AECOM

Wood Green
Decentralised Energy Options

FINAL Report

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Contents

Executive Summary

Executive Summary

The London Borough of Haringey has the ambitious target to reduce carbon emissions across the borough by 40% of 2005 levels by 2020, and promotes the development of district heat networks in appropriate locations in line with the London Plan policies.

Wood Green has been identified in a borough-wide Energy Master Plan as one of three areas where development of a heat network could be viable.

Regeneration and development within the Wood Green area is anticipated to be driven by the proposed arrival of Crossrail 2 stations at Turnpike Lane and Alexandra Palace. A provisional masterplan is being produced by Fluid and AECOM to support the development of a Wood Green Area Action Plan.

AECOM's Building Engineering team have been engaged to provide a techno-economic assessment of a district heat network for the Wood Green Investment Framework area. This work needs to be progressed in line with, and as evidence to support, the area action plan and emerging planning policy for the area.

The specific objectives of the study are to:

- Assess potential energy demands for the Wood Green Investment Framework area.
- Identify potential low carbon energy sources and the route to carbon neutrality.
- Develop initial plant space requirements and a heat network layout.
- Carry out a techno-economic assessment to show the potential viability of a heat network to support the area action plan.
- Identify potential procurement routes for delivery of a scheme.

Energy demands have been estimated based on the current masterplan and benchmark data and an initial development programme has been identified which is in line with the anticipated development and operation of Crossrail 2. A number of existing buildings are also anticipated to be retained and actual consumption data has been obtained for these. The estimated total annual heat demand on full build out of the masterplan is 28.2 GWh.

The initial source of low carbon heat is anticipated to be gas-fired combined heat and power, with an aspiration to connect to the energy from waste plant in Edmonton in the longer term. Other low carbon heat may be available from heat recovery from building cooling systems or Crossrail tunnels. Opportunities would need to be investigated as the masterplan is developed in more detail.

An assessment of potential energy centre sites has identified an energy centre integrated into the proposed Clarendon Square development as the preferred option and this location has been used in the techno-economic analysis of the proposed heat network. An energy centre area of around 2700m^2 is estimated to be required to serve the fully built out district heating scheme. Due to pressures on land use the energy centre is anticipated to need to be integrated with other building uses regardless of which site is chosen. Heating plant can be installed as required to meet the growing heat load but the energy centre building will need to be fully built out at the start of the project. The fully built out scheme is estimated to require around 28MW of gas boiler plant and 5.3MWth of gas-fired CHP.

The current analysis is based on sale of electricity via a Licence Lite agreement at a current price of £36.3 per MWh, varying over the life of the scheme according to IAG projections on energy prices. If some or all of the electricity generated could be sold over private wire then a higher value could be realised and the scheme would return a higher IRR. If a sale price of around £65-£66 per MWh can be achieved then the scheme would return an IRR of around 10%. Potential private wire customers include Haringey Council or the rail works to the west of the scheme.

The IRR could also be improved by increasing the heat price. The current analysis is based on selling heat at a 10% discount compared to the cost of providing heat from individual gas boilers. If the heat price were raised to be equal to the cost of heat from individual gas boilers (ie no discount compared to business as usual) then the IRR could be increased to around 6%.

The relatively low IRR is unlikely to be attractive to private investment unless developers within the Wood Green AAP area see other advantages to a single area wide network and are interested in supporting such a scheme. In addition to or instead of improved revenue from electrical sales, it may be possible for the Council to improve the IRR by funding and owning specific assets such as the energy centre or heat generation, as part of a JV delivery model. A further option is for gap funding from the Heat Network Investment Project or Community Infrastructure Levy to improve the IRR, possibly to a level acceptable to the private sector.

