OPDC

North Acton District Heating Network

Additional Information

ISSUE |

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 258341-00

Ove Arup & Partners Ltd
13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

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	Stephen Cook
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		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.

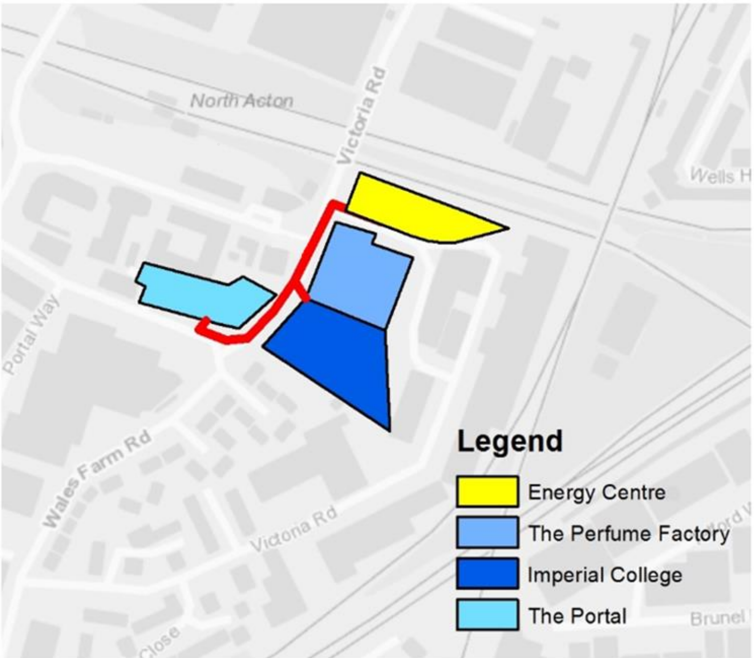


Figure 1 Kick-start network proposal

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 (CO2g/kWth)	2016 SAP Lifetime Emission Savings (tCO2)	BEIS Average Carbon Intensity (CO2g/kWth)	BEIS Lifetime Emission Savings (tCO2)
		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.

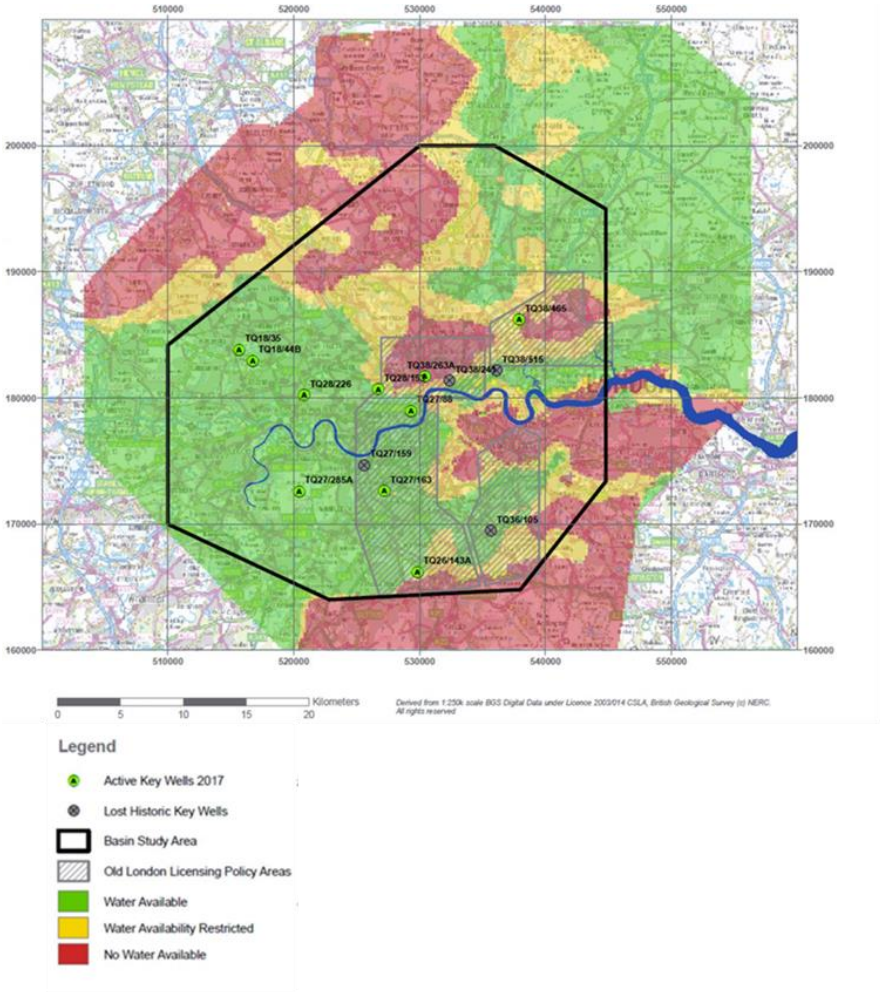


Figure 2 London Aquifer borehole locations

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

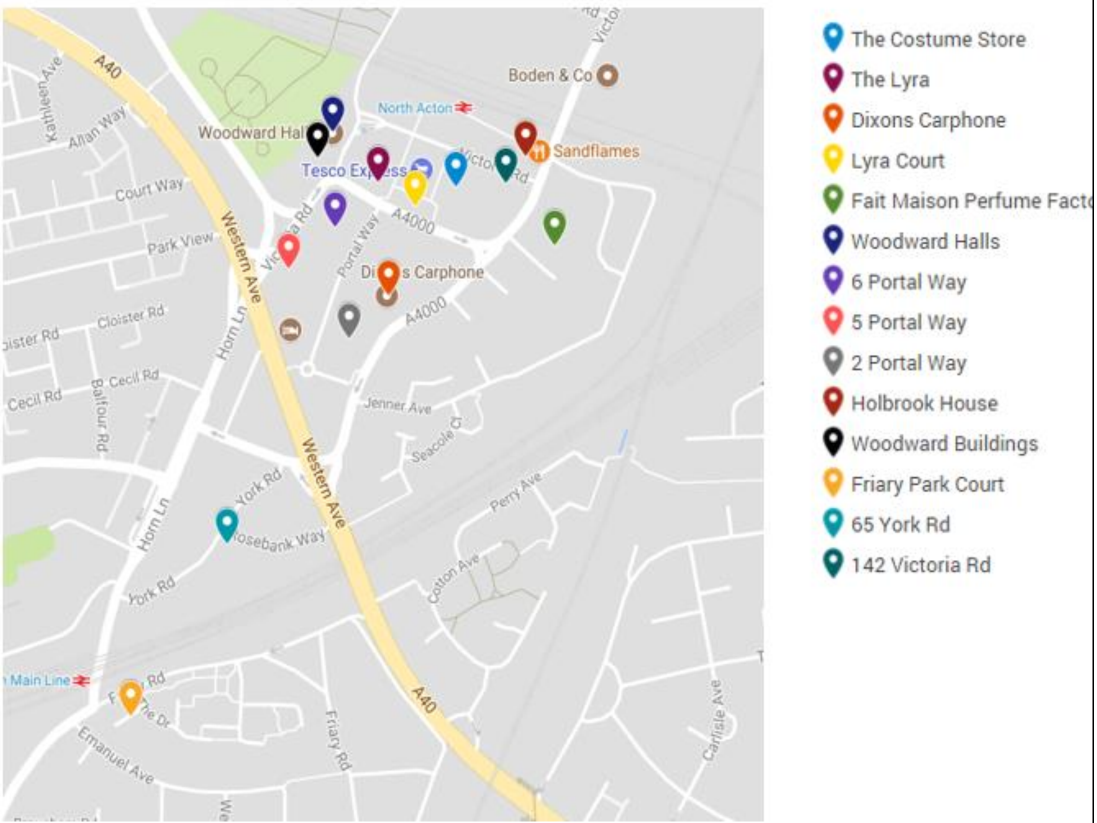
Arup has conducted a review and validation of the data available for developments that were identified in the original AECOM report for North Acton. We have made (or attempted) contact with all the developers identified in order to validate their scale and, where possible, predicted energy demands.

