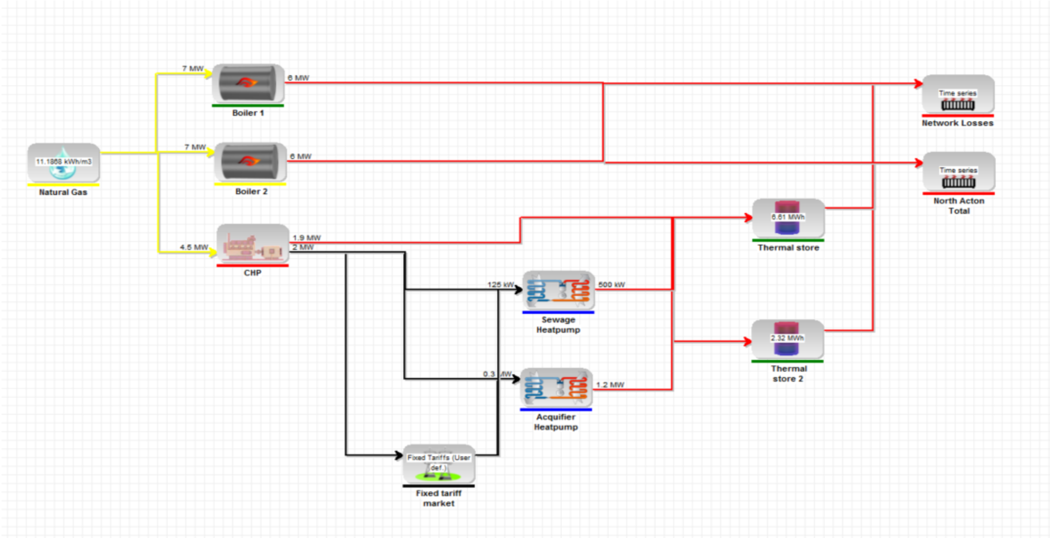
Scenario 2: Aquifer HP + sewage HP + backup boilers

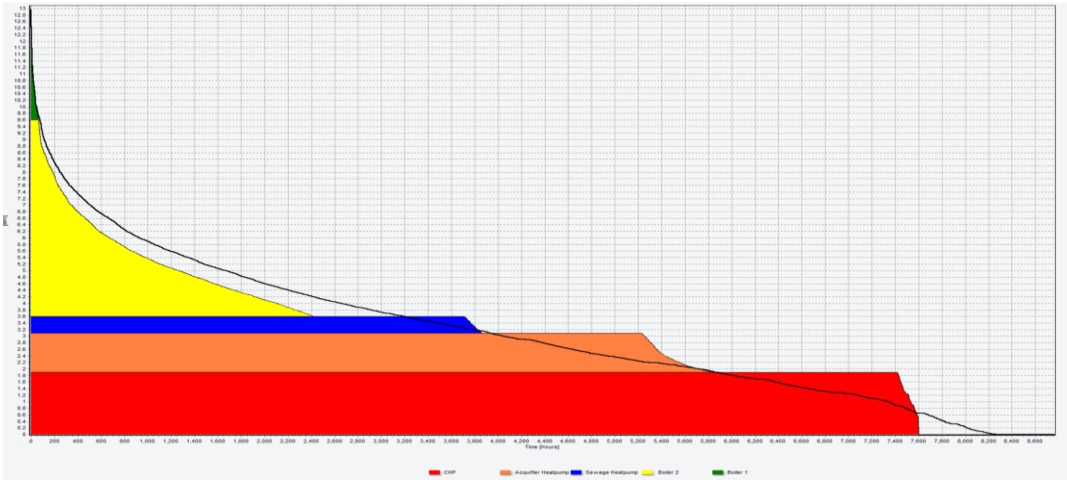

11.1868 kWh/m3
Natural Gas
7 MW
Boiler
6 MW
7 MW
Boiler 2
6 MW
Fixed Tariffs (User def.)
New Fixed tariff market
125 kW
Sewage Heatpump
500 kW
0.3 MW
Acquifier Heatpump
1.2 MW
4.40 MWh
Thermal store
Time series
Network Losses
Time series
North Acton Total

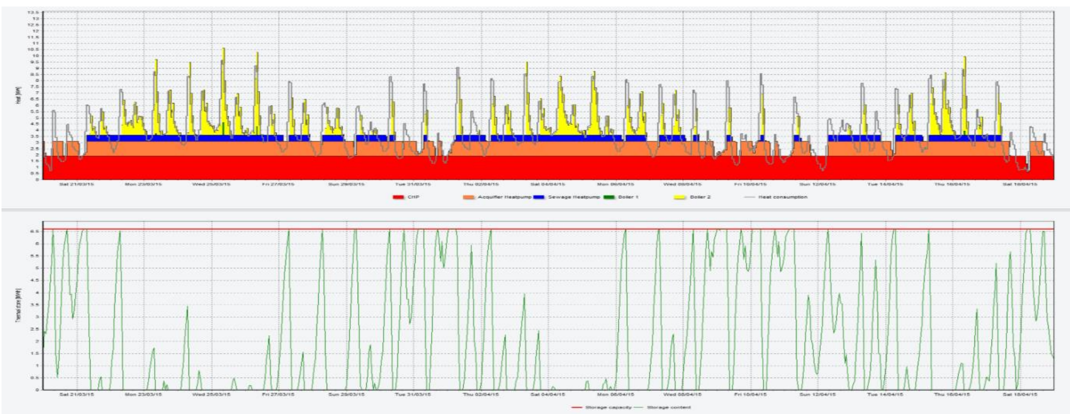

Time [hours]
Acquifier Heatpump
Sewage Heatpump
Boiler 2
Boiler


Acquifier Heatpump
Sewage Heatpump
Boiler 2
Boiler
Heat consumption
Storage capacity
Storage content

Scenario 3: CHP + aquifer HP + sewage HP + backup boilers







6.3 Update 03-11-2017

Emerging Findings – Rolling Summary Report
Update 03-11-2017

Work stream: North Acton DHN Feasibility Study	**Lead**: Stephen Cook – Arup Alaina Tolhurst - OPDC

15. Objective:

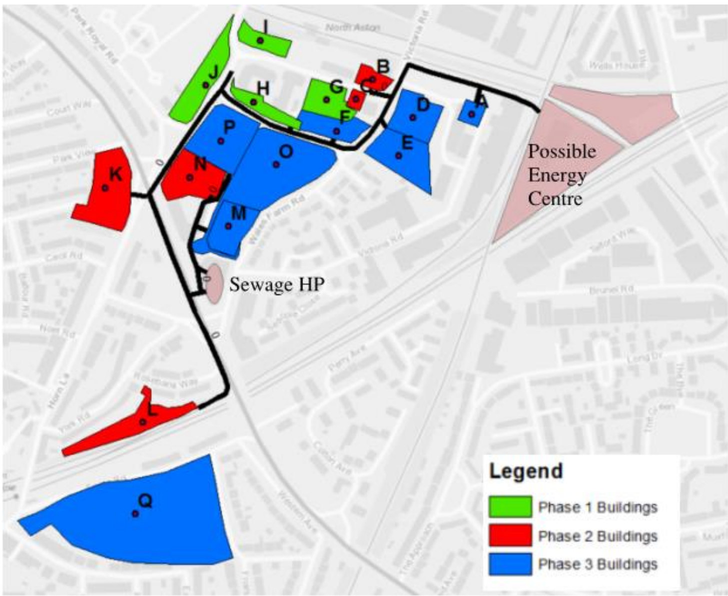
To test the feasibility of a decentralised energy (DCE) network in the North Acton area, as the initial phase of an Old Oak area-wide DEC network. The work includes assessment of heat demand and supply, and to ascertain appropriate buy-in from developers to enable the development of a business case to create a North Acton DCE network, if appropriate.

16. Emerging Options to be considered:

This preliminary analysis carried out split the buildings into 3 different phases to reduce the complexity of the modelling and technical evaluation. They are defined as:

Phase 1 - Buildings already completed
Phase 2 - Buildings due to be completed by the end of 2019
Phase 3 - Buildings due to be completed between 2020 and 2027

The indicative network route has been plotted following main roads to minimise cost and disruption during construction and maintenance. The phase splits and routing can be seen in **Error! Reference source not found.**Figure 1 in the network routing section.



A	Monarch House
B	Holbrook House
C	142-154 Victoria Road
D	Perfume Factory
E	Imperial College
F	The Portal
G	Former BBC Costume Store
H	Lyra Court
I	Victoria Square
J	NEC House
K	Gypsy Corner
L	Land to the rear of Western Court Rose Bank
M	2 Portal Way
N	5 Portal Way
O	Carphone Warehouse
P	6 Portal Way
Q	Friary Park Estate

Figure 9 Indicating the phasing and routing of the OPDC scheme

17. Techno-economic modelling

Arup has completed the techno-economic model which has enabled financial and technical appraisal of the heat network scenarios.

During the modelling process it was concluded that the proposed capacity sizing of the Aquifer and Sewage heat pumps do not alone have the capability to cater for the site, therefore CHP has been included on all scenarios. This will be re-revised in future weeks with the development of other low carbon solutions.

The scenario structure is as shown in Table 4, with the varying heat demands and supply technologies modelled.

Table 4 Indicating the scenarios that have been modelled

	Supply						Total Demand (cumulative)
Scenario	CHP	Backup boilers	Aquifer Heat recovery	Sewer Heat Recovery	Canal Heat Recovery	Data Centre Heat Recovery	
Phase 1	1 CHP (0.6 MW)	1 Boiler (5 MW)	1 Aquifer HP (0.6 MW)	0	0	0	Phase 1 (4.9 GWh/yr)
Phase 2	1 CHP (0.6 MW)	1 Boiler (5 MW)	1 Aquifer HP (0.6 MW)	0	0	0	Phase 2 (9.6 GWh/yr)
Phase 3	3 CHP (1.8 MW)	1 Boiler (15 MW)	2 Aquifer HP (1.2 MW)	1 Sewer HP (0.5 MW)	0	0	Phase 3 (25 GW/yr)

The modelling included preliminary costing for different scenarios. All the costs are based on the information provided by AECOM report and other information that Arup found related to the topic.

18. Preliminary Financial Results:

The preliminary results are presented in Table 5, based on the modelling conducted thus far. The results indicate that there is a district heating scheme that would provide lower carbon heat while also providing a discount in energy prices to those buildings connected to the network.

Table 5 Indicating the preliminary results of the study with a 6% discount rate

Scenario	40 year IRRs (%)	40 year NPV (£m)*	25 year IRR (%)	25 year NPV (£)*	Carbon Saving (CO_2t)*
Phase 1 with CHP & Aquifer HP	N/A	-£11.85	N/A	-£11.30	21,500
Phases 1&2 with CHP & Large Aquifer HP	6.8%	£1.05	5.1%	-£0.85	42,000
Phases 1,2&3 with CHP & Large Aquifer HP & Sewage HP	10.7%	£12,70	9.6%	£6.80	137,500

*Using SAP 3 year carbon intensity projections for UK electricity and gas

The most favourable buildings to connect are those that will not be constructed until 2020 and beyond, meaning that designs can be more easily changed and the potential cost savings of the network realised. The way the network would be phased is therefore a key consideration.

19. Risks that will affect delivery of the objectives:

See risk register in excel document

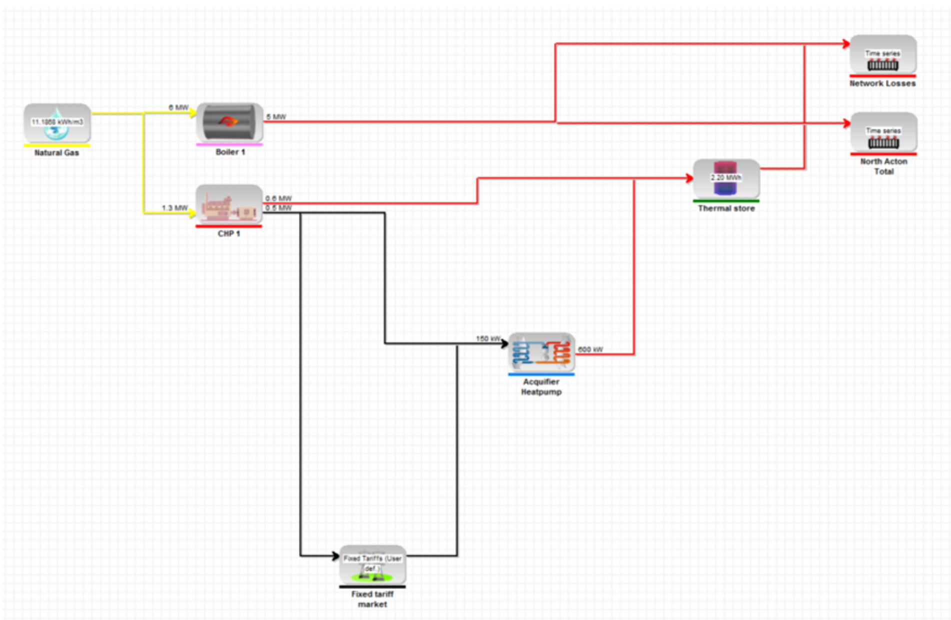
20. Next Steps

The scenarios modelled have demonstrated that a combination of CHP and heat pumps can deliver a lower carbon solution. Future scenarios are now being tested to evaluate even lower carbon network set ups.