Recommendations

The following recommendations are made regarding next steps and further feasibility work:

1. Integrate information and recommendations into the AAP to ensure a district heating network can be developed. This should include:
    - All new developments should be required to connect on to the district heating network. Where it is not possible in the initial years, new developments should be required to include the following:
        - Provide space for a heat exchanger
        - Safeguard routes for installation of the network connection route
        - Design the space heating as a low temperature system (70ºC flow / 40ºC return) to allow the building to be connected to the heat network in due course.
    - Identify the preferred location for an energy centre within the Clarendon Square site.
    - Identify the potential pipework route and safeguard this where it does not run through existing adopted roads.
    - Require developers and encourage Crossrail to look for opportunities for recovering heat where cooling is required. This could be facilitated by the use of central water cooled chillers (rather than VRV or split unit cooling). Also opportunities for serving several closely linked buildings from central chillers should also be investigated as part of the design development options.

2. During discussions with Crossrail determine:
    - Plans for providing cooling to stations (water cooled chillers would facility heat recovery if mechanical cooling is proposed) and where cooling assets are likely to be located.
    - Potential for incorporating heat recovery into stations and / ventilation shafts - integration of air-to-water heat exchangers in ventilation shafts, fan coil units at stations?
    - Locations of ventilation shafts.

3. Any Stage 2 feasibility investigations should include:
    - Update heat loads and timing based on masterplan current at the time and review the potential for connecting heat loads outside but in close proximity to the AAP area.
    - Investigate further opportunities for heat recovery from buildings and other sources,
    - Investigate potential for heat being taken from Edmonton EfW – Development plans already being considered, ambition for expansion, potential timeframes for expansion, potential heat sale price and carbon intensity.
    - Given updated masterplan confirm preferred location for energy centre and need for temporary energy centre(s).
    - Obtain information on potential utility supplies and connections for an energy centre.
    - Size plant and design energy centre to RIBA Stage C to ensure energy centre has space for major items of plant and the necessary ancillary equipment.
    - Identify whether the existing buildings proposed to be connected can operate at 70 / 40ºC and if not whether modifications can be made or whether top up heating plant should be retained. This will enable an estimate of connection costs for the existing buildings to be made.
    - Identify all major utilities (trunk sewers or water mains, national grid gas and electrical assets) and other potential barriers to heat network development. Where possible identify depth of these together with depth of Victoria tube line.

- Update the pipe route and sizing based on revised masterplan, network constraints and energy centre location.
- Investigate opportunities for private wire connections, identifying potential customers and volume of electrical sales possible.
- Carryout techno-economic analysis, including a sensitivity analysis.
- Based on the results from the techno-economic analysis identify the preferred business structure for developing the scheme.

Introduction

01

1. Introduction

This section outlines the context for this report, including the motivation for, and objectives of, the study.

1.1. Background

Haringey Council has the ambitious target to reduce carbon emissions across the borough by 40% of 2005 levels by 2020, and it promotes the development of decentralised energy networks in appropriate locations in line with the London Plan policies. This support has led to a borough-wide Energy Master Plan (EMP) being commissioned which identified three potential areas within the borough where district heat networks (DHN) could be developed.

One of these opportunities is Wood Green where the potential development of Crossrail 2 stations at Turnpike Lane and Alexandra Palace is expected to stimulate investment and growth.

A provisional masterplan for the regeneration of Wood Green is being produced by Fluid and AECOM to support the development of an Area Action Plan (AAP).

AECOM's Building Engineering team have been engaged to provide a techno-economic assessment of a DHN for the Wood Green Investment Framework area. This work needs to be progressed in line with, and as evidence to support, the AAP and emerging planning policy for the area.

1.2. Objectives of the Study

The specific objectives of the study are to:

- Assess potential energy demands for the Wood Green Investment Framework area.
- Identify potential low carbon energy sources and the route to carbon neutrality.
- Develop initial plant space requirements and a heat network layout.
- Carry out a techno-economic assessment to show the potential viability of a heat network to support the AAP.
- Identify potential procurement routes for delivery of a scheme.

Energy Demand

02

2. Energy Demand

This section describes the scope of the district heating assessment, the energy data collected and how this has been developed to create consistent energy demands.

2.1. Scope and Baseline

The current Wood Green regeneration masterplan areas form the core of the district heating assessment.