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.	

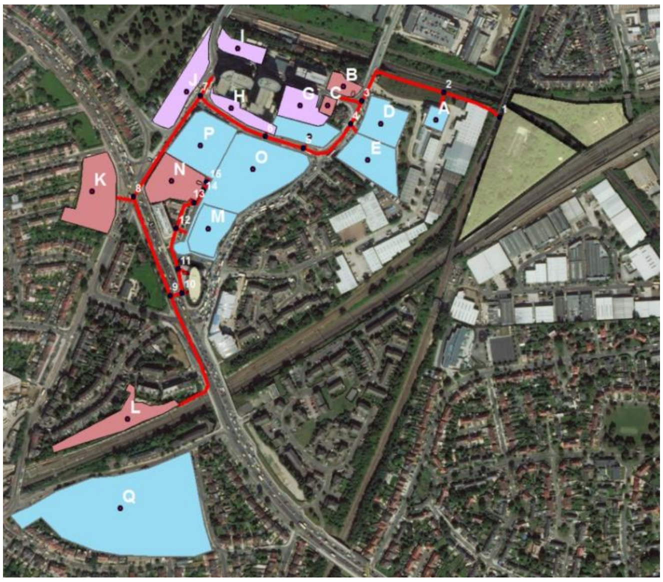
- The current draft OPDC local plan promotes district energy solutions at Old Oak common in line with GLA London Plan policy.

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

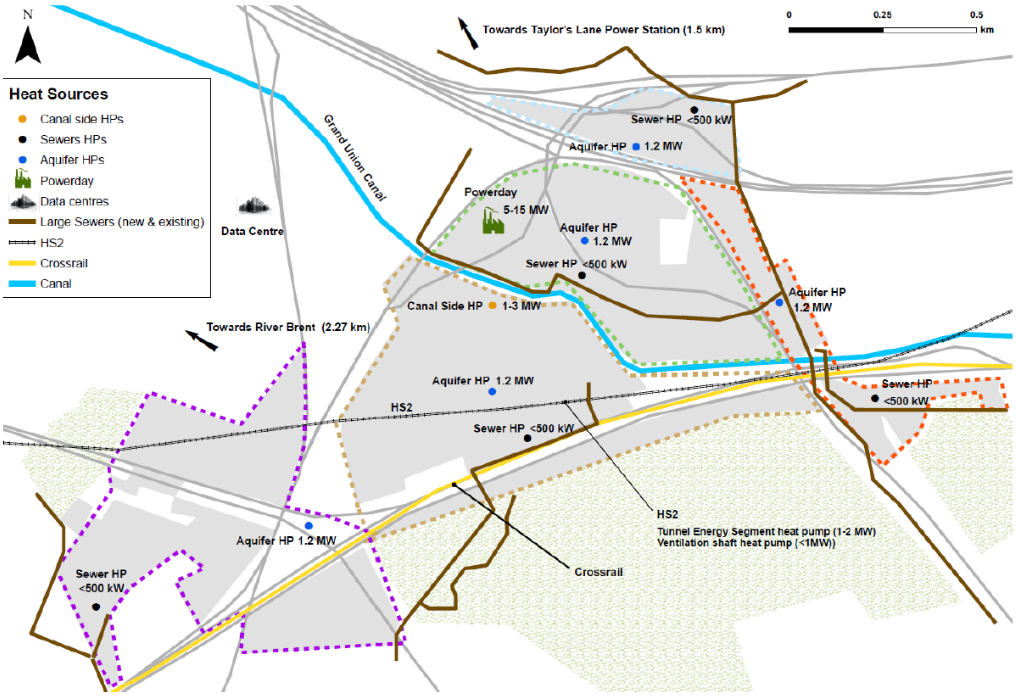
A	Monarch House
B	Holbrook House
C	142-154 Victoria Road
D	Perfume Factory
E	Imperial College
F	The Portal
G	Former BBC Costume Store
H	Lyra Court
I	Victoria Square
J	NEC House
K	Gypsy Corner
L	Land to the rear of Western Court Rose Bank
M	2 Portal Way
N	5 Portal Way
O	Carphone Warehouse
P	6 Portal Way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

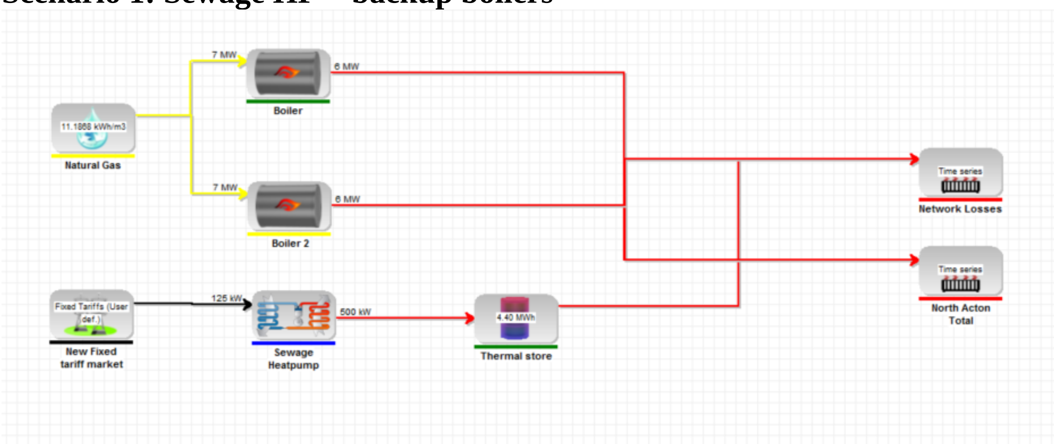
As mentioned, canal heat recovery and data centre heat recovery has been considered and discarded as viable options for the moment. These two energy sources could be considered for a future wider area integrated district heating grid.

14.	**Next Steps**

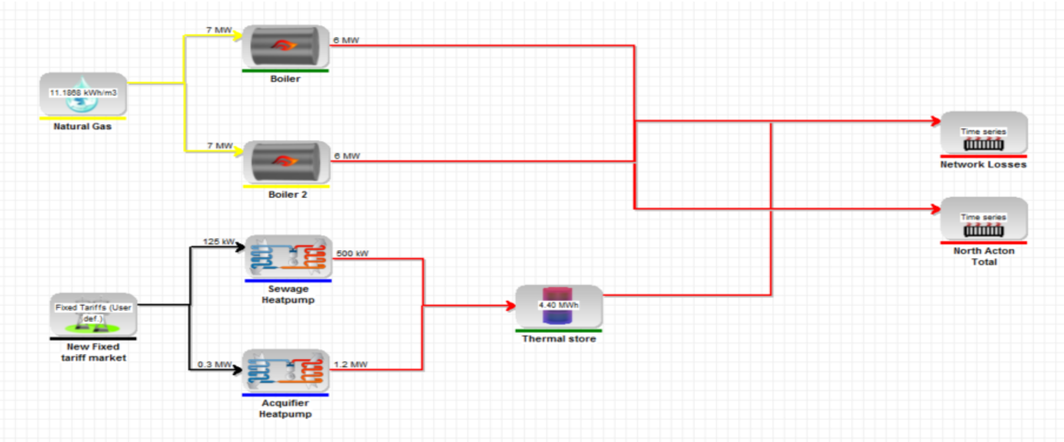
Arup will continue to model scenarios and will produce NPV and IRR results to compare in a draft technical report.