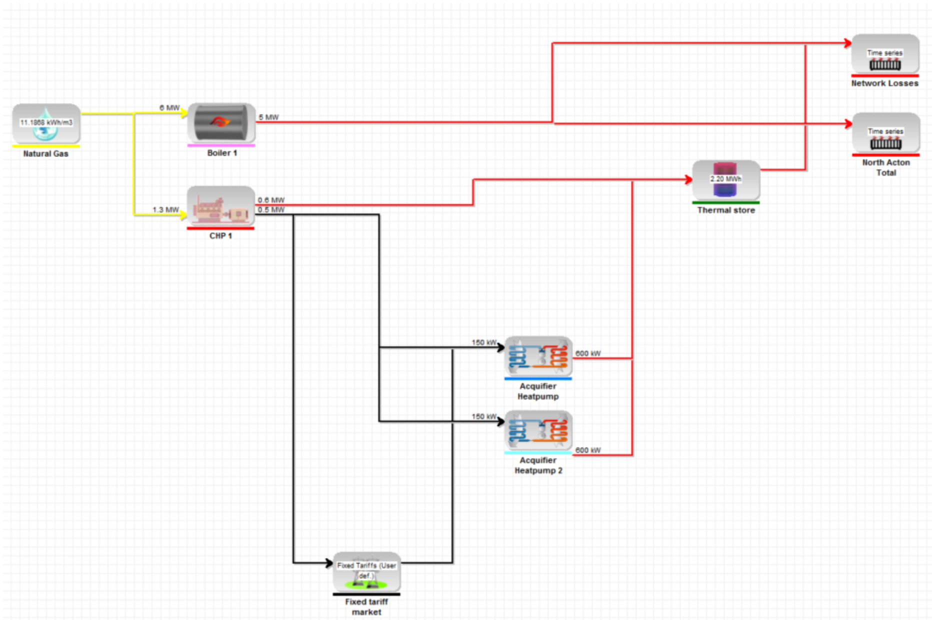
These scenarios will include a zero carbon solution and a no network solution.

Appendix – Energy Pro Modelling

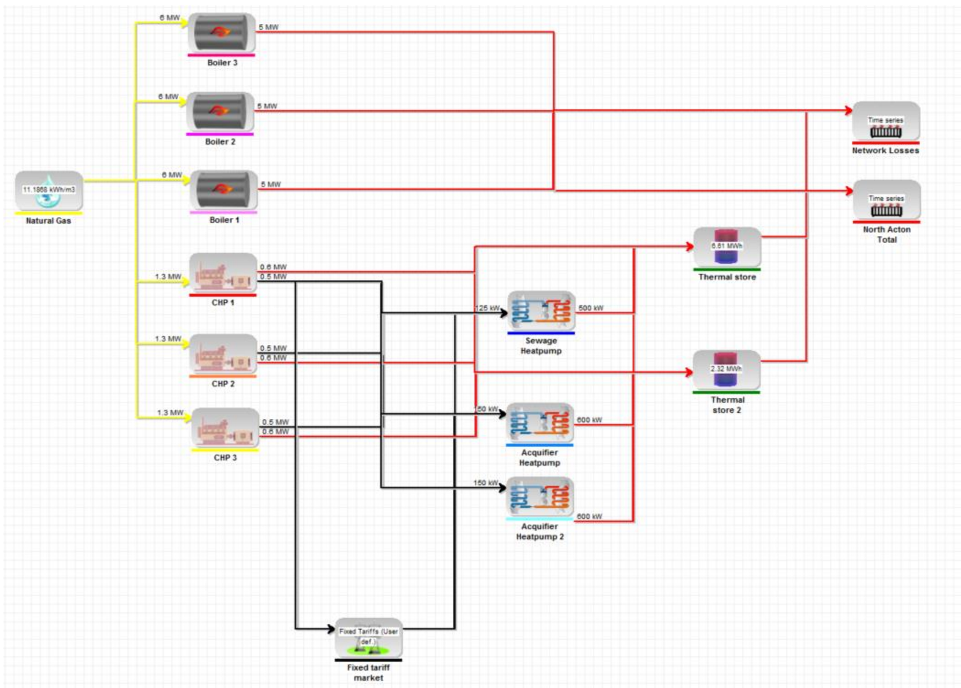
Scenario 1: CHP + Aquifer HP + backup boilers



Scenario 2: CHP + Aquifer HP + backup boilers



Scenario 3: CHP + aquifer HP + sewage HP + backup boilers



6.4 Update 13-11-2017

Emerging Findings – Rolling Summary Report
Update 13-11-2017

Work stream: North Acton DHN Feasibility Study	**Lead:** Stephen Cook – Arup, Alaina Tolhurst - OPDC

21. Objective:

To test the feasibility of a decentralised energy (DCE) network in the North Acton area, as the initial phase of an Old Oak area-wide DEC network. The work includes assessment of heat demand and supply, and to ascertain appropriate buy-in from developers to enable the development of a business case to create a North Acton DCE network, if appropriate.

22. Emerging Options to be considered:

The options evaluated this week are summarised in Table 6 Indicating the scenarios that have been modelled. It includes both a zero-carbon network (full dependence on electricity) and minimal network scenarios.

Because the proposed capacity sizing of the Aquifer and Sewage heat pumps do not alone have the capability to cater for the site, a Ground Source Heat Pump was included in the zero-carbon network. The feasibility and space requirements of this still need to be confirmed.

Table 6 Indicating the scenarios that have been modelled*

Scenario	CHP	Ground Source Heat Pump	Aquifer Heat recovery	Sewer Heat Recovery	Air Source Heat Pump
Zero Carbon Network	-	1 no. GSHP (2MW)	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	1 no. ASHP (1.5 MW)
CHP led Network	3 no. CHP (1.8 MW)	-	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	-
Building Local solutions	-	-	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	Building Local ASHP (17.0 MW)

*All scenarios include back up boilers for resilience

23. Preliminary Financial Results:

The preliminary results are presented in Table 5, based on the modelling conducted thus far. The summary headline figures can be seen in the Appendix.

Table 7 Indicating the preliminary results of the study with a 6% discount rate

Scenario Name	**Zero Carbon Network**	**CHP Led Network**	**Building local solutions**
Average Annual Heat Demand (kWh)	25,475,050	25,475,050	25,475,050
Total Capital Costs (£)	**£18,197,785**	**£17,315,654**	**£21,728,171**

25 year pre-tax IRR	3.5%	0.9%	1.3%
25 year pre-tax NPV (6% discount rate)	-£2,989,985	-£5,389,493	-£7,021,505

In terms of carbon, the performance of the different supply technologies will be changing over time. This is displayed in the graph below;

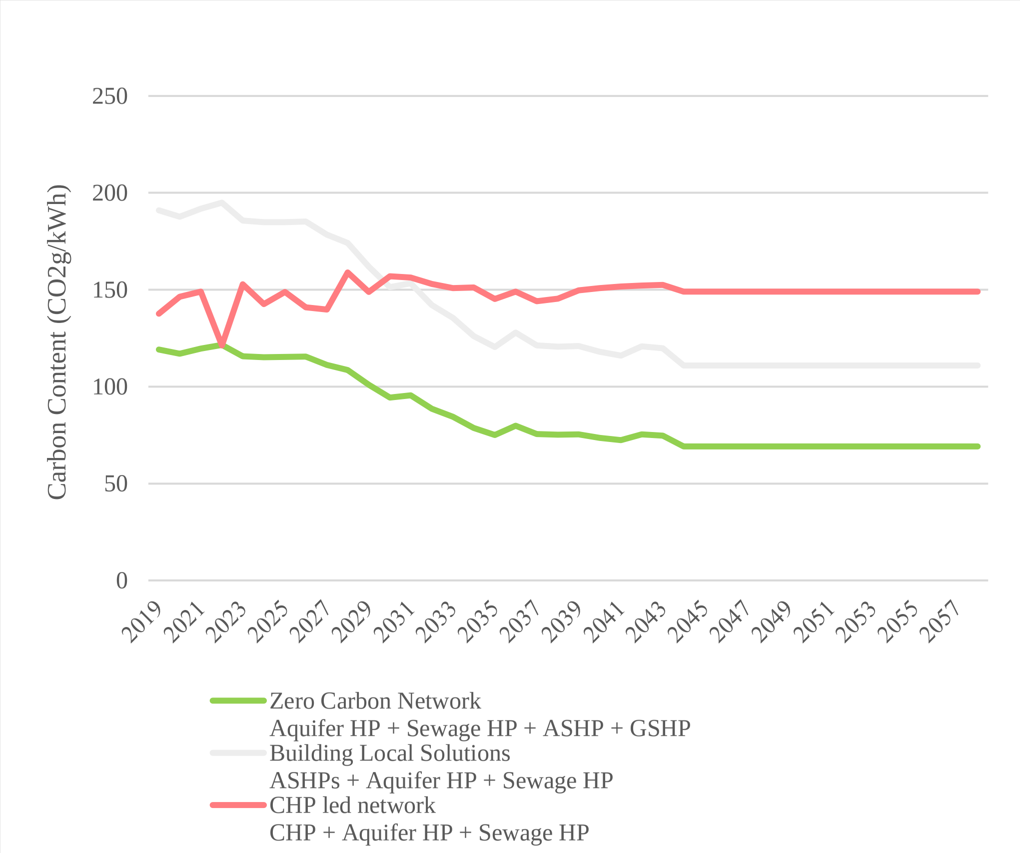


Figure 10 Carbon performance of the different scenarios to 2050*

*Both the zero carbon and building local solution only have electricity as the power source so their carbon intensity can be dropped to zero if the electricity bought is zero carbon. The above graph shows the average carbon intensity.

24. Risks that will affect delivery of the objectives:

See risk register in excel document. Note that 4 new risks have been added

25. Next Steps

Review of the costing and revenue assumptions

Add in a value for carbon in the techno economic assessment.

Prepare the commercial option note

Prepare a slide deck for the developers

Addition of building phasing to the model

Discussion with the Data centre operator, refine Aquifer HP and Sewage HP assumption to confirm costs and technical considerations

Appendix A Financial Summary

Scenario Name	Zero Carbon Network	CHP led network	Building Local Solution
Scenario Number	1	2	3
Cost inputs and heat demand summary			
Supply Option			
Average Annual Heat Demand (kWh)	25,475,050	25,475,050	25,475,050
Total Capital Costs (£)	**£18,197,785**	**£17,315,654**	**£21,728,171**
Average Annual Revenues (£)	**£1,818,188**	**£2,200,711**	**£2,124,802**
Total Connection Charge Revenue (£)	**£836,548**	**£836,548**	**£400,328**
Total Plant Replacement Costs	**£180,000**	**£1,350,000**	**£180,000**
Average Annual Operational Costs (£)	**£144,568**	**£275,698**	**£302,697**
Average Annual Total Commodities Cost (£)	**£377,441**	**£848,946**	**£605,394**
Carbon Savings			
% Emission reduction (SAP 2016) over 40 years	49.85%	53.31%	20.99%
Tonnes of CO_2 saved over scheme lifetime (SAP 2016) (tCO_2) over 40 years	127,950	136,842	53,889
% Emission reduction (BEIS) over 40 years	66.10%	41.14%	45.63%
Tonnes of CO_2 saved over scheme lifetime (BEIS) (tCO_2) over 40 years	169,682	105,599	117,133
% Emission reduction (BEIS) over 15 years	54.91%	38.75%	27.68%
Tonnes of CO_2 saved over scheme lifetime (BEIS) (tCO_2) over 15 years	50,338	35,522	25,373
Financial Performance Summary			
Pre-tax Financial Results			
25 year pre-tax IRR	3.5%	0.9%	1.3%
25 year pre-tax NPV (6% discount rate)	-£2,989,985	-£5,389,493	-£7,021,505
40 year pre-tax IRR	5.22%	3.84%	2.56%
40 year pre-tax NPV (6% discount rate)	-£1,258,613	-£3,520,904	-£6,193,414

6.5 Update 16-11-2017

Emerging Findings – Rolling Summary Report
Update 16-11-2017

Work stream: North Acton DHN Feasibility Study	**Lead**: Stephen Cook – Arup

Alaina Tolhurst - OPDC

26. Objective:

To test the feasibility of a decentralised energy (DCE) network in the North Acton area, as the initial phase of an Old Oak area-wide DEC network. The work includes assessment of heat demand and supply, and to ascertain appropriate buy-in from developers to enable the development of a business case to create a North Acton DCE network, if appropriate.

27. Emerging Options to be considered:

Starting from the supply scenarios evaluated last week (summarised in Table 1), we are analysing two different connection scenarios based on first year of district heating network operation.

Table 8 Indicating the scenarios that have been modelled*

Supply Scenario	CHP	Ground Source Heat Pump	Aquifer Heat recovery	Sewer Heat Recovery	Air Source Heat Pump
Zero Carbon Network	-	1 no. GSHP (2MW)	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	1 no. ASHP (1.5 MW)
CHP led Network	3 no. CHP (1.8 MW)	-	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	-
Building Local solutions	-	-	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	Building Local ASHP (17.0 MW)

*All scenarios include back up boilers for resilience

This analysis will help the feasibility evaluation of the district heating network in case ESCo procurement timeframes will take too long to include buildings completed by the end of 2019.