The baseline has been scoped to also include some current buildings not due for redevelopment, but deemed to be of interest because of their significant energy loads; a recently completed development in Lymington Avenue/Noel Park Road; and the plots highlighted in Fluid's preliminary masterplanning schedule which includes all areas identified for potential future redevelopment.

The current buildings and sites expected to be retained and included in the baseline are:

- Trinity Primary Academy
- Alexandra Infants and Junior School
- St Michael's CoE Primary School
- The Chocolate Factory (office accommodation)

The proposed development at Clarendon Square has also been included in the model. While outline permission for this site has already been granted it is understood that the plans are under review by the developer. The most up to date area schedule available has been used in this analysis.

The current masterplan is shown in Figure 1.

2.2. Modelling assumptions

New Development

Gross areas provided have been converted to net areas for the masterplan plot residential schedules. For non-domestic uses, gross areas as provided have been used. This, together with the associated use type for each allocated plot area, have enabled the assessment of estimated annual heat and electricity demands for all future development via the use of corresponding benchmarks.

Net housing areas are estimated as 80% of gross areas (as provided by Fluid), and an assumed average of 70m^2 per flat has been used. All residential areas are assumed to have new flats and benchmarks for these have been used to estimate annual heat and electricity demands.

The benchmarks for both domestic and non-domestic buildings have been taken from the 2015 GLA study for the London Energy Plan[1]. For non-domestic areas, benchmarks relevant for each use type (e.g. A1/A2, B1 …) have been used from the London Energy Plan model based on the "peri-urban" dataset.

The benchmarks for domestic hot water have been evenly distributed during the year, whilst the space heating benchmark has been distributed monthly using heating degree days (for a 12^{o}C base temperature). For future educational uses, any residual space heating demand for July and August has been allocated to January and February.

[1] AECOM has developed the domestic and non-domestic energy demand model for the Greater London Authority (GLA) to support the London Energy Plan.