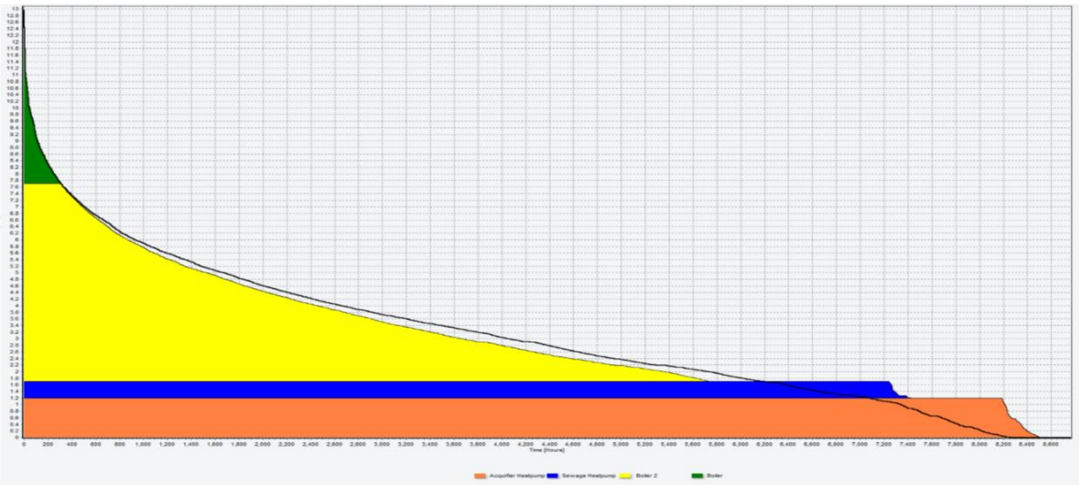
Appendix – Energy Pro Modelling

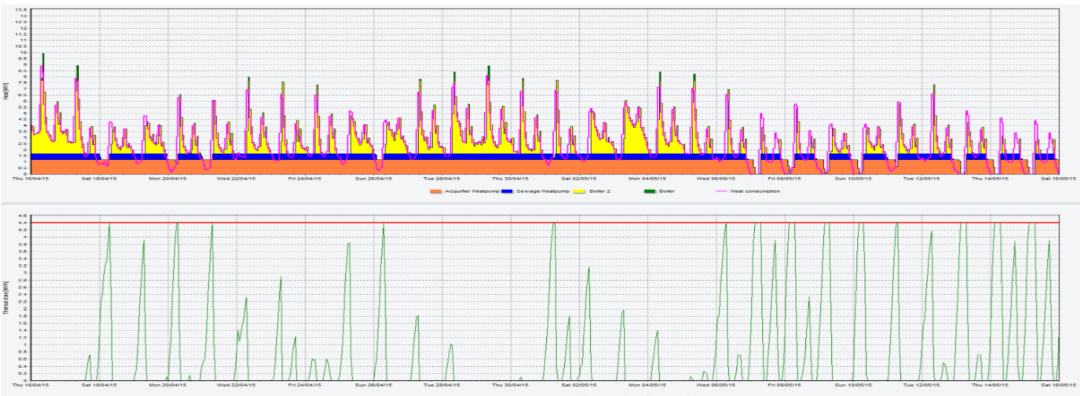
Scenario 1: Sewage HP + backup boilers



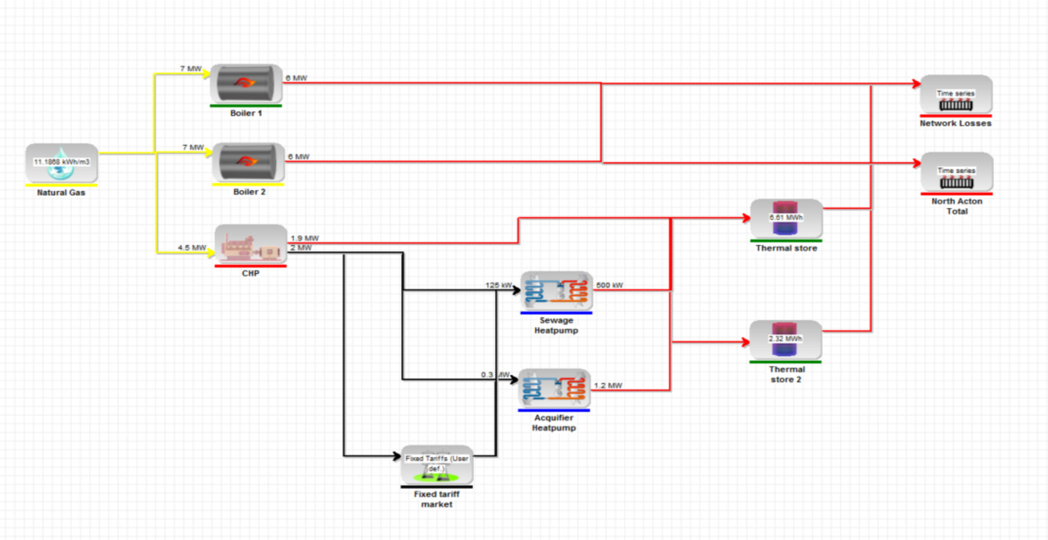
Scenario 2: Aquifer HP + sewage HP + backup boilers

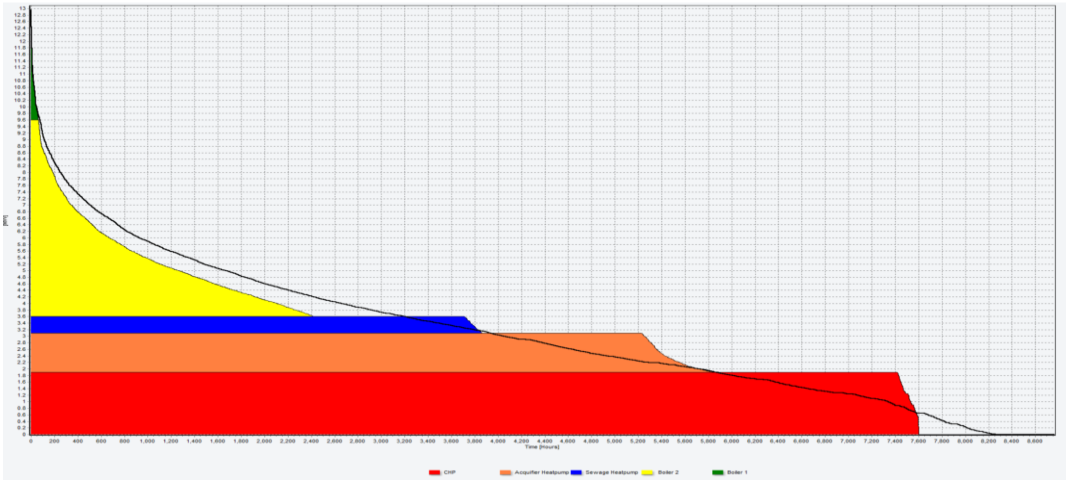

7 MW
6 MW
Boiler
11.1868 kWh/m3
Natural Gas
7 MW
6 MW
Boiler 2
Time series
Network Losses
Time series
North Acton
Total
125 kW
500 kW
Sewage
Heatpump
Fixed Tariffs (User def.)
New Fixed
tariff market
4.40 MWh
Thermal store
0.3 MW
1.2 MW
Acquifier
Heatpump