In both scenarios, existing buildings, not connected from the first year, are considered to be connected in around 2030, when their heating system will need a replacement.

Table 9 Annual breakdown of heat loads

Connection Scenario	Heat loads connected (GWh)				
	2019	2020	2021	2027	2030
DH operating from 2019	5.2	12.8	17.1	21	26.3
DH operating from 2020	0	7.7	12	15.8	26.3

In the Figure 11 below you can see the cumulative growth of heat demand in North Acton.

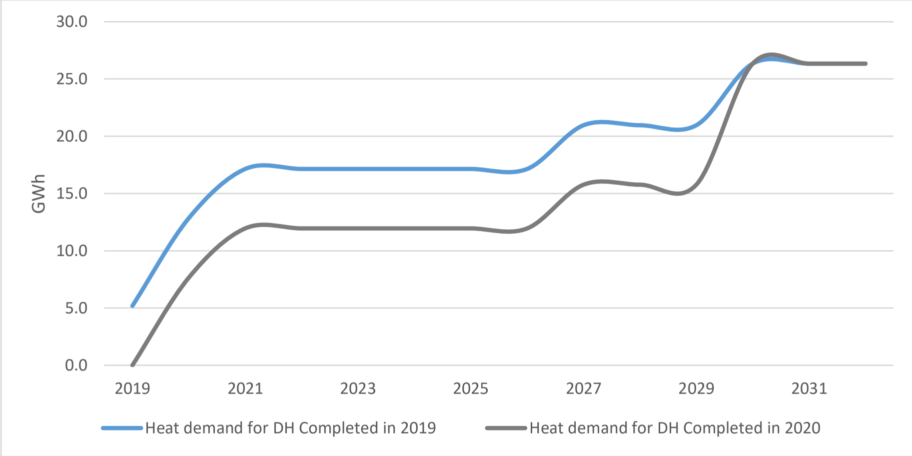
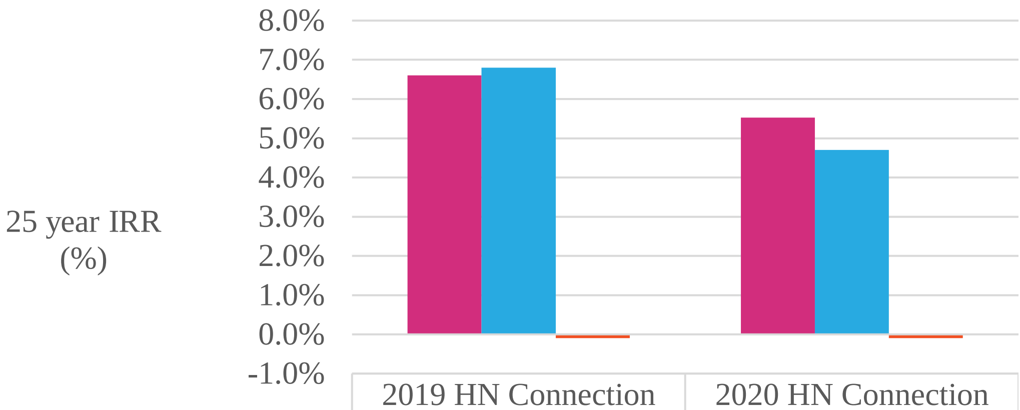


Figure 11 Cumulative Heat Loads on the OPDC site

28. Preliminary Financial Results:

The preliminary updated commercial findings indicate that these network solutions perform better than building local solutions. This was not expected and is undergoing further investigation. This can be seen in Figure 12.

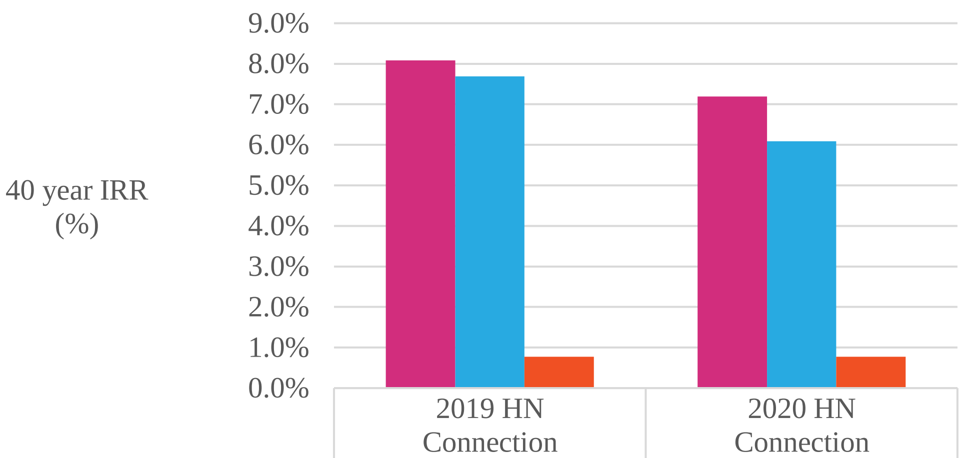


	2019 HN Connection	2020 HN Connection
CHP Led Network	6.6%	5.5%
Zero Carbon Network	6.8%	4.7%
Building Local Solution	-0.1%	-0.1%

Figure 12 Financial performance of the different scenarios over 25 years

As can be seen in figure 2, the sensitivity to the network start date is significant. If the connection date of the heat network is delayed by one year, from 2019 to 2020, the IRR of the schemes decreases by >1%. This is because the fixed costs for the scheme (pipe and energy centre cost) will not change significantly, yet there will be reduced financial savings for the buildings that will have been construction by 2020.

Although the zero carbon network achieves the highest IRR over the initial 25 years, the CHP network is better performing over 40 years. For the initial 20 years of network operation, the renewable heat incentive (RHI) payments are received which strengthens the IRR in the short term. After this period these revenues are no longer received and the CHP led network will outperform the zero carbon network. This difference can be seen in Figure 13.



	2019 HN Connection	2020 HN Connection
CHP Led Network	8.1%	7.2%
Zero Carbon Network	7.7%	6.1%
Building Local Solution	0.8%	0.8%

Figure 13 Financial performance of the different scenarios over 40 years

Gap funding

It was investigated what potential impact some level of grant funding might have on the viability of the scheme. It is noted that the range values IRR before any gap funding are above the cost of borrowing for certain funding sources that are readily available to private sector borrowers (or a public-private collaboration), at an assumed rate of 12%.

Table 3 Gap Funding necessary to achieve a 25 year IRR of 12%

	CHP Led Network (£m)	Zero Carbon Network (£m)
2019	2.6	2.0
2020	2.9	2.8

The results indicate that public capital would be needed to realise the scheme through a private ESCo.

29. Risks that will affect delivery of the objectives:

See risk register in excel document.

30. Commercial Note

See commercial note document

31. Meeting with Metropolitan

On Wednesday 8th November Aecom hosted a meeting with Arup, OPDC and Metropolitan Infrastructure Limited, to discuss about ESCo opportunities. The outcome of this discussion was that Metropolitan is open to different commercial option for the district heating:

- Public sector led - DBOM
- ESCo consection model - DBFO
- Utility adopted model
- Franchising model

A crucial point remains the developers' intention to connect and the supply temperature.

Metropolitan also suggested that they can be partner for all services (electricity, water, wastewater, gas, FTTH) and mentioned the King's Cross project in which they are involved in a joint venture with Argent.

32. Next steps

Meetings with other ESCos

Review of the costing and revenue assumptions

Add in a value for carbon in the techno economic assessment.

Prepare a slide deck for the developers

Appendix A Financial Summary

Scenario Name	Zero Carbon 2019	CHP Led 2019	Zero Carbon 2020	CHP Led 2020	Building Local Solution
Cost inputs and heat demand summary					
Average Annual Heat Demand (kWh)	23,132,921	23,132,921	21,999,624	21,999,624	25,475,050
Total Capital Costs (£)	£12,773,730	£14,180,580	£12,773,730	£13,967,328	£22,000,283
Average Annual Revenues (£)	£1,600,203	£2,246,574	£1,457,661	£2,102,390	£2,124,802
Total Connection Charge Revenue (£)	£2,788,494	£2,788,494	£2,788,494	£2,788,494	£2,788,494
Total Plant Replacement Costs	£180,000	£1,710,000	£180,000	£1,710,000	£180,000
Average Annual Operational Costs (£)	£136,297	£252,146	£130,826	£239,155	£132,697
Average Annual Total Commodities Cost (£)	£535,545	£848,720	£505,468	£832,691	£988,399
Carbon Savings					

% Emission reduction (SAP 2016) over 40 years	47%	32%	46%	34%	21%
Tonnes of CO_2 saved over scheme lifetime (SAP 2016) (tCO_2) over 40 years	97,978	61,881	91,979	66,498	53,889
% Emission reduction (BEIS) over 40 years	66%	17%	66%	22%	46%
Tonnes of CO_2 saved over scheme lifetime (BEIS) (tCO_2) over 40 years	137,771	32,969	131,482	43,728	117,133
% Emission reduction (BEIS) over 15 years	54%	-14%	55%	20%	28%
Tonnes of CO_2 saved over scheme lifetime (BEIS) (tCO_2) over 15 years	33,031	(5,819)	26,742	9,551	25,373
Financial Performance Summary					
25 year pre-tax IRR	6.8%	6.7%	5.0%	5.5%	-0.1%
25 year pre-tax NPV (6% discount rate)	£598,259	£668,000	-£839,105	-£431,038	-£7,798,253
40 year pre-tax IRR	7.69%	8.08%	6.09%	7.19%	0.77%
40 year pre-tax NPV (6% discount rate)	£1,653,230	£2,912,987	£90,610	£1,547,903	-£7,482,253

6.6 Update 24-11-2017

Emerging Findings – Rolling Summary Report
Update 24-11-2017

Work stream: North Acton DHN Feasibility Study	**Lead**: Stephen Cook – Arup Alaina Tolhurst - OPDC
33. Objective:	
To test the feasibility of a decentralised energy (DCE) network in the North Acton area, as the initial phase of an Old Oak area-wide DEC network. The work includes assessment of heat demand and supply, and to ascertain appropriate buy-in from developers to enable the development of a business case to create a North Acton DCE network, if appropriate.	
34. Emerging Options to be considered:	
Starting from the supply scenarios evaluated (summarised in Table 1), we are analysing two different connection scenarios based on first year of district heating network operation.	

Table 10 Indicating the scenarios that have been modelled*

Supply Scenario	CHP	Ground Source Heat Pump	Aquifer Heat recovery	Sewer Heat Recovery	Air Source Heat Pump
Zero Carbon Network	-	1 no. GSHP (2MW)	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	1 no. ASHP (1.5 MW)
CHP led Network	3 no. CHP (1.8 MW)	-	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	-
Building Local solutions	-	-	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	Building Local ASHP (17.0 MW)

*All scenarios include back up boilers for resilience

This analysis will help the feasibility evaluation of the district heating network in case ESCo procurement timeframes will take too long to include buildings completed by the end of 2019.

In both scenarios, existing buildings, not connected from the first year, are considered to be connected in around 2030, when their heating system will need a replacement.

Table 11 Annual breakdown of heat loads

Connection Scenario	Heat loads connected (GWh)				
	2019	2020	2021	2027	2030
DH operating from 2019	5.2	12.8	17.1	21	26.3
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In the Figure 11 below you can see the cumulative growth of heat demand in North Acton.

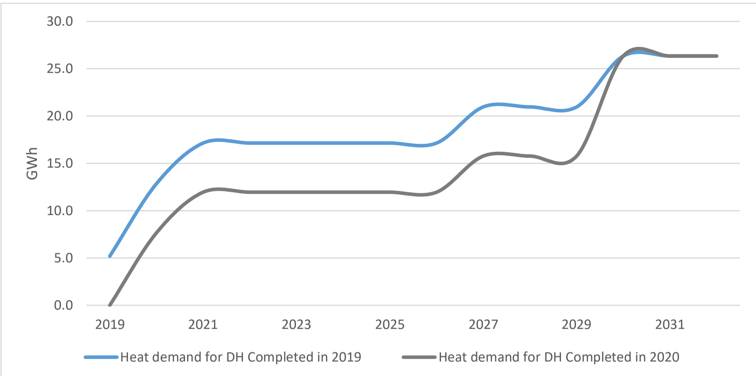

Figure 14 Cumulative Heat Loads on the OPDC site

Arup has continued to work on improving the assumptions behind the zero carbon, CHP led and building local solutions.

This includes more detailed analysis of the connection charge, marginal cost of heat supplies and costs.

35. Preliminary Financial Results:

Technical assumptions have improved resulting in slightly higher IRRs.

Table 12 Indicating the preliminary results of the study with a 6% discount rate

Scenario Name	Zero Carbon Network	CHP Led Network	Building local solutions
Average Annual Heat Demand (kWh)	25,500,000	25,475,050	25,500,000
Total Capital Costs (£)	£13,400,000	£14,199,255	£22,000,000
25 year pre-tax IRR	9.1%	9.3%	1.4%
25 year pre-tax NPV (6% discount rate)	£2,200,000	£2,900,000	-£5,300,000

36. Risks that will affect delivery of the objectives:

See risk register in excel document.