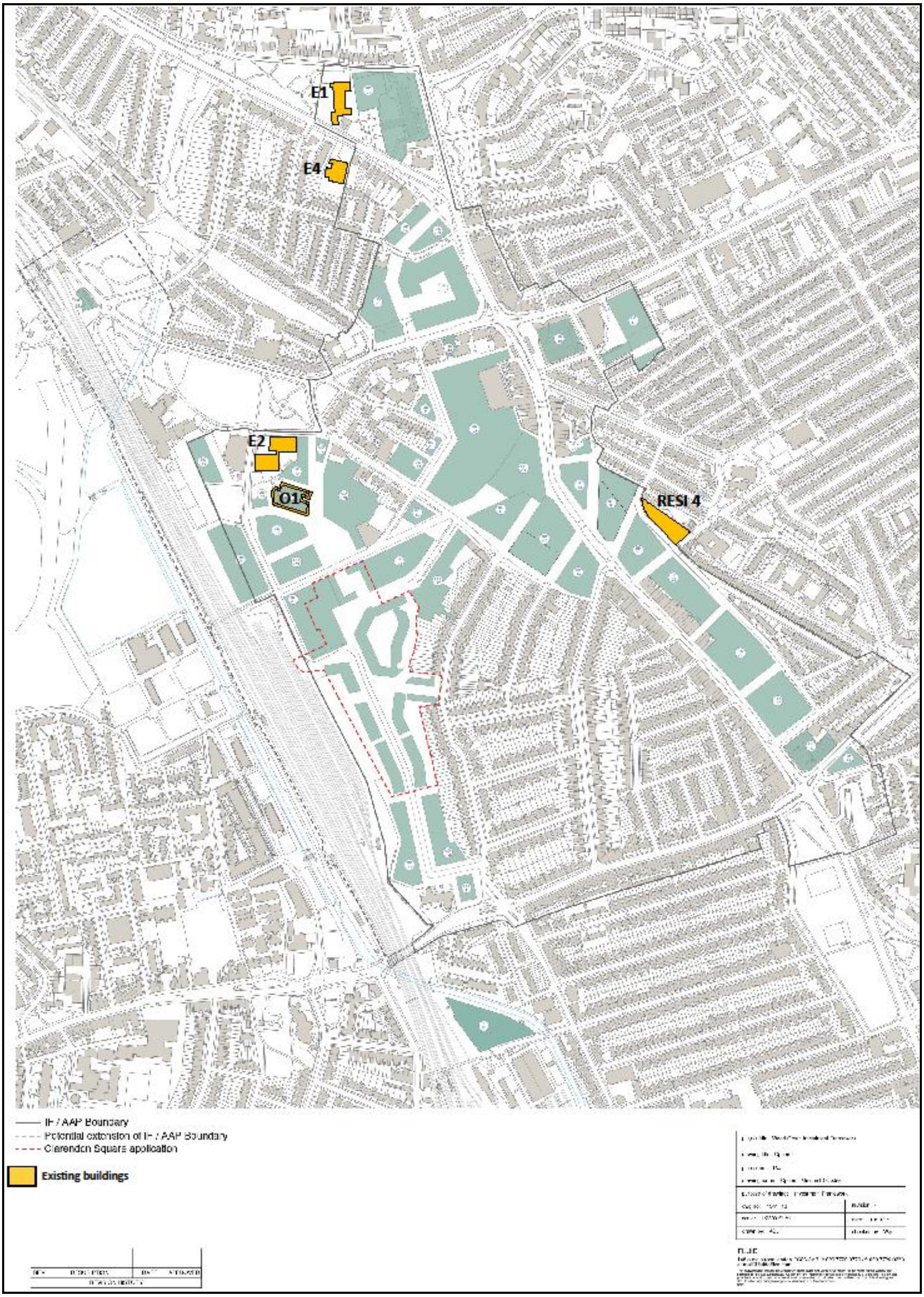

Figure 1: Wood Green AAP Masterplan

Existing Buildings

For the existing buildings identified, energy demand data (gas and electricity) have been provided for each site for the period April 2014 to March 2015[2].

For the recent development at Lymington Avenue/Noel Park Road (Artizan Court) the number of flats was provided and the energy demands (heat and electricity) estimated using benchmarks for new residential developments (flats).

For these existing buildings and sites, to calculate the monthly heating profile an assumption has firstly been made of 15% of heat energy being used for domestic hot water which is equally distributed amongst all months of the year (apart from for schools where July and August are considered shut down periods). The remaining heating demand is assumed to be space heating which has been distributed monthly using heating degree days (for a 12ºC base temperature). For schools, any residual space heating demands for July and August have been allocated to January and February.

Electrical Consumption

Monthly heating and electricity consumption profiles were generated for all modelled buildings and sites. Electricity monthly profiles assume similar electricity consumption in each month of the year with the exception of school buildings. In the case of schools July and August are considered as shut down periods and therefore electricity consumption has been equally distributed amongst the remaining 10 months of the year.

User Type	Gross Areas (m^2)	Nr. Of Dwellings	Estimated Demands (MWh pa)	
			Heat	Electricity
RETAINED BUILDINGS / SITES				
Residential		66	191	187
Education			808	309
Mixed Used (offices/retail/assembly)			648	747
MASTERPLAN PLOT SCHEDULE				
Residential	454,214	5191	15,043	14,712
A1 - A2	106,074		3,500	6,683
A3 - A5	2,282		155	395
B1	76,779		1,689	7,371
D1 Education	21,013		651	1,282
D1 Health	1,750		119	214
D1 Other	15,535		513	1,476
D2	20,057		1,665	2,688
CLARENDON SQUARE SCHEDULE				
Residential		**1080**	**3,130**	**3,061**
A1 – A2	700		23	44
A3 – A5	550		37	95
B1	700		15	67
D1 Other	550		18	52
Total Energy Demands			**28,205**	**39,382**

Table 1: Wood Green Estimated Energy Consumptions

Total Energy Consumptions

The estimated energy consumptions for the sites included in the assessment are set out in Table 1. Energy data is set out in more detail in Appendix 1. Figure 2 shows the monthly heat demand profile for the fully built out scheme.