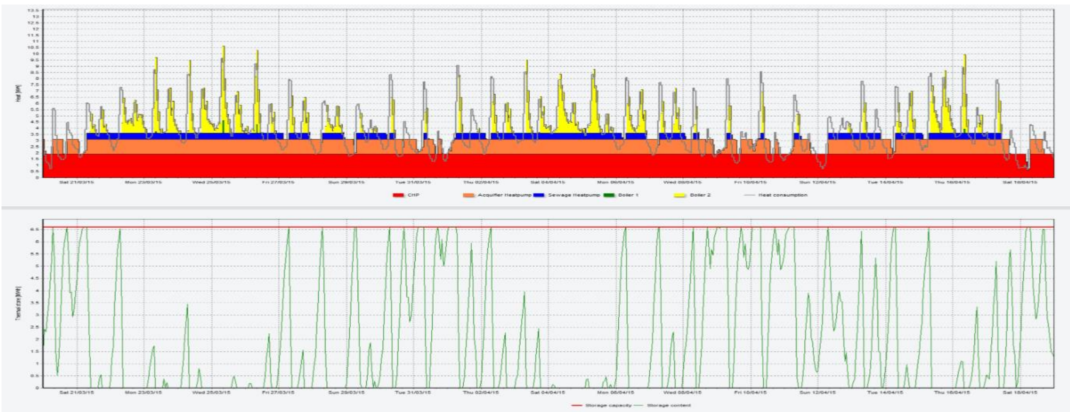




Scenario 3: CHP + aquifer HP + sewage HP + backup boilers







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.

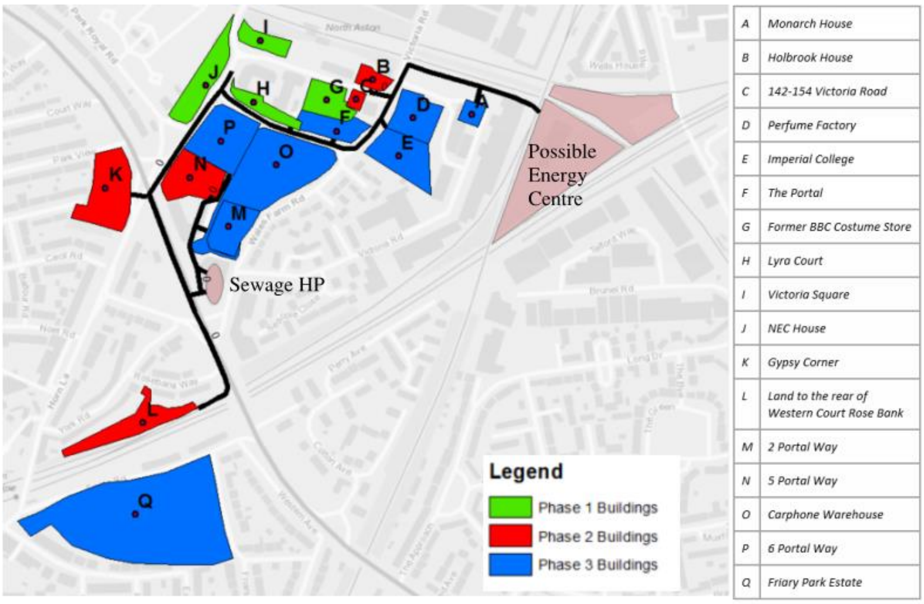


Figure 9 Indicating the phasing and routing of the OPDC scheme

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.

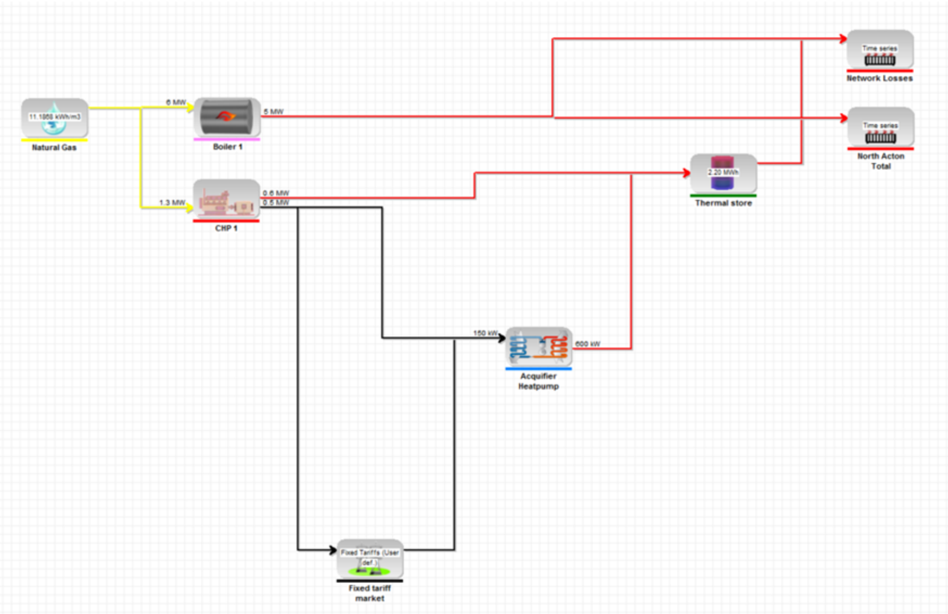
Table 5 Indicating the preliminary results of the study with a 6% discount rate

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

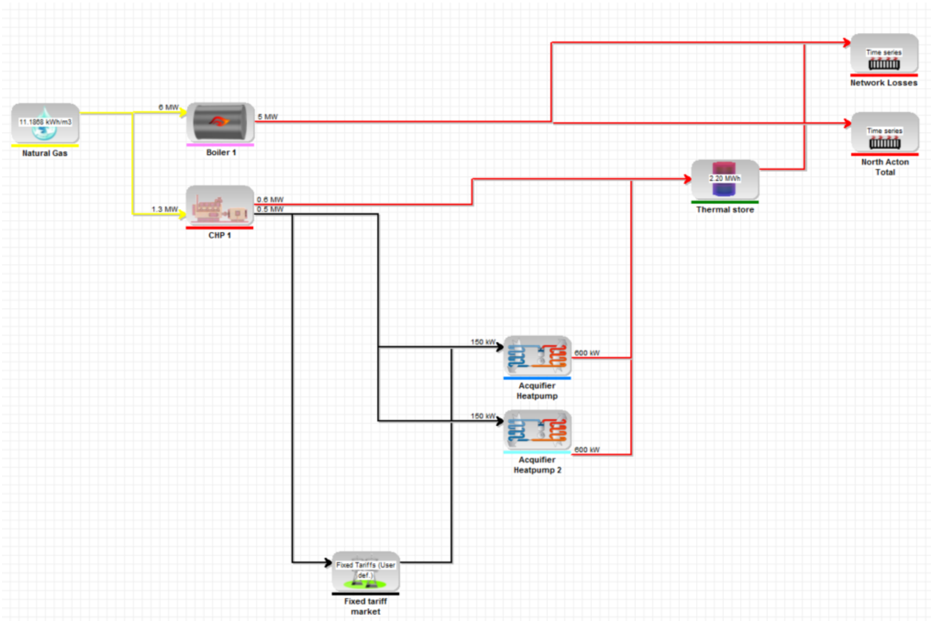
*Using SAP 3 year carbon intensity projections for UK electricity and gas The most favourable buildings to connect are those that will not be constructed until 2020 and beyond, meaning that designs can be more easily changed and the potential cost savings of the network realised. The way the network 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