37. Commercial Note

See commercial note document. Comments from OPDC + Steering Group awaited

38. Meeting with Developers

On Wednesday 21st November Arup hosted a meeting with OPDC, Ealing, GLA and some developers (Essential Living, Linchfield, Imperial and Meed Hurst), to discuss District heating opportunities. Thomas Briault (Arup) gave an overview of all global aspects of district heating with a focus on delivery models and commercial aspects.

The outcomes of this meeting are shown in the meeting report, summarised here:

- Imperial: not planning to install CHP for 5 years, after which if they are not connected they will install CHP. They also need certainty of a network going ahead, and costs.
- Carphone Warehouse: will be completed at 2024 at the earliest
- The Portal: Currently negotiating S106 agreement to have gas boilers & a future commitment to connect to a District Heating Network. There will be PV on the roof
- Perfume factory: Currently in planning. Their energy strategy is to have gas boilers and plan to connect to a District Heating Network.
- Arup and OPDC actions: Investigate ownership of possible energy centres
- Engage a wider group of developers and provide a high level overview of the project.

39. Site visit

On the 22/11/2017 Arup conducted a site visit in North Acton. The main outcomes are the following.

Main Energy Centre

The only way to access the site is via the side of the railway. However, this was not possible due to security and fences. The structure of the railway bridge doesn't seem to allow enough space for routing of pipes. Confirmation from OPDC is needed will be necessary to identify the ownership of the land and the possibility of using it for the energy centre.

Secondary Energy Centre

The location is close to a major road. The position of the sewer is not clear, and more detailed underground utility maps will be needed. Arup will investigate ownership of possible Energy Centre locations

Land to the Rear of Western Court and Rose Bank

This site is small and remote from the other planned developments and surrounded by other residential areas not included in OPDCs list. We will investigate the impact of excluding this development from the network.

Pipe Routing

The pipe routing has typical challenges associated with urban developments. It will be necessary to make a few road crossings which will cause disruption. However, there are no bridges, significant tunnelling or gradients that can cause difficulties.

40. Next steps

Meetings with other ESCos

Investigate ownership of all energy centre options

Review of the costing and revenue assumptions

Add in a value for carbon in the techno economic assessment.

6.7 Update 01-12-2017

Emerging Findings – Rolling Summary Report
Update 01-12-2017

Work stream: North Acton DHN Feasibility Study	Lead: Stephen Cook – Arup Alaina
1. Objective:	

To test the feasibility of a decentralised energy (DCE) network in the North Acton area, as the initial phase of an Old Oak area-wide DEC network. The work includes assessment of heat demand and supply, and to ascertain appropriate buy-in from developers to enable the development of a business case to create a North Acton DCE network, if appropriate.

2. Emerging Options to be considered:

New Energy Centre position

After conducting a site visit which highlighted access problems with the main Energy Centre, Arup identified a new location (Figure 1) closer to the development but with less available area for an energy centre:

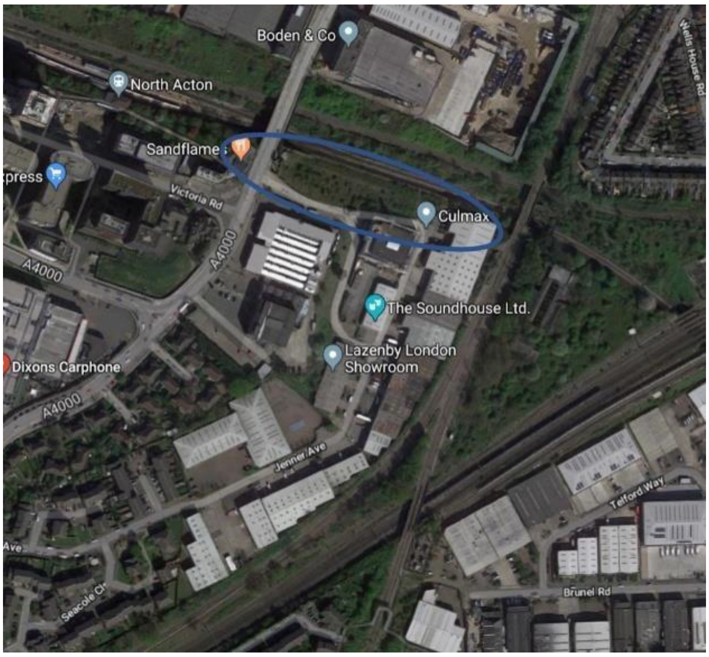

Figure 1 Energy Centre location

The ownership of this new location needs to be identified, and OPDC or Ealing Council can help Arup on this topic.

The network configuration (Figure 2) with this new Energy Centre location will not have lots of changes other than the costs avoided in not crossing the railway line. The main pipe will provide heat to the whole development excluding building A which will be provided for by another pipe directly from the Energy Centre.

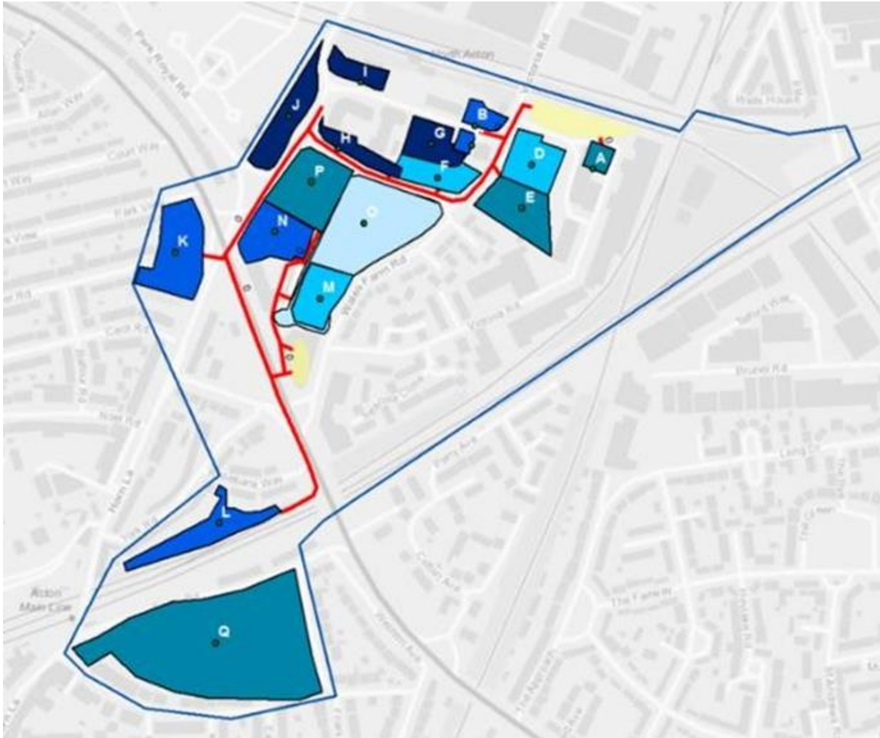

Figure 2 New Plant configuration

Due to the reduction of land availability of the new site, a ground source heat pump will not be able to be accommodated.

The engagement with the developers showed that a low temperature network was not possible. The new buildings are being designed for a high temperature circuit which would result in a low efficiency of air source heat pumps.

As a result, the only viable low carbon heating solutions are the aquifer heat pump and sewage heat pump Regarding sewer heat pump, the land availability for the secondary Energy Centre can be problematic and so the final solution may have only an aquifer heat pump with only one Energy Centre.

3. Preliminary Financial Results:

The techno-economic model was updated to reflect the change in location of energy centre and energy supply technologies. The summary of the model outputs can be seen below in Table 1. The setup of this solution can be seen in the appendix.

Table 1 The financial performance of the new energy centre location

	New Energy Centre Location with Aquifer HP & CHP
25 year pre-tax IRR	5.04%

25 year pre-tax NPV (6% discount rate)	-£695,223
40 year pre-tax IRR	6.72%
40 year pre-tax NPV (6% discount rate)	£735,581

The changes to the energy centre location and operation result in lower revenues associated with RHI payments because there is no ground or sewage source heat pump included.
There is also greater use of boilers which reduces revenues from electricity sales. This scenario currently excludes the complexity of phasing.

4. Risks that will affect delivery of the objectives:

See risk register in excel document.

5. Commercial Note

See commercial note document. Comments from OPDC + Steering Group awaited

6. Meeting with E.ON

On Thursday 30th November AECOM hosted a meeting with OPDC Arup and E.ON to discuss District heating opportunities.

The outcomes of this meeting are summarised here:

- Heat losses can be more than calculated
- E.ON will prefer low temperature network due to heat losses
- CHP is still the preferred technology for a condensing loop network if it was developed
- They agree for intermediate solution like CHP plus heat pumps
- Timeline for CHP use in future network is uncertain
- They prefer DBOM model
- The adoption model can generate problems due to the standard used for construction
- E.ON also agree to be a Multi Utility Service Company (MUSCo)
- Minimum time for an ESCo contract is 6 months but it can go up to 12 months
- Contracts with commercial developments can include max energy and timing of heat supply in order to reduce the peak power and pipes' diameter
- North Acton site can be problematic due to the delivery time
- E.ON agree for temporary solutions
- North Acton can be contractually complicated due to the number of developers
- The commitment and financial contribution of OPDC will be

7. Site visit

On the 22/11/2017 Arup conducted a site visit in North Acton. The main outcomes are the following:

Main Energy Centre

The only way to access the site is via the side of the railway. However, this was not possible due to security and fences. The structure of the railway bridge doesn’t appear to allow enough space for routing of pipes. Confirmation from OPDC is needed to identify the ownership of the land and the possibility of using it for the energy centre.

Secondary Energy Centre

The location is close to a major road. The position of the sewer is not clear, and more detailed underground utility maps will be needed. Arup will investigate ownership of possible Energy Centre locations

Land to the Rear of Western Court and Rose Bank

This site is small and remote from the other planned developments and surrounded by other residential areas not included in OPDCs list. We will investigate the impact of excluding this development from the network.

Pipe Routing

The pipe routing has typical challenges associated with urban developments. It will be necessary to make a few road crossings which will cause disruption. However, there are no bridges, significant tunnelling or gradients that can cause difficulties

8. Next steps

Investigate ownership of all energy

centre options Produce a draft final

report

Review of the costing and revenue assumptions

7 Interim Technical Note

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Project title	North Acton District Heating Network	**Job number** 25831-00
cc		**File reference**
Prepared by	Guido Bollino, Catrina Cassie, Ewan Frost-Pennington	**Date** November 2017
Subject	Technical Note	

7.1 Introduction

Arup was appointed by OPDC to test the feasibility of a decentralised energy (DCE) network in the North Acton area, as the initial phase of an Old Oak area-wide DEC network. The work includes assessment of heat demand and supply, and to ascertain appropriate buy-in from developers to enable the development of a business case to create a North Acton DCE network, if appropriate.

7.1.1 Scope of the note

This note is an interim update on the heat supply and network scenarios which Arup proposes to investigate as part of this study. The note covers which buildings and technology types are the most suitable for a heat network based on initial techno-economic modelling.

7.1.2 Study drivers

The GLA's commitment to carbon emissions reduction is a key driver for this study, with a motivation to exploit low temperature secondary source heat supplies. The North Acton area is of interest due to the amount of new developments planned. A large number of these developments have had planning permission granted and have existing energy strategies including building local Combined Heat and Power plants.

7.2 Energy Mapping Overview

7.2.1 Study area

In accordance with the project brief, the primary focus area for this study is North Acton. While some existing buildings in the area will remain, the majority of buildings will be constructed over the next 10 years. The area will be mixed used with large amounts of residential and due to the proximity of Imperial University there will be also be numerous student accommodation units. The challenges of developing a heat network in this area are its location as it lies between the A40 and Central line railways. The high density of the dwellings planned is another primary constraint of the types of heat resources that can be applicable. The developments and existing buildings evaluated in this report can be seen in Figure 15.