[2] *Data for council buildings was supplied by Haringey Council, data for the Chocolate Factory was supplied by Workspace*

An initial assessment indicated that the site north of Station Road (UID 54) and a site identified to the North of Hornsey rail depot (UID 51) are relatively small and are significant distances from other masterplan sites. These two sites have therefore been considered unlikely to connect to a heat network supplying Wood Green and have not been included in the current analysis.

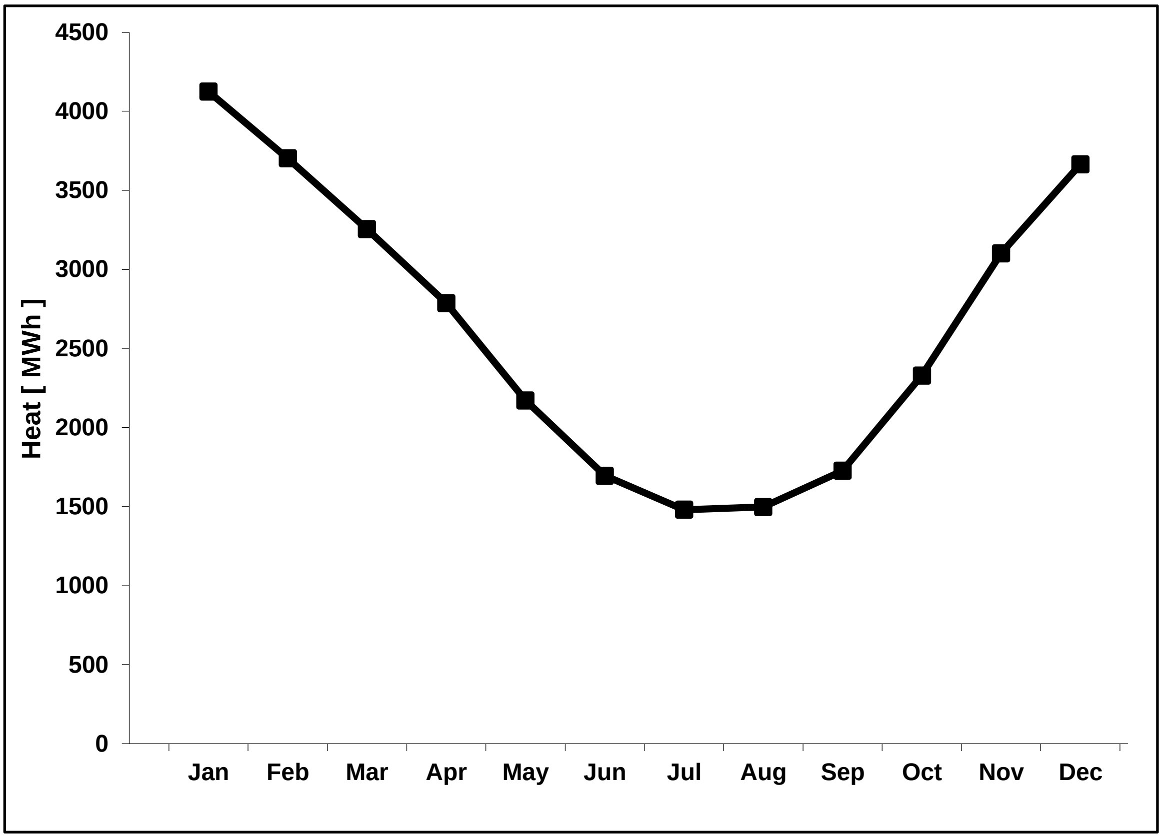

Figure 2: Total Monthly Heat Demand

2.3. Indicative Phasing

At the time of writing this report a phasing plan has not been developed for the Wood Green masterplan. In order to allow for the impact of the build out of the masterplan over time an initial estimate of the potential phasing has been made based on information in Haringey's Local Plan Site Allocations DPD Consultation Document[3], and the estimated development time of Crossrail 2, seen as a major driver for the development and growth of the Wood Green area.

The Clarendon Square development has already been granted outline planning permission and is considered likely to proceed, although plans are currently under review. This has been taken as the first area of development.