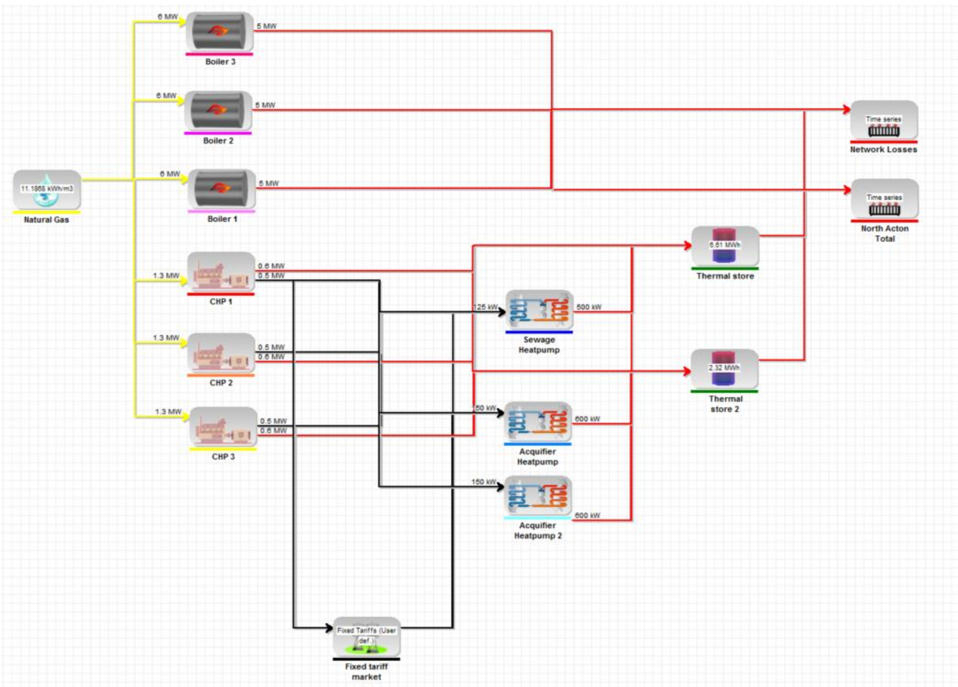
Scenario 1: CHP + Aquifer HP + backup boilers



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;

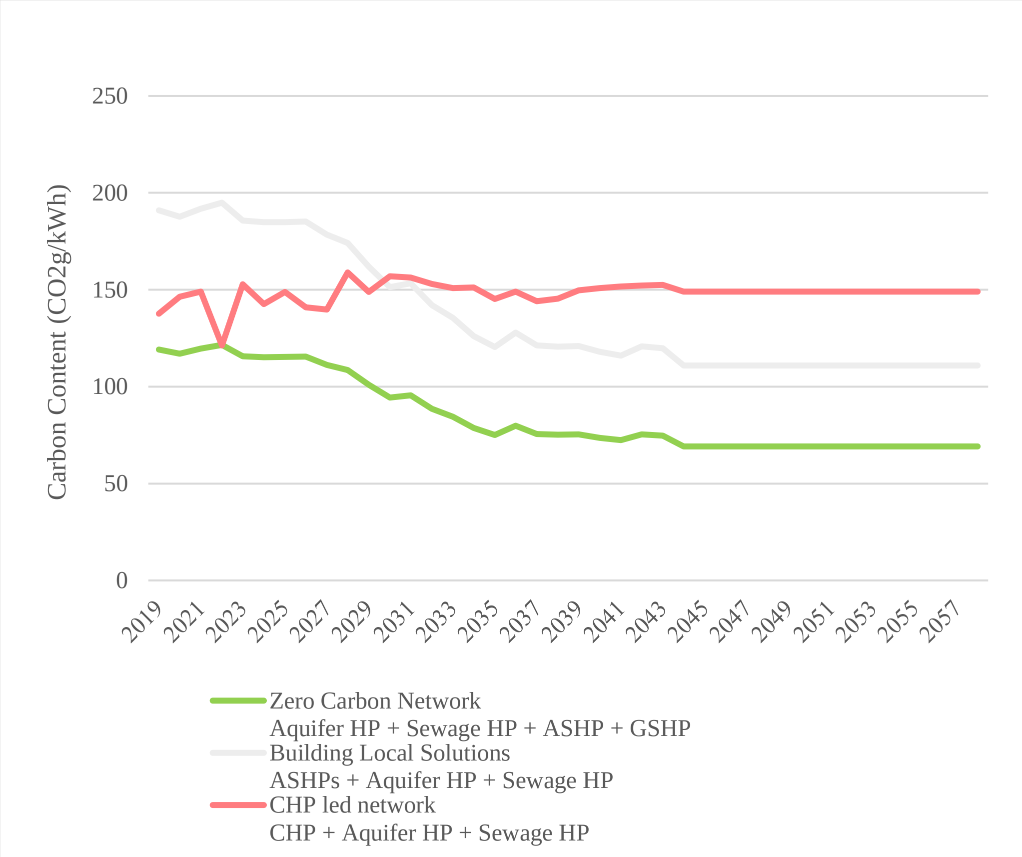


Figure 10 Carbon performance of the different scenarios to 2050*

*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 CO2 saved over scheme lifetime (SAP 2016) (tCO2) over 40 years	127,950	136,842	53,889
% Emission reduction (BEIS) over 40 years	66.10%	41.14%	45.63%
Tonnes of CO2 saved over scheme lifetime (BEIS) (tCO2) over 40 years	169,682	105,599	117,133
% Emission reduction (BEIS) over 15 years	54.91%	38.75%	27.68%
Tonnes of CO2 saved over scheme lifetime (BEIS) (tCO2) 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.

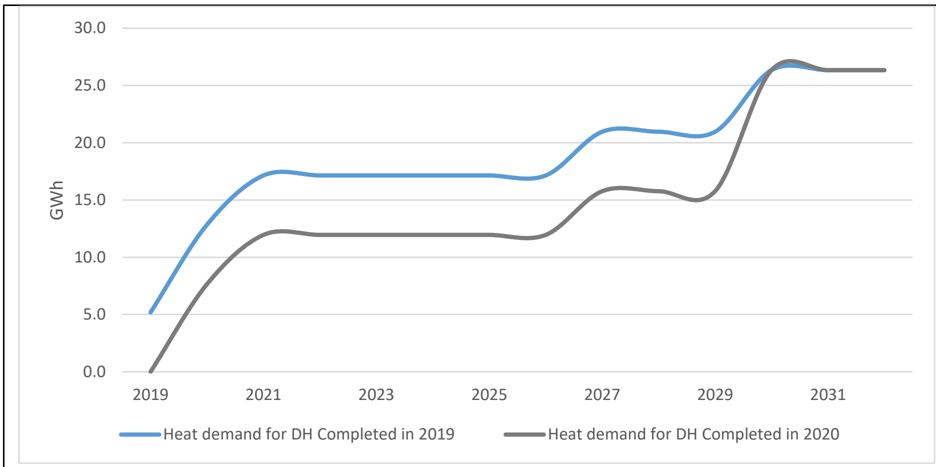
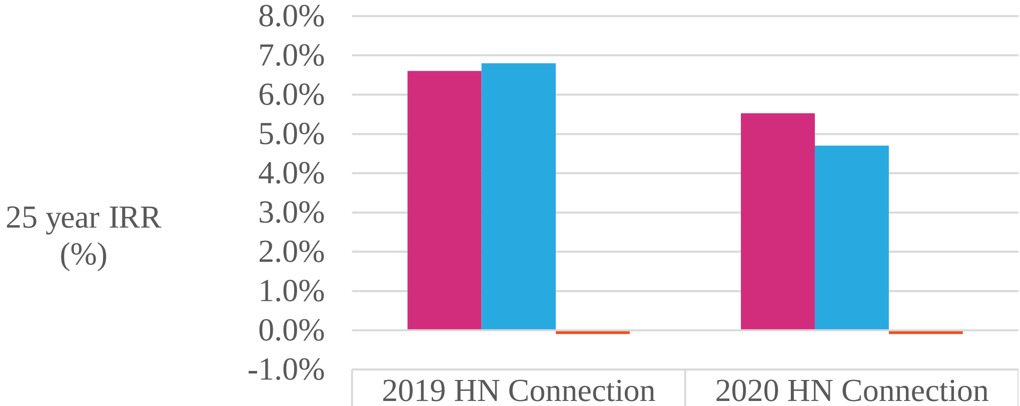


Figure 11 Cumulative Heat Loads on the OPDC site

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.