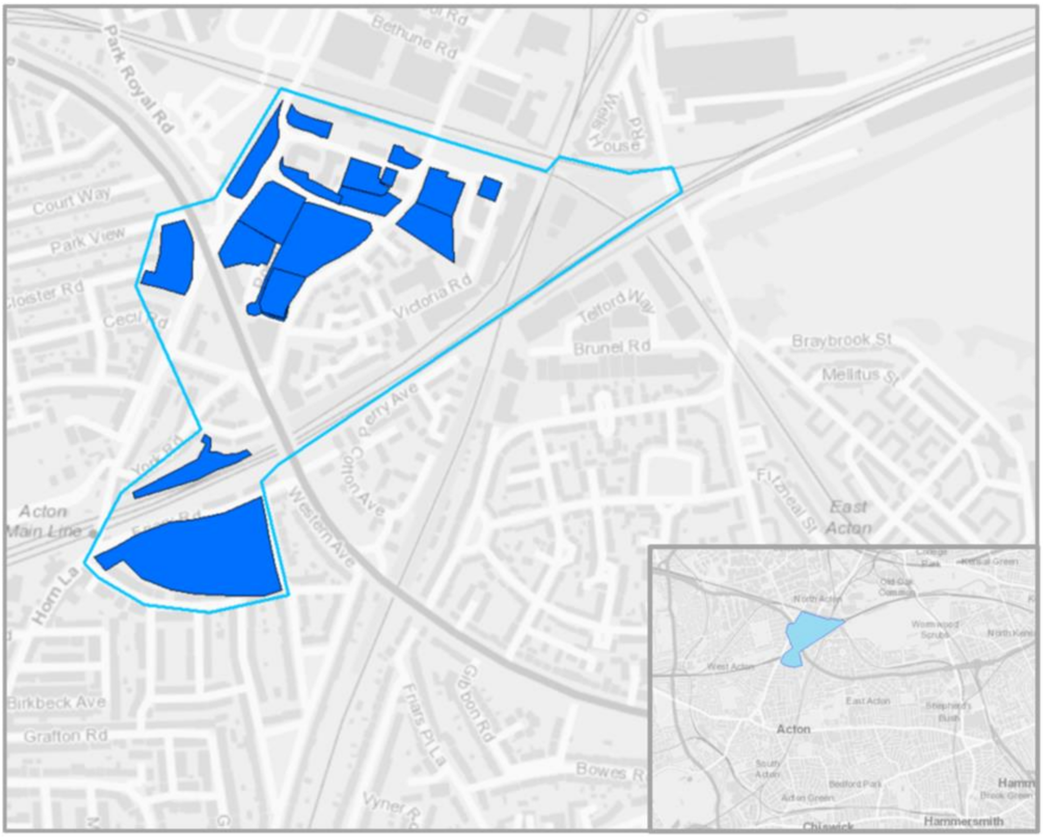

Figure 15 North Acton Area with key buildings filled in blue

7.2.2 Energy Demand Assessment Methodology

The studies accuracy is reliant on the energy demand data. Accordingly, it is important that energy demand data is sourced to the best level of quality that is reasonably practicable to obtain within the programme and budget limitations of the study. The following subsections describe the demand assessment process was adopted.

7.2.2.1 Heat Demand Assessment

The AECOM Utilities study completed for the OPDC had already identified the buildings of interest to this study, however this did not contain the accurate heat demands needed for modelling. To overcome this data gap, the hierarchy heat load data sources was used, opting for the most accurate wherever possible, this can be seen in Figure 16.

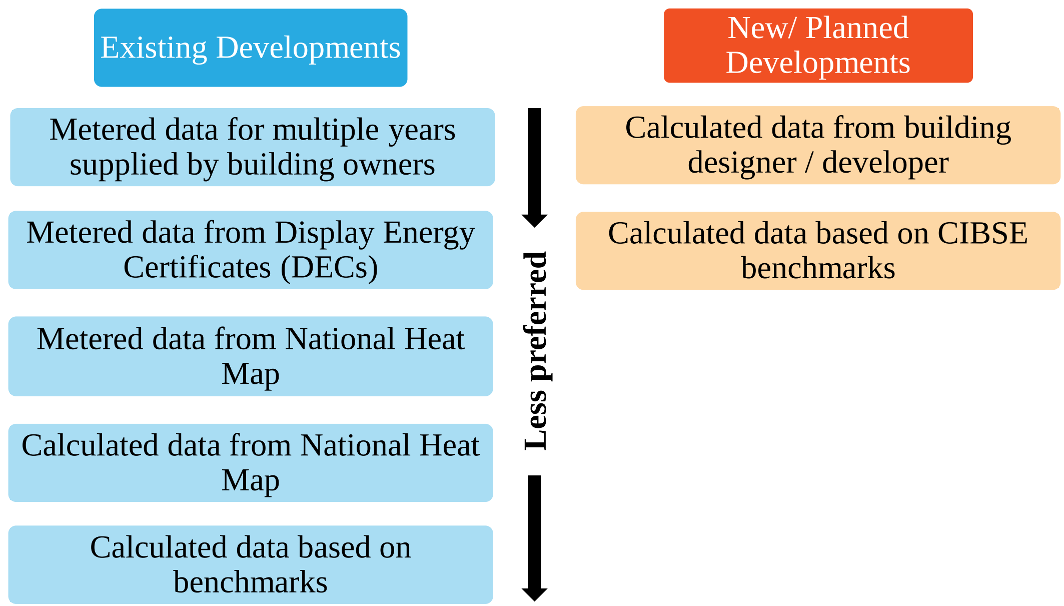

Figure 16 showing the hierarchy of heat load data

There were uncertainties associated with building locations, property size and typology in the AECOM study. To overcome this, under OPDC guidance Arup contacted each developer and building owner to confirm that the floor area and building typology and any changes that had occurred.

The stakeholder engagement revealed that there were buildings whose designs remain unconfirmed, for example the developer who owns 142-154 Victoria Road could not confirm their aspirations for the site. In these situations where the developer could not confirm load the details on the most recent planning documentation were included as they are the best possible information that could be accessed.

The floor areas and construction completion dates collected for the different buildings can be seen in Table 13 Energy Demands Summary.

Table 13 Energy Demands Summary

Building	**Heat on Date**	**Heat Load (kWh/year)**	**Floor Area (m^2)**
Perfume Factory	January 2021	1,616,580	25,050

Building	Heat on Date	Heat Load (kWh/year)	Floor Area (m^2)
Imperial College	January 2020	2,419,333	31,326
Carphone Warehouse / 1 Portal Way	January 2027	3,665,268	51,034
6 Portal Way	September 2020	493,288	3,079
The Portal	January 2021	1,321,353	21,849
Lyra Court	complete	459,871	7,098
Former BBC Studio	complete	1,553,417	26,639
Holbrook House	June 2019	721,313	12,526
Monarch House	January 2020	1,959,393	12,631
Gypsy Horn Lane	January 2019	2,379,456	12,393
Victoria Square	complete	718,362	10,920
NEC House	complete	1,996,826	21,020
2 Portal Way	January 2021	2,279,898	27,046
Friary Park Estate	January 2020	2,412,018	60,000
142-154 Victoria Road	January 2019	250,434	3,998
5 Portal Way	January 2019	631,669	3,943
Land to the Rear of Western Court Rosebank	January 2019	138,209	2,297

7.2.2.2 Cooling Demand Assessment

Using BSRIA benchmarks for cooling loads for office, hotel and retail space, we carried out a preliminary analysis of cooling demand in North Acton, to compare it with yearly heating demand and consider the opportunity to make a district cooling network or a condensing loop network.

The estimated cooling demand is around 8 MWh year, while total heating demand is around 25 MWh year. At this stage of the study, total cooling demand is not sufficient to justify further investigation of cooling networks in North Acton.

7.2.2.3 Electrical Demand Assessment

Building	Heat on Date	Electrical Load (kWh/year)	Floor Area (m2)
Perfume Factory	January 2021	277,050	25,050
Imperial College	January 2020	1,580,148	31,326
Carphone Warehouse / 1 Portal Way	January 2027	706,350	51,034
6 Portal Way	September 2020	695,899	3,079
The Portal	January 2021	190,275	21,849
Lyra Court	complete	75,662	7,098
Former BBC Studio	complete	205,921	26,639

Building	Heat on Date	Electrical Load (kWh/year)	Floor Area (m2)
Holbrook House	June 2019	92,690	12,526
Monarch House	January 2020	55,860	12,631
Gypsy Horn Lane	January 2019	42,840	12,393
Victoria Square	complete	121,320	10,920
NEC House	complete	580,455	21,020
2 Portal Way	January 2021	34,762	27,046
Friary Park Estate	January 2020	420,000	60,000
142-154 Victoria Road	January 2019	38,730	3,998
5 Portal Way	January 2019	891,118	3,943
Land to the Rear of Western Court Rosebank	January 2019	32,942	2,297

7.3 Scenario Formulation

7.3.1 Phasing Considerations

The buildings on the site are due to be complete in different years, this is shown in Figure 17.

When evaluating a potential district heating scheme the different connection dates are very important both technically and commercially. For example a pipe may have to be oversized to be large enough to cater for future loads that will connect, adding cost and operational complexities with no additional revenues in the near-term. For this reason a scheme has to be designed and modelled to give careful consideration to the phasing.

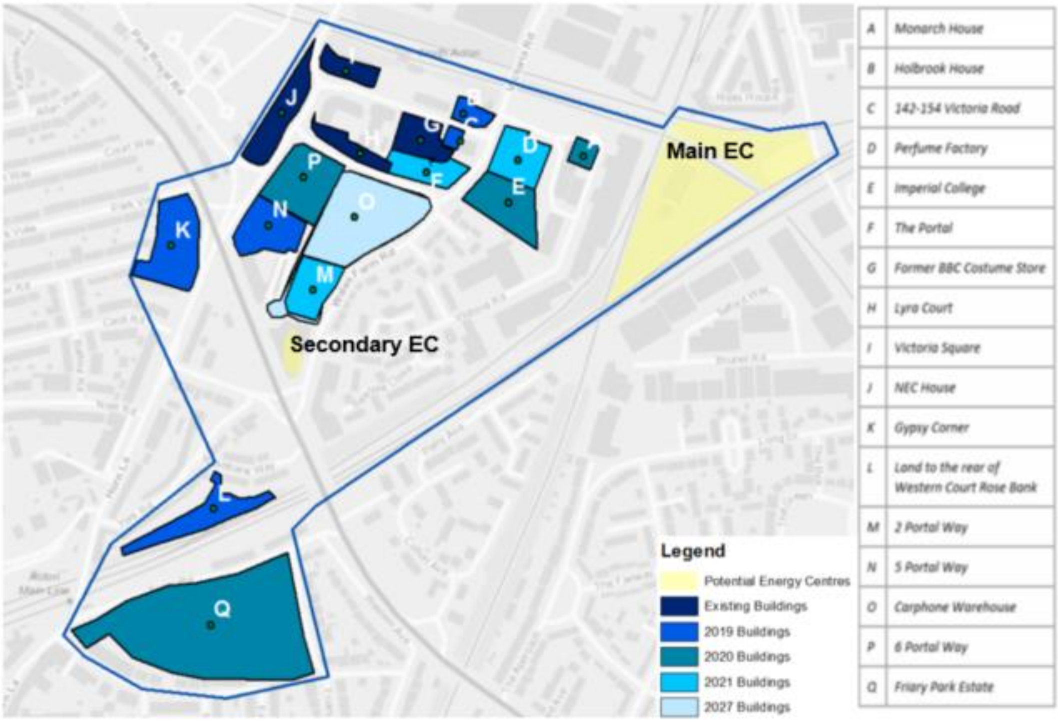

Figure 17 Buildings of interest split by phase

As can be seen in Figure 17 the buildings are not clustered dependent on completion date, making phasing less advantageous. Without temporary heating solutions being installed in the new buildings, the entire network would need to be constructed by 2020 to cater for the periphery buildings which will be complete by 2020. This installation of the network with a smaller number of buildings initially connected to a heating load will make the scheme less economical.

Changing the design of a building to accommodate a heat network connection is more complex and expensive at the later stages of design. Therefore the most plausible buildings to be connected to a network will be those built after 2020, given that designs can still be updated with minimal cost.

The least plausible buildings to connect to a heat network are those that exist, as they already have capital tied up in their plant and will gain little benefit from the space saving, as retrofit costs for existing plant rooms can be costly.

7.4 Technology Analysis

This section presents the different heat sources available as identified by AECOM and reviewed by Arup. This analysis fed into the development of the initial scenarios developed.

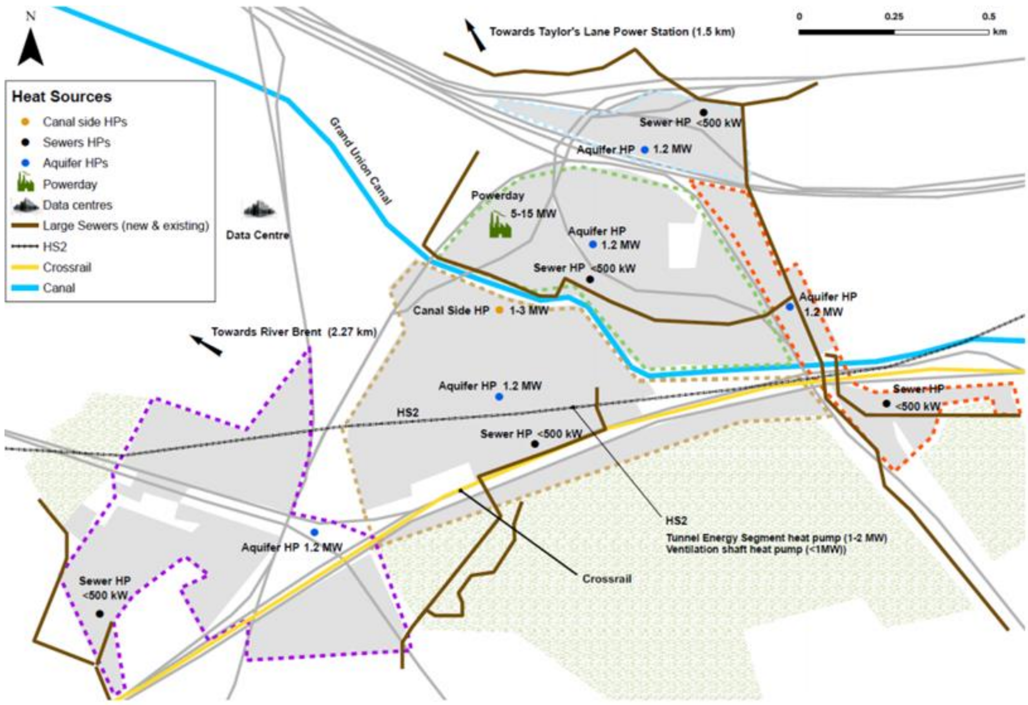

Figure 18 Map of supply sources as produced by AECOM

7.4.1 Heat Pumps

Heat pumps are a reliable and proven technology, which operate using a vapour-compression cycle. Operation is similar to that of a domestic refrigerator turning a unit of high-grade electrical energy into multiple units of low-grade heat energy. They are therefore typically driven through electricity via a connection to the electricity network. The efficiency of heat pumps is measured using the Coefficient of Performance (COP) which indicates the ratio of heat energy output to electrical energy input to the system.