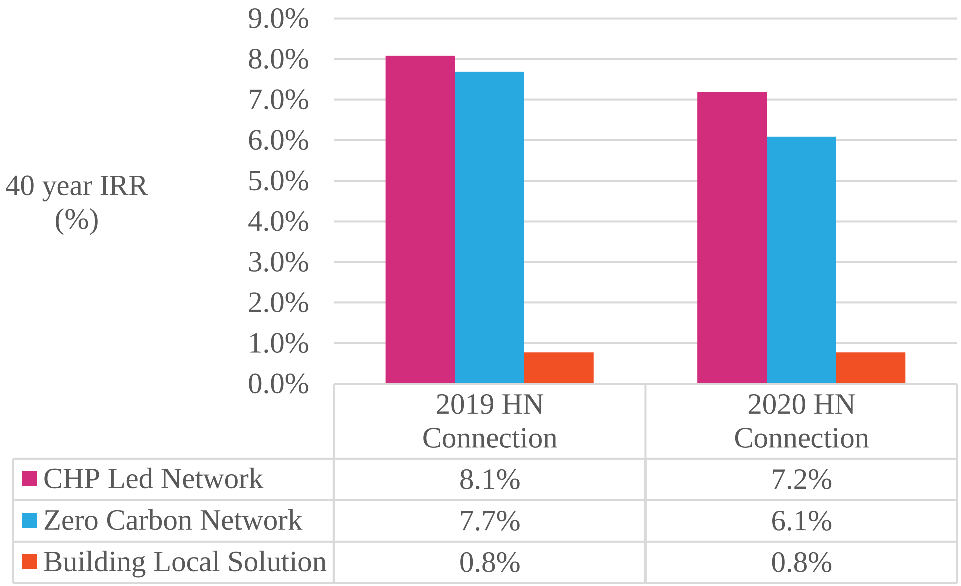


Figure 13 Financial performance of the different scenarios over 40 years

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 CO2 saved over scheme lifetime (SAP 2016) (tCO2) 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 CO2 saved over scheme lifetime (BEIS) (tCO2) 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 CO2 saved over scheme lifetime (BEIS) (tCO2) 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
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.

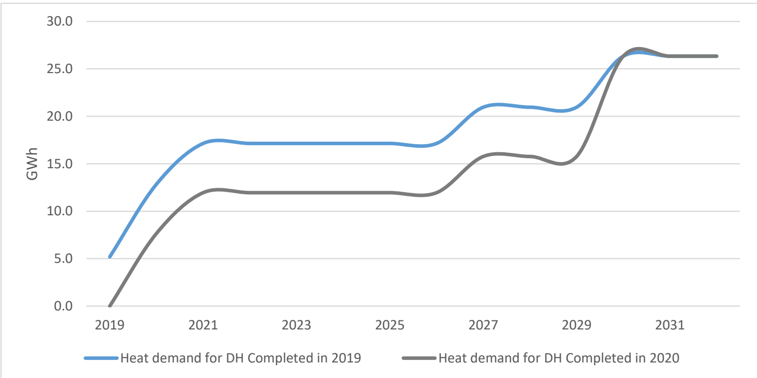


Figure 14 Cumulative Heat Loads on the OPDC site

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:

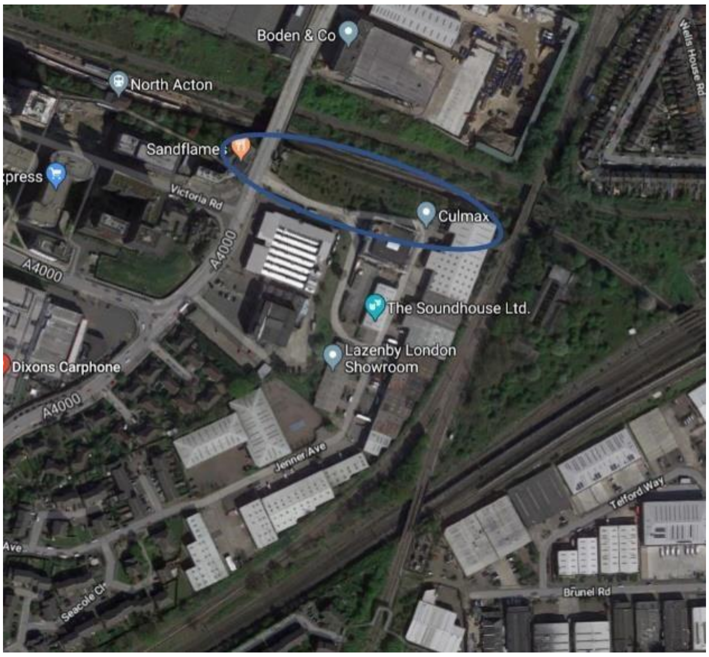


Figure 1 Energy Centre location

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.

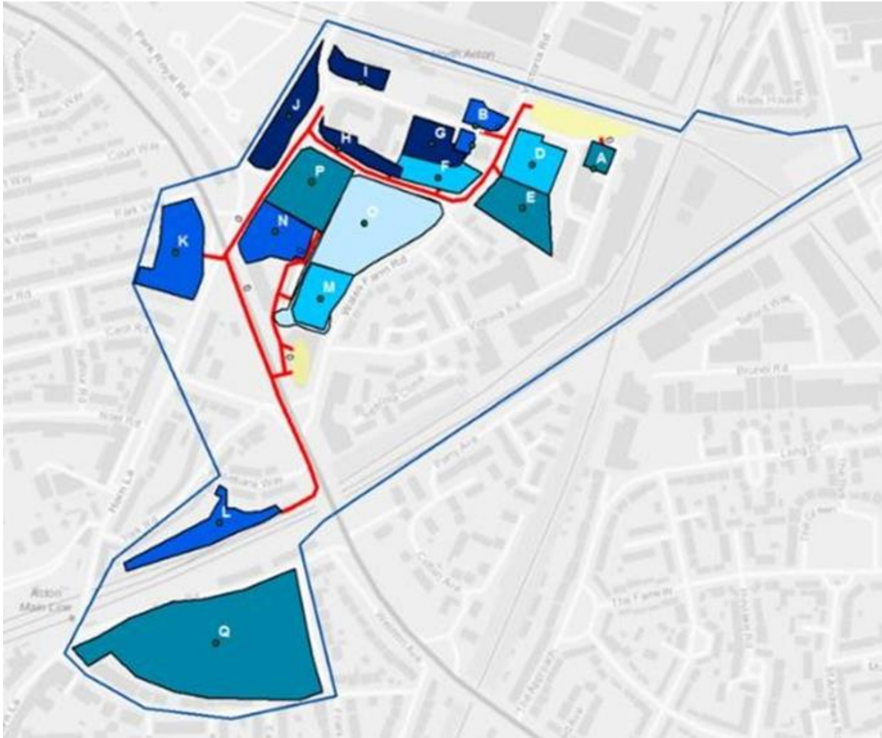


Figure 2 New Plant configuration

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

13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

t +44 20 7636 1531
d +44 20 77553834

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.