Heat pumps are most suited to heating and cooling systems that require relatively moderate temperatures. However, low grade heat produced by heat pumps can be boosted by other energy supply technologies if higher grade heat is required (e.g. boilers).

Heat pumps do not release pollutants, commonly associated with degrading air quality such as nitrous oxides, sulphides or particulates. However, heat pumps depend on refrigerants which tend to be based on HFCs associated with adverse climate change impact.

7.4.2 Canal Heat Pump

One option of low grade heat that has been explored is the Grand Union canal. The water can be taken from the canal and the heat the extracted from it, via a water side heat pump. In order to comply with regulations, the water would then be returned to the canal at a lower temperature. Research by AECOM has suggested that the canal could potentially provide 1-3MW of heat. However, the location of the canal favours the connection of other heat loads which are closer and would not require c.1km of piping needed to reach North Acton. For this reason, it is not analysed in any of the scenarios modelled.

7.4.3 Sewage Heat Pump

This technology exploits the waste heat in sewer systems that could potentially be recovered and used in a district heating network. It consists of a series of curved metal heat exchangers each of approximately 1m in length. The maximum total length that can currently be installed is 200m with the main constraint on this being pumping and hydraulic considerations. Each 200m length is expected to produce 200-500kW of heat. The advantages of harnessing the waste heat from this resource is that it will generate the most energy during peak times. For example, in the morning when the heat demand is higher due to an increased use of hot water (showers etc.), the sewage also increases in temperature as the shower water goes into the sewer, resulting in a higher amount of potential heat recovery. SUEZ has experience of 15 case studies in France, the largest of which being the Sainte-Genevieve in Nanterre. The in–sewer heat exchangers output capacity equals 370 kW and the recovered wastewater heat is approximately, 337 MWh.

This is a relatively novel technology for the UK but has been delivered successfully by SUEZ and others in Europe. Previous conversations that Arup has had with Thames Water on the technology has suggest that they are positive about a potential pilot, but this will need to understand potential impacts for them and will need to be commercially attractive.

7.4.4 Aquifer Heat Pump

An open loop system could be installed in boreholes that allows water from the aquifer to be brought to the surface. If abstraction rates of approximately 20l/s were achieved per borehole then the expected thermal energy output of this resource could be 1.2MW. Extraction rates will be uncertain until boreholes are sunk, but this is a potentially deliverable source of heating and cooling that has been exploited elsewhere in London. Necessary licences would need to be obtained and renewed.

7.4.5 Gas CHP

Gas CHP systems capture the heat released during the power generation process. The most common technology used in small scale CHP applications are reciprocating gas engines. A well designed system can result in higher system efficiencies than using gas boilers combined with grid electricity.

Gas CHP systems are an established technology with a relatively low delivery risk. They use natural gas supplied by a gas provider and would normally require a gas booster to achieve the minimum input pressures required.

However, as the grid decarbonises, gas CHP will become more carbon intensive than electrical heating technologies, so in the future gas CHP will need to be replaced for low carbon technology. Gas CHP is currently a transitional technology and the validity of using gas CHP in a network depends on the emissions factors used. BEIS has concluded that any CHP commissioned after 2023 will have no net carbon savings over its lifetime. Using BEIS's Green Book long term average carbon emission factors we estimate that gas CHP will not be low carbon from 2018 onwards.

7.4.6 Seasonal Thermal Storage

Seasonal thermal energy storage provides a balancing function between the supply and demand of heat. Additionally, can act as an emergency buffer to ensure continuous supply in the instance of the other technologies failing or requiring maintenance. Typically heat energy can be gathered in the warmer summer months to be used in winter when peak demand is higher. Large hot water tanks are commonly used as an effective method of storing heat energy with a high thermal capacity of 70kWh/m^3, although such schemes are usually associated with a high CAPEX. An alternative solution is Pit storage, these schemes are comprised of a shallow dug pit that are filled with gravel and water. Storage pits are covered with a layer of insulation and then soil, so the land can continue to be used for alternative purposes. These generally have lower construction costs, than large water tanks, and a thermal capacity between 40-50 kWh/m^3. Pit Thermal storage is highly utilised in Danish district heating systems. The world largest thermal store (200,000m^3) was commissioned in Vojens, Denmark, in 2015, and allows solar heat to provide 50% of the annual energy for the world largest solar enabled district heating system.

7.5 Preliminary Scenarios

The preliminary scenarios tested are outlined in Table 14 below. The scenarios modelled includes a zero-carbon network (full dependence on electricity), a CHP led network and a building local solution.

Because the proposed capacity sizing of the Aquifer and Sewage heat pumps do not alone have the capability to cater for the site, a Ground Source Heat Pump was included in the zero-carbon network. The feasibility and space requirements of this still need to be confirmed.

Table 14 Preliminary Scenarios Tested

Scenario	CHP	Ground Source Heat Pump	Aquifer Heat recovery	Sewer Heat Recovery	Air Source Heat Pump
Zero Carbon Network	-	1 no. GSHP (2MW)	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	1 no. ASHP (1.5 MW)
CHP led Network	3 no. CHP (1.8 MW)	-	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	-
Building Local solutions	-	-	2 no. Aquifer HP (1.2 MW)	1 no. Sewer HP (0.5 MW)	Building Local ASHP (17.0 MW)

7.5.1 Network Routing

The indicative network route has been plotted following main roads to minimise cost and disruption during construction and maintenance. The secondary network is positioned approximately to supply groups of buildings, based on geographical and phasing considerations. The approximate total length of primary pipe for the indicative route is c. 1,250m. The route can be seen in Figure 19.

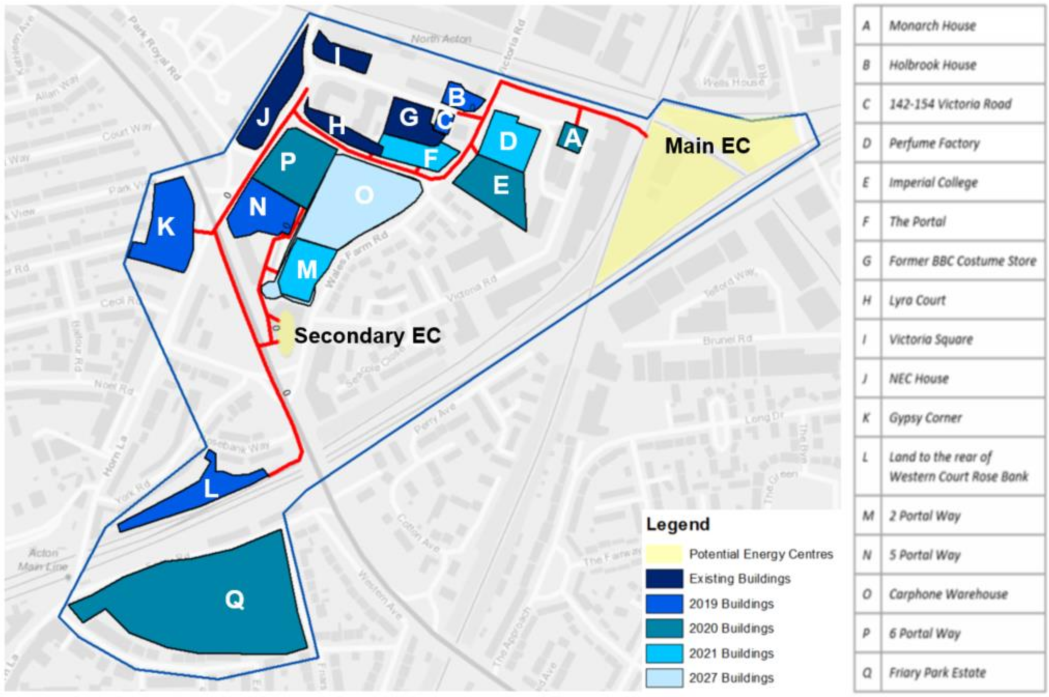

Figure 19 Proposed Network Routing of full scheme built out

The location of the proposed energy centres (in yellow) has been taken into consideration when proposing the indicative network route. The route encompasses separate energy centres/sources so that sewer heat recovery, CHP and aquifer can be used in combination to optimise the heat supply for the network.

7.6 Site Visit

On the 22/11/2017 Arup conducted a site visit in North Acton. The main outcomes are the following.

7.6.1 Main Energy Centre Location

The only way to access the site is via the side of the railway. However, this was not possible due to security and fences. The structure of the railway bridge doesn't seem to allow enough space for routing of pipes. Confirmation from OPDC is needed to identify the ownership of the land and the possibility of using it for the energy centre.

Figure 20 Access to the area

Figure 21 Main Energy Centre location

7.6.2 Secondary Energy Centre Location

The location is close to a major road. The position of the sewer is not clear, and more detailed underground utility maps will be needed. Arup will investigate ownership of possible Energy Centre locations.

Figure 22 Crossroad near the location

7.6.3 Land to the Rear of Western Court and Rose Bank

This site is small and remote from the other planned developments and surrounded by other residential areas not included in OPDCs list. Arup will investigate the impact of excluding this development from the network.

Figure 23 Development seen from the other side of the railway

7.6.4 Pipe Routing

The pipe routing has typical challenges associated with urban developments. It will be necessary to make a few road crossings which will cause disruption. However, there are no bridges, significant tunnelling or gradients that can cause difficulties.

7.7 Preliminary Results

7.7.1 Presentation of financial results

The financial results have been reported as follows:

25 and 40 year Net Present Value (NPV) of scheme at a **6%** discount rate and calculation of the connection charge per new dwelling required to make the NPV in each case equal to zero.

25 and 40 year Internal Rate of Return (IRR) of scheme

The validity of results are strongly dependent on the assumptions these are based upon. Given this is based on preliminary planning documents and new supply technologies, certain cost and technical assumptions may need to be revisited when progressing to a more detailed appraisal stage. Heat pricing and connection charges will be subject to agreements with the respective building owners and may vary on a case by case basis.

The preliminary results are presented in Table 5, based on the modelling conducted thus far.

Table 15 Indicating the preliminary results of the study with a 6% discount rate

Scenario Name	Zero Carbon Network	CHP Led Network	Building local solutions
Average Annual Heat Demand (kWh)	25,500,000	25,475,050	25,500,000
Total Capital Costs (£)	£13,400,000	£14,199,255	£22,000,000
25 year pre-tax IRR	9.1%	9.3%	1.4%
25 year pre-tax NPV (6% discount rate)	£2,200,000	£2,900,000	-£5,300,000

7.7.2 Carbon Calculations

The carbon results show a significant decrease in carbon emissions in all three scenarios compared to the counterfactual, as shown by Figure 24.

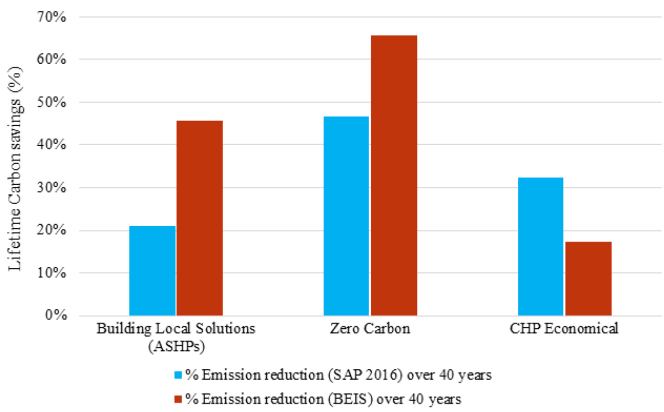

Figure 24: Carbon emissions change in different scenarios

The building local solution is reliant on Air Source Heat pumps which require more electricity than the heat pumps used on the network, this results in a lower carbon saving.

7.7.3 Sensitivity Analysis

The uncertainty of the timeframes remains the largest risk associated with the proposed network. As discussed in section 7.3.1, the delay will result in multiple buildings being completed before being connected, which will reduce their incentive to connect.

To analyse the effect of a delay, the project start date was tested as a sensitivity, with those buildings constructed by 2019 not connecting until 2030 when their plant will need replaced. The change in IRR can be seen in Figure 25.