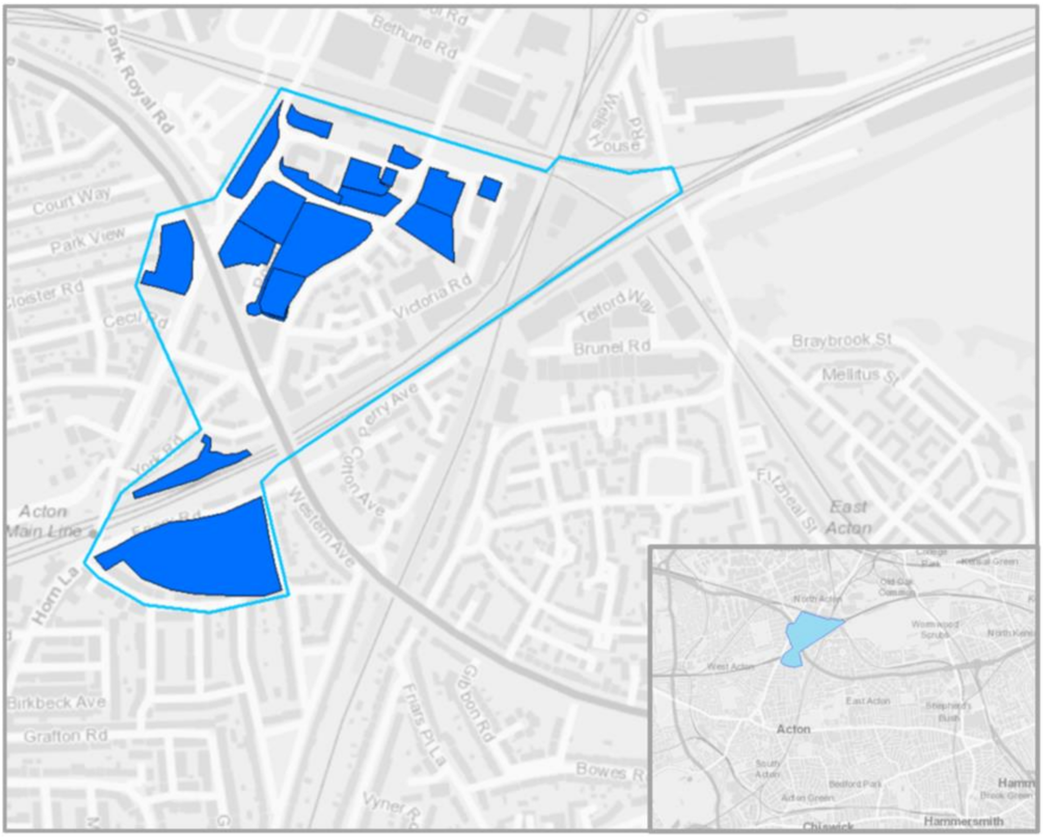


Figure 15 North Acton Area with key buildings filled in blue

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.

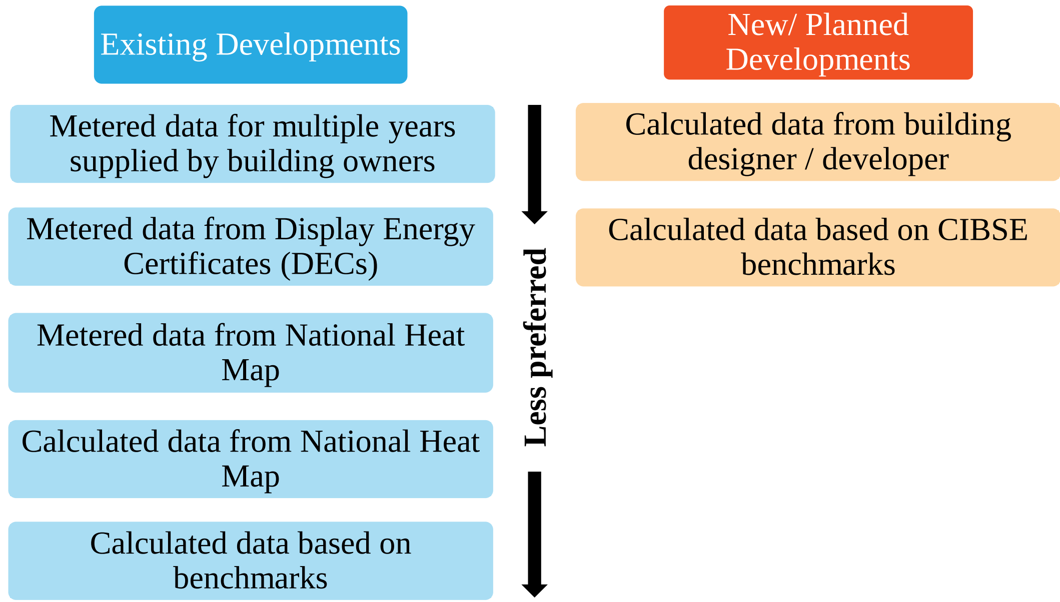


Figure 16 showing the hierarchy of heat load data

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.

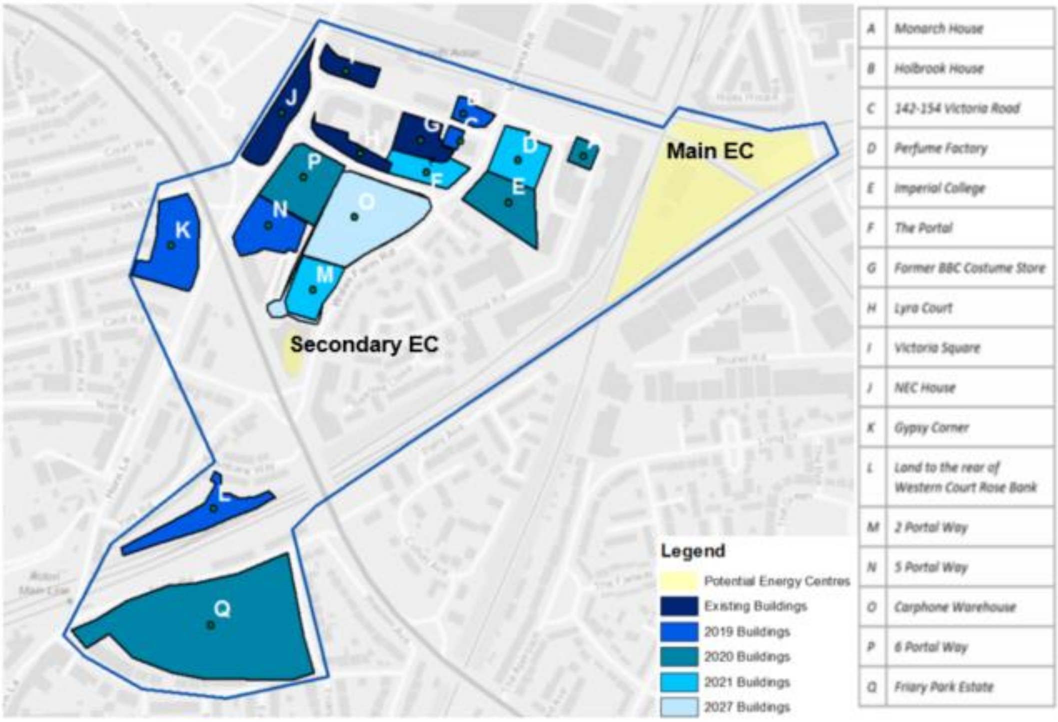


Figure 17 Buildings of interest split by phase

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.