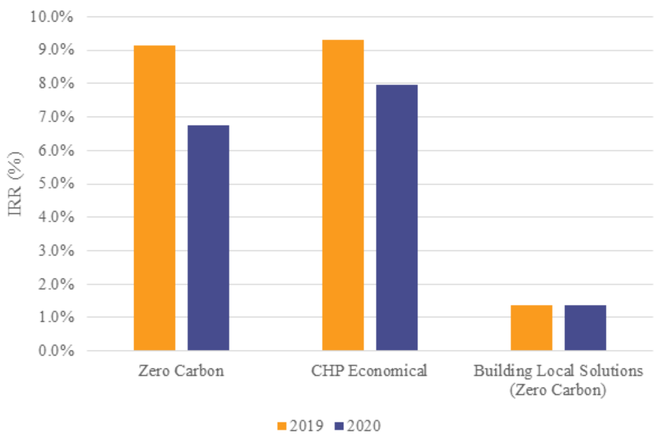

Figure 25 Change in IRR (%) if the scheme is delayed by one year

7.8 Preliminary Conclusions

The results indicate that there is a district heating scheme that would provide lower carbon heat while also providing a discount in energy prices to those buildings connected to the network.

The most favourable buildings to connect are those that will not be constructed until 2020 and beyond, meaning that designs can be more easily changed and the potential cost savings of the network realised.

Delaying the construction of the scheme from 2019 to 2020 will have a detrimental effect on the IRR of the scheme. If the scheme is not complete by 2019 a large proportion of buildings on the site will already have completed construction and have purchased heating plant. This will reduce the financial incentive for these buildings which will have an overall detrimental impact on the economics of the proposed scheme.

The scenarios modelled have demonstrated that a combination of CHP and heat pumps can deliver a lower carbon solution. Future scenarios will be tested to evaluate even lower carbon network set ups.

8 Interim Commercial Note

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Project title	North Acton District Heating Network	**Job number**	25831-00
cc		**File reference**	4-07
Prepared by	Stephen Cook Alper Ozmumcu	**Date**	November 2017
Subject	Interim Note on Commercial Delivery Models		

8.1 Introduction

8.1.1 Purpose

This note provide an interim review of potentially suitable commercial delivery models for the proposed North Acton heat network.

8.1.2 Approach

In contrast to other utility services, the heat market is largely unregulated at the national level; it is therefore the contracts between the different parties to a heat service that establish the necessary rights and obligations of each party. Consequently practice varies widely, and delivery models range from wholly public to wholly private, with many configurations in between.

Arup's 2016 guidance for BEIS on commercial delivery of heat networks identifies thirteen different roles associated with heat networks (see Appendix A for a summary of these roles).[1] The particular choice of delivery model is closely related to how these roles are allocated by circumstance or by choice (see Appendix A for more information on roles).

We have drawn upon this guidance and prior project experience, along with the circumstances at North Acton, to consider the potential allocations of roles and how these allocations could combine into particular structures of contractual relationships between the relevant parties.

8.1.3 Basis of review

The review takes account of:

- the current technical parameters of the proposed network; and
- our current understanding of the key actors, their drivers, preferences for roles and their appetite for risk.

In the case of developers, at the time of writing we have very limited direct information on their drivers, preferences and risk appetite; therefore assumptions have been made based on prior experience. This information gap will be addressed through the planned engagement with developers over the next fortnight.

In the case of ESCos, we have completed two of three planned ESCo market engagement discussions; the responses of these two ESCos, along with prior experience, are reflected in the note.

8.1.4 Structure

The note is structured as follows:

- Section 2 sets out the particular commercial context in North Acton which has shaped the selection of commercial delivery options
- Section 3 describes the three proposed commercial delivery options
- Section 4 provides a summary and comparison of the three options, in relation to allocation of roles, risks and opportunities.

Two appendices provide additional background information in relation to commercial options:

- Appendix A provides additional context on the roles in a heat network

- Appendix B describes the different ways a heat network is paid for

8.1.5 Next steps

Following receipt of comments from OPDC and project steering members (i.e. LB Ealing, GLA) and feedback from the developer and remaining ESCo consultation, the text of this note will be updated and incorporated into a draft final report.

8.2 North Acton commercial context

In relation to the North Acton area, we have identified the main features of significance:

Table 16 North Acton features of commercial significance

Feature	Significance
The area is characterised by multiple new private development sites of medium scale (all but one site with less than 2.5GWh/annum and 60,000m^2). We have identified 17 development sites, each with a different owner/developer, although Imperial College appears to have control and/or influence over several of these sites.	Developers rarely take unilateral action to coordinate development and infrastructure beyond their boundaries or direct interests, particularly when there is no dominant development site in a given area. Similarly, private ESCos will not seek to develop a heat network where there is no certainty over whether and when developments will connect. We conclude that: • OPDC, LB Ealing or GLA needs to take the **Promoter** role. • A public sector body or an appointed ESCo will need to take the **funding** and **sale of heat** roles.
Four of the seventeen developments have already been built, and nine others are due for completion by 2020 or sooner.	Securing commitment of the early developers demands an early, rapid process to confirm the entity which can commit to deliver heat to the developers' sites. Procurement of a private sector partner through a "beauty contest" (see section 8.3.2) approach could be a faster route to market than a procurement based on a fully developed scheme. A public sector ESCo could also be set up quickly, although this depends on governance timescales within the relevant body (OPDC, LB Ealing or GLA).
The economic assessment of a network serving the new developments indicates a return on investment of 4-6% over 25 years (depending on different scenarios). This performance is eroded if the 2019 developments are not connected from the start.	At such a rate of return, the scheme would be considered economically beneficial but not commercially attractive. Additional funding would be needed to bring the scheme up to a commercially attractive rate of return (typically 12%). Alternatively, a public sector body could choose to deliver the scheme.

Feature	Significance
No significant sites are in public ownership.	The public sector cannot provide guarantees on heat demand from private sites, nor is a concession-type delivery model practicable. Therefore agreements with developers for a heat connection are a necessary pre-requisite to any private-led heat network model.
OPDC and LB Ealing each have the necessary powers to raise finance, acquire land and to procure and own a heat network. OPDC has sought funding from the government's Housing Infrastructure Fund which could give it access to substantial low cost capital.	OPDC or LB Ealing could choose to deliver a public-owned network, with a simple DBOM-type contract for delivery and operation of the network. A utility adoption model could provide OPDC/Ealing with a possible exit route following initial investment in the network.
Market engagement with ESCOs highlighted the need to underwrite demand risk and to coordinate the delivery of area-wide infrastructure.	As noted above, securing developer agreement to connect is a key network pre-requisite. Forward funding the primary network infrastructure would give developers confidence that the network will be delivered

8.3 Delivery models

We have identified three main options for delivery which appear to be consistent with the conditions described above. These are:

- Private ESCo voluntary concession (the Nine Elms model)
- Public sector initiated with a utility adoption
- Public sector led with a DBOM contract

Each are described in turn in the following sections. Roles, risks and opportunities for the three options are shown together in Section 4.

8.3.1 Private ESCo voluntary concession

The central challenge in North Acton is that there are seventeen different developers. Most of these have a commitment to connect to a heat network if it is built but none has a commitment to build it. A similar situation arose around the developments at Embassy Quarter in the Vauxhall Nine Elms Opportunity Area, which is described in the next section.

8.3.1.1 Embassy Quarter example

The US Embassy development had proposed to install large CHP engines and would deliver the heat to a network, but neither the embassy nor the nearby developers were willing to take responsibility for a network.

The GLA with support from Arup worked with the Nine Elms Vauxhall Partnership and the main developers to secure agreement to an approach that would overcome this "chicken and egg" situation. The key steps of this approach were:

1. A memorandum of understanding (MoU) was drafted and signed by all parties to enable GLA in-kind support to be provided by Arup through the Decentralised Energy Project Delivery Unit (DEPDU).
2. DEPDU ran a non-binding procurement process that resulted in the appointment of a preferred bidder ESCo and a secondary ESCo should the first fail to deliver.
3. DEPDU then facilitated preferred bidder engagement in contractual negotiations with all parties; developers were bound not to engage with other ESCos during this period as agreed through a Letter of Intent.

The process of negotiation by the ESCo (Engie) with the US Embassy and the respective developers has taken nearly two years to date. Although a considerable length of time, there have been notable achievements:

- The ESCo worked with developers through their building design stages to align them with the future network
- The local council (LB Wandsworth) underwrote the construction of a critical path section of pipework prior to full construction of the network.

8.3.1.2 Voluntary concession approach for North Acton

Applying the Embassy Quarter approach to North Acton, the voluntary concession option would involve the following key features:

- OPDC or LB Ealing act as project promoter, including procurement of an ESCo and securing agreement of developers to give exclusive rights to the selected ESCo to negotiate heat supply agreements with each developer.
- The ESCo would become the permanent owner and operator of the network and the seller of heat.
- If necessary, OPDC or LB Ealing underwrite early investment in critical path sections of the network.
- If necessary, OPDC or LB Ealing secures the necessary land acquisitions, easements and rights of way to enable the energy centre(s) and network to be constructed.
- LB Ealing as highway authority provides a commitment to grant the necessary licences for laying the network in the public highway.
- LB Ealing as development control authority agrees to vary conditions allow the developments to be supplied from temporary sources (gas boilers most likely) until the network is delivered. Similarly, conditions requiring on-site CHP would be relaxed.
- The heat supply and purchase agreements would be between the ESCo and the respective developers. Neither OPDC nor Ealing would be a counterparty to these agreements (although step-in rights may be secured for a "supplier of last resort" event).

The possible sequence of steps needed to achieve this option is illustrated in the figure below:

Figure 26 Indicative activities to deliver the voluntary concession model

		Quarter											
Activity	**Duration (months)**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
OPDC / Ealing governance process to confirm approach	3												
Negotiate MoUs with 17 developers	3												
Undertake procurement of ESCo	6												
ESCo negotiation period	12												
Development build period	24												
Network build out	12												

8.3.2 Public sector initiated with utility adoption

The second delivery model envisages a greater level of involvement by the public sector, but with a clear route for privatisation of the network and recovery of the initial public sector investment. Under the utility adoption model, there are two main phases of development:

- Phase 1 (pre-adoption): a public sector body – OPDC or LB Ealing – secures the necessary heat supply agreements with the developers and procures the delivery of a network. Depending on the details, the network could be fully delivered and the public body operating as an ESCo for the new developments.
- Phase 2 (post-adoption): an appointed private ESCo adopts the completed infrastructure, in whole or in part, and makes payments to OPDC / Ealing as the network is adopted.

The key feature of this approach is to keep the network delivery with the public sector during the high risk early phase, on the basis that OPDC or Ealing is more suited to manage the early process. Once the network is established and proven, it will be more attractive to the private ESCo market.

This approach also would enable OPDC / Ealing to proceed quickly to negotiate with developers for heat supply agreements. These agreements could be secured one by one and temporary solutions provided to deliver heat to properties which were occupied prior to completion of the network. In the event that insufficient numbers of developments were secured for the public ESCo, the agreements could be transferred back to the developer or successor landlord / estate management company.

A variant of this approach would be for OPDC / Ealing to appoint a private ESCo partner at an early stage through a simpler procurement based mainly on qualifications and strategic approach. This so-called “beauty contest” would avoid the duration and complexity of a procurement based on a fully worked up reference scheme and detailed pricing for works or heat supply. Once appointed, the role of the private ESCo would be to advise and support OPDC / Ealing while the developer supply agreements were negotiated. During this time, the ESCo partner would proceed with a design to be agreed by both parties. A contract price for the build would be negotiated following completion of the design, or OPDC / Ealing could procure the build by a third party contractor.

In either case, the adoption of the completed network by the private ESCo would be accompanied by payments to OPDC / Ealing, who thereby recover all or part of their initial investment in the network.

In common with the voluntary concession model, the public sector can also assist delivery of the network through a number of other actions:

- If necessary, OPDC or LB Ealing fund or underwrite early investment in critical path sections of the network.
- If necessary, OPDC or LB Ealing secures the necessary land acquisitions, easements and rights of way to enable the energy centre(s) and network to be constructed.
- LB Ealing as highway authority provides a commitment to grant the necessary licences for laying the network in the public highway.
- LB Ealing as development control authority agrees to vary conditions allow the developments to be supplied from temporary sources (gas boilers most likely) until the network is delivered. Similarly, conditions requiring on-site CHP would be relaxed.

The possible sequence of steps needed to achieve this option is illustrated in the figure below:

Figure 27 Indicative activities to deliver the public with utility adoption model

		Quarter											
Activity	**Duration (months)**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
OPDC / Ealing governance process to confirm approach	3	■											
Negotiate heat supply agreements with 17 developers	6		■	■									
Undertake procurement of ESCo partner	6			■	■								
Network build out	12							■	■	■	■		
Development build period	24					■	■	■	■	■	■	■	■
Network adoption period	6											■	■

8.3.3 Public sector led with DBOM contract

The simplest option would be for a wholly public sector led network, with all heat sale and purchase transactions remaining with OPDC, LB Ealing or a wholly owned special purpose vehicle (SPV) established to own and operate the network.