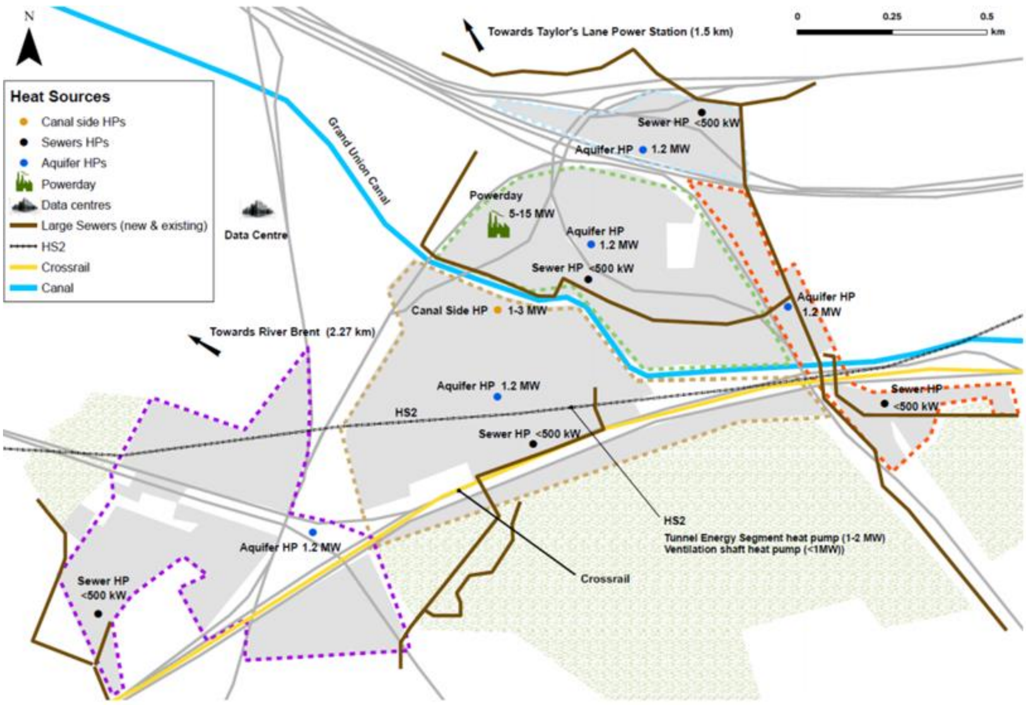


Figure 18 Map of supply sources as produced by AECOM

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.

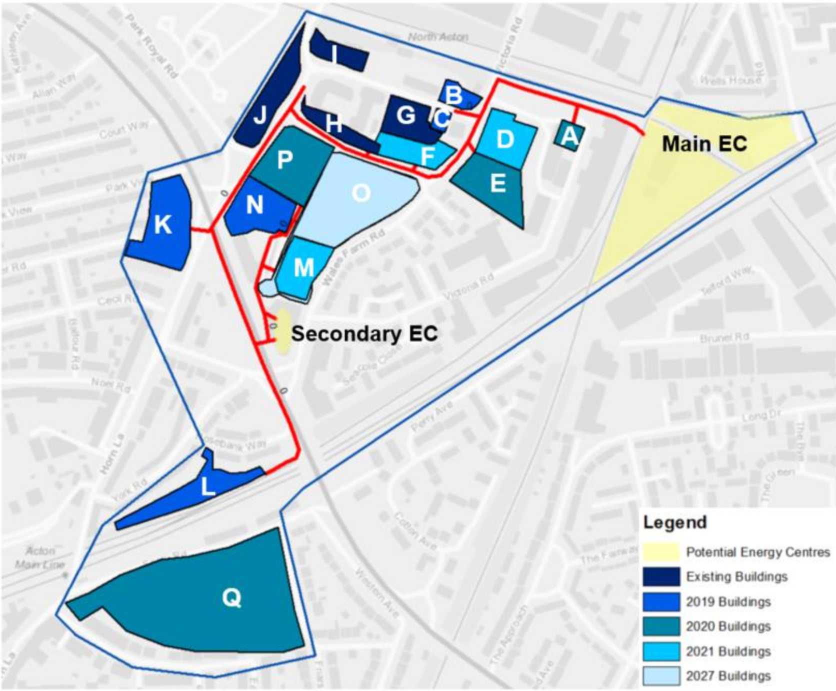
Because the proposed capacity sizing of the Aquifer and Sewage heat pumps do not alone have the capability to cater for the site, a Ground Source Heat Pump was included in the zero-carbon network. The feasibility and space requirements of this still need to be confirmed.

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.



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 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.

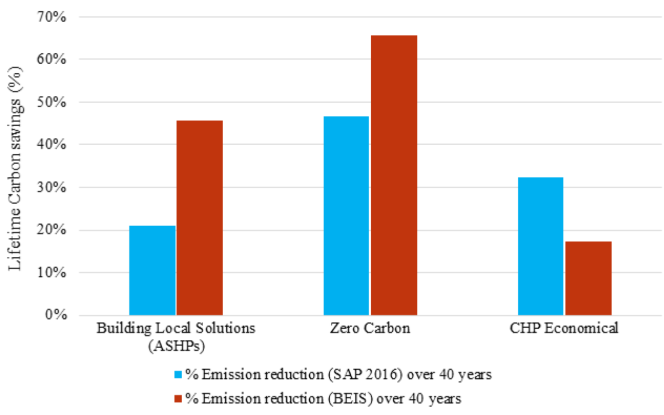


Figure 24: Carbon emissions change in different scenarios

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.

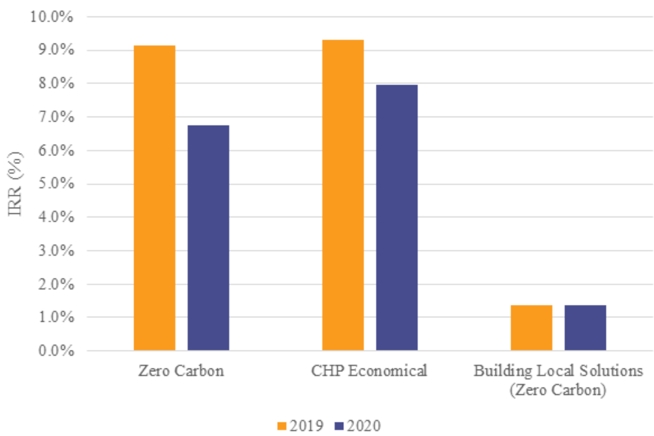


Figure 25 Change in IRR (%) if the scheme is delayed by one year

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

13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

t +44 20 7636 1531
d +44 20 77553834

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.

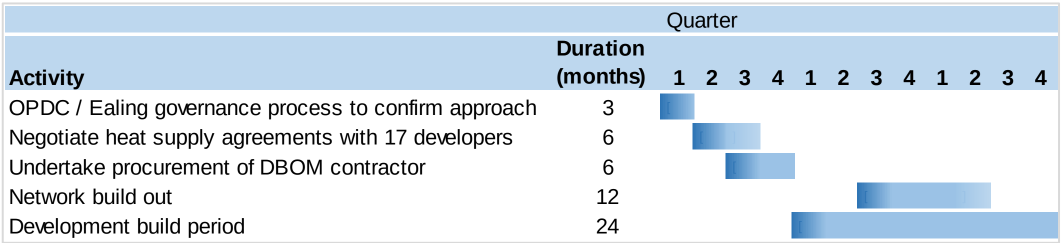
We would expect the network itself to be delivered and operated under a conventional design, build, operate and maintain (DBOM) contract. This would be a fixed price contract, potentially with incentives for system efficiency or minimising carbon emissions. Metering and billing services could be outsourced 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.