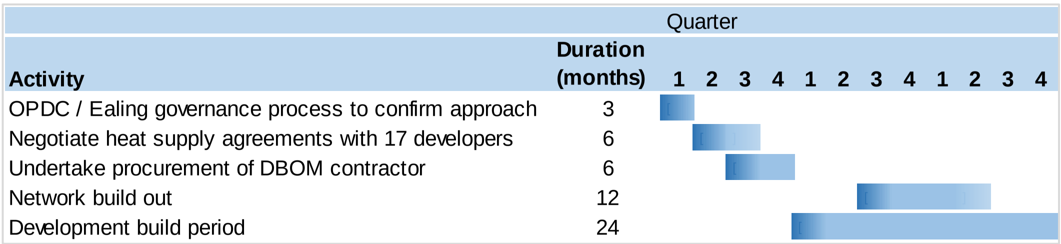
We would expect the network itself to be delivered and operated under a conventional design, build, operate and maintain (DBOM) contract. This would be a fixed price contract, potentially with incentives for system efficiency or minimising carbon emissions. Metering and billing services could be outsourced or kept in house, depending on whether OPDC / Ealing has or can acquire in-house resources for these services.

In common with the voluntary concession model, the public sector can also assist delivery of the network through a number of other actions:

- If necessary, OPDC or LB Ealing fund or underwrite early investment in critical path sections of the network.
- OPDC or LB Ealing secures the necessary land acquisitions, easements and rights of way to enable the energy centre(s) and network to be constructed.
- LB Ealing as highway authority provides a commitment to grant the necessary licences for laying the network in the public highway.
- LB Ealing as development control authority agrees to vary conditions allow the developments to be supplied from temporary sources (gas boilers most likely) until the network is delivered. Similarly, conditions requiring on-site CHP would be relaxed.

The possible sequence of steps needed to achieve this option is illustrated in the figure below:

Figure 28 Indicative activities to deliver the public with public led model



8.4 Summary of commercial options

The roles for the commercial delivery options are summarised in the table below. A further table summarises the key risks and opportunities for each option.

Table 17 Summary of delivery models and roles

Role	**Private ESCo voluntary concession**	**Public delivery with adoption**	**Public sector led with DBOM**
Promotion	OPDC or LB Ealing	OPDC or LB Ealing	OPDC or LB Ealing
Customer	Developers (initially) Landlords Tenants Owners / leaseholders	Developers (initially) Landlords Tenants Owners / leaseholders	Developers (initially) Landlords Tenants Owners / leaseholders

Role	Private ESCo voluntary concession	Public delivery with adoption	Public sector led with DBOM
Governance	Private ESCo, with representation by developers and customers	Pre-adoption: OPDC or Ealing (or an SPV owned by them), with representation by developers and customers Post-adoption: Private ESCo (e.g. SPV transferred to SPV), with representation by developers and customers	OPDC or Ealing (or an SPV owned by them), with representation by developers and customers
Regulation	The Heat Trust	The Heat Trust	The Heat Trust
Funding	Private ESCo Developers (through connection agreements)	Pre-adoption: • OPDC or LB Ealing • Other public funding such as HNIP or HIF • Developers (through connection agreements) Post-adoption: • Private ESCo (reimburse OPDC/Ealing through adoption payment)	OPDC or LB Ealing Other public funding such as HNIP or HIF Developers (through connection agreements)
Asset Ownership	Private ESCo	Pre-adoption: OPDC or Ealing (or an SPV owned by them) Post-adoption: Private ESCo (e.g. SPV transferred to SPV)	OPDC or Ealing (or an SPV owned by them)
Development of Property	Developers (17 no.)	Developers (17 no.)	Developers (17 no.)
Land Ownership	Private ESCo, Ealing and Developers	Pre-adoption: OPDC or Ealing (or an SPV owned by them) and Developers Post-adoption: Private ESCo (e.g. SPV transferred to SPV), Ealing and Developers	OPDC or Ealing (or an SPV owned by them), Ealing and Developers
Landlordship	Private landlords (where relevant)	Private landlords (where relevant)	Private landlords (where relevant)
Installation	Private ESCo	DBOM contractor	DBOM contractor

Role	Private ESCo voluntary concession	Public delivery with adoption	Public sector led with DBOM
Operation	Private ESCo	Pre-adoption: DBOM and metering & billing contractors Post-adoption: Private ESCo	DBOM contractor Metering & billing contractor
Sale of heat	Private ESCo Some landlords may on-sell to tenants	Pre-adoption: OPDC or Ealing (or an SPV owned by them) Post-adoption: Private ESCo (e.g. SPV transferred to SPV) Some landlords may on-sell to tenants both pre- and post-adoption	OPDC or Ealing (or an SPV owned by them) Some landlords may on-sell to tenants
Supplier of last resort	Development landlords / management companies LB Ealing could reserve step-in rights for primary infrastructure.	Development landlords / management companies LB Ealing (especially for primary infrastructure)	LB Ealing

Table 18 Risks and opportunities for each delivery model option

Role	Private ESCo voluntary concession	Public delivery with adoption	Public sector led with DBOM
Risks	• Too few developers agree to the approach to make a viable network • The market response is poor due to lack of confidence among bidders • The procurement takes too long and developers build stand-alone solutions • Negotiations take too long and developers build stand-alone solutions • Future network expansion and decarbonisation	• Too few developers agree to a heat supply agreement with OPDC/Ealing to make a viable network • The market response is poor due to lack of confidence among bidders • The procurement takes too long and developers build stand-alone solutions • Negotiations take too long and developers build stand-alone solutions • Future network expansion and decarbonisation	• Too few developers agree to a heat supply agreement with OPDC/Ealing to make a viable network • Public sector takes most risks on the scheme, including demand risk • OPDC / Ealing does not have access to necessary skills and resources to deliver and own a heat network, leading to poor contracts and/or poor network performance. • Future network expansion and decarbonisation

Role	**Private ESCo voluntary concession**	**Public delivery with adoption**	**Public sector led with DBOM**
	may be difficult to achieve.	may be difficult to achieve.	may be difficult to achieve.
Opportunities	• A network is privately financed with little or no public sector investment • The approach becomes a model for wider cooperation in the area on infrastructure planning	• Procurement is faster, or obviated in the short term, due to deferment of private sector investment and adoption of network • Commitments to expand, and to decarbonise network can be incorporated into adoption conditions	• Financial benefits from scheme stay with the public sector • OPDC / Ealing retains control to enable future network expansion and to decarbonise network. • DBOM contractor is easier and faster to procure than an ESCo

8.5 Heat Network Roles

The following is adapted from the Arup 2016 guidance for BEIS on strategic and commercial case for heat networks:

There are certain roles that need to be performed if a heat network is to be successfully implemented. These roles should be distinguished from the parties that might undertake them, since one party may take multiple roles and, likewise, a role could be fulfilled by multiple parties. The main roles that need to be undertaken during the delivery of any heat network are:

1. **Promotion**: The Promoter is a party with the motivation to establish a successful heat network and which takes responsibility for driving delivery.
2. **Customer**: The Customer (domestic or non-domestic) purchases heat delivered by the heat network.
3. **Governance**: The Governance role includes setting objectives, prescribing policies and rules of conduct and overseeing performance. These objectives, rules and policies will need to be prescribed by the contract(s) under which the network is operated.
4. **Regulation**: The Regulation role is focussed on consumer protection and to prevent abuse of the monopoly position of a heat network.
5. **Funding**: The Funder provides or arranges finance. Funders will normally require security against the funding they are providing, to mitigate their risk of financial losses.
6. **Asset Ownership**: The Asset Owner legally owns the physical assets of the network. Ownership could be split for different classes of assets (for example, generation assets, primary network and secondary networks).
7. **Development of Property**: In the context of heat networks, Developers of Property are the parties responsible for constructing or maintaining the buildings which will receive heat from the heat network.
8. **Land Ownership**: The role of the land owner, in this context, is to grant leases and easements for the siting of network assets and provide rights of access for the installation, operation and maintenance of plant and equipment.
9. **Landlordship**: The Landlord role, for buildings connected to heat networks, usually involves responsibilities for some network assets within the building, which may include the secondary and tertiary systems.
10. **Installation**: The installer designs and installs the heat network. Typically, this is the energy centre and primary network, with the secondary network being the responsibility of the Property Developer.
11. **Operation**: An Operator is responsible for the operation and maintenance of the heat network in such a manner as to ensure that heat (and potentially cooling and electricity) of suitable quality and quantity can be delivered to Customers.

12. **Sale of heat**: The sale of heat as a service is a logically distinct role from the physical delivery of heat to customers, as can be seen in the nationally regulated UK electricity and gas markets.
13. **Supplier of last resort**: Since heat is not regulated like gas or electricity, it is best practice to make alternative provision for a "supplier of last resort". This role involves providing heat to the customers if the scheme's provider is unable to do so.

Parties will need to be identified who can take on the responsibilities, risks and opportunities associated with each role. In many cases the roles will fall naturally to one or more parties – the Landlord role, for example – but in other cases a deliberate choice will have to be made to play a particular role. Each role comes with responsibilities that results in a set of risks and opportunities. Therefore where a role allocation is not pre-determined, the appetite of a Local Authority, or any other party, to take on a particular role will be influenced by their perception of the risks and opportunities.

The arrangement of parties and roles into a defined set of relationships, responsibilities and rights is referred to as a delivery model. Delivery vehicles might involve formal corporate entities created for the purpose of heat network delivery (e.g. a Joint Venture body or Special Purpose Vehicle), or they may make use of existing organisational structures.

There are many ways in which a heat network can be set up, from a wholly private sector solution with no public sector involvement to an entirely public sector funded, owned and operated scheme.

Agreeing the parties to undertake the roles will help determine this commercial setup. The process of allocating parties to roles is inherently iterative; needing to be aligned with the workable contract structures and procurement routes and also tested with the parties themselves. It is very important that proposed parties are engaged and their appetite for given roles tested before completion of the business plan and commitment made to a particular delivery model.

8.6 Heat Tariffs and Revenues

8.6.1 Standard heat network tariff

Most modern heat networks have a metered supply and charge customers based on a combination of a fixed annual standing charge and a variable heat consumption tariff. This approach is common to all retail energy utilities.

In the case of gas and electricity, a regulated market provides customers with the opportunity to compare suppliers and choose a particular service package and price which suits their needs and preferences. For heat networks, customers do not normally have the ability to switch suppliers in the market. Therefore the standard means of protecting consumers is to establish within the heat supply agreement a reference market price.

The reference market price is typically a local market comparator against an equivalent gas supply contract, taking account of the cost of maintenance and replacement of the boiler and other equipment (as these fall within the ESCo's responsibility). For tenanted properties, an ESCo may split the bill so that the portion related to the landlord's responsibility (under the Landlord and Tenant Act) to provide a heating system can be paid by the landlord, with the portion related to actual consumption paid by the tenant.

Based on Arup analysis, a new build two-bedroom flat with a consumption of 4,000kWh/year is likely to be paying in the region of 16p/kWh when maintenance and replacement costs are factored in.

Our recommendation is that the customer price should be based on a transparent comparator and provide minimum 10% discount on that for customer protection.

8.6.2 Heat as a service

An alternative tariff model would be offer a customer a service-based contract, where the ESCo was contracted to deliver an agreed level of comfort. This would be agreed as a fixed annual or multi-year charge based on an agreed target temperature and occupancy rate.

The heat service model offers a number of important advantages to a standard consumption-based tariff:

- The ESCo has an incentive to drive down consumption and maximise the efficiency of the system.
- The ESCo can invest in building efficiency measures to reduce the cost of delivering heat.

Such a model would be especially attractive for a network serving poorly insulated and maintained buildings. However many new buildings also exhibit a large performance gap between design and actual energy efficiency.

This model also carries significant risks and complexities:

- Customers may be confused by an unfamiliar tariff structure and may be concerned about the lack of flexibility to switch target temperatures.
- Significant monitoring equipment would be needed to ensure the ESCo was able to detect when a customer breached the conditions of the service agreement (e.g. opening windows in the winter).

Notwithstanding these challenges, the advent of smart metering and monitoring technologies and new service models in a variety of markets (e.g. transport, telecommunications and residential tenancies) suggest that heat service models should be seriously considered for future heat networks.

8.6.3 Developer contributions

Developers are typically required to make a capital contribution to new utility connections such as water, gas and power. A connection charge is also typically paid for heat network connections.

A developer's willingness to pay a connection charge will normally be no more than the developer's avoided costs as a result of that connection. This so-called counterfactual case will be made of three elements:

- Plant and equipment which the developer does not have to pay for (e.g. energy centre building, heating plant and heat interface units).
- Plant, equipment and/or building design standards needed to meet regulatory and planning requirements for carbon emissions. In London, the zero carbon standard and a £1800/tonne offset levy (£60/tonne x 30 years) means that a low or zero carbon heat network can deliver significant savings to a developer.
- Space savings on the development site which can be used for additional development floorspace.

Our approach is to focus on the first two of these elements in modelling potential connection charges. In London the estimate of avoided costs can range between £2000 and £6000 per dwelling unit for new developments. For existing developments, the avoided costs are often zero, or even negative, unless the timing of connection coincides with a major heating plant replacement milestone.