Areas around the Cultural Quarter and The Mall are identified for potential earlier development compared to other areas. Other areas are all identified for development after 2020.

Phase 1 has been taken as Clarendon Road, areas adjacent to the railway and the Cultural Quarter. Phase 2 has been taken as the Mall, Morrisons and High Road South. Phase 3 has been taken as the Civic Centre, Bus Depot and Mecca Bingo sites.

Each of these major phases has been assumed to be split into sub-phases, each developed evenly over the assumed timeframe of the sub-phase. It has been assumed that the development around the Mall will occur concurrently with the end of phase 1 rather than after phase 1 is complete.

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[3] *Haringey's Local Plan Preferred Option Site Allocations DPD Consultation Document February 2015*

It has been assumed that the masterplan will be fully built out by the end of 2034, which corresponds to the timeframe for the opening of the Crossrail 2 station in the area.

Figure 4 illustrates the assumed phasing for the masterplan, while Table 2 shows the assumed timeframe for the development of the masterplan and

Figure 3 shows the assumed heat load build-up over time. The detailed list of development sites assumed to be in each phase is provided in Table 3.

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Phase 1.1																		
Phase 1.2																		
Phase 1.3																		
Phase 2.1																		
Phase 2.2																		
Phase 2.3																		
Phase 3.1																		
Phase 3.2																		

Table 2: Assumed Timeframe for Wood Green Masterplan

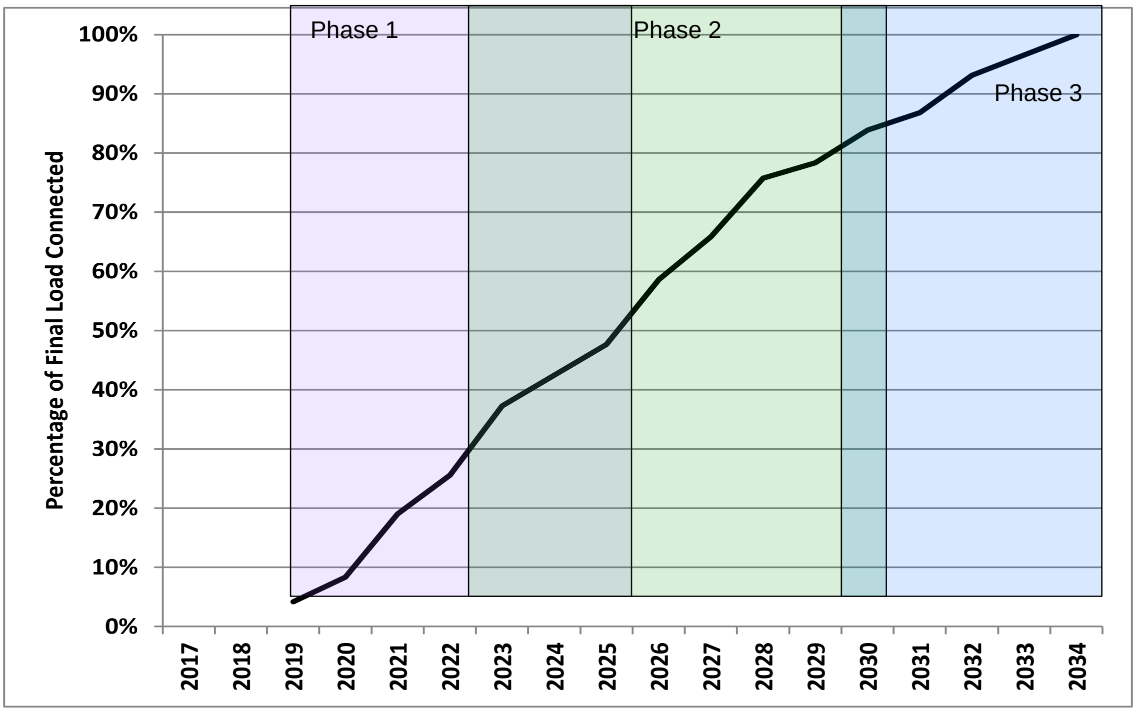


Figure 3: Heat Load Build-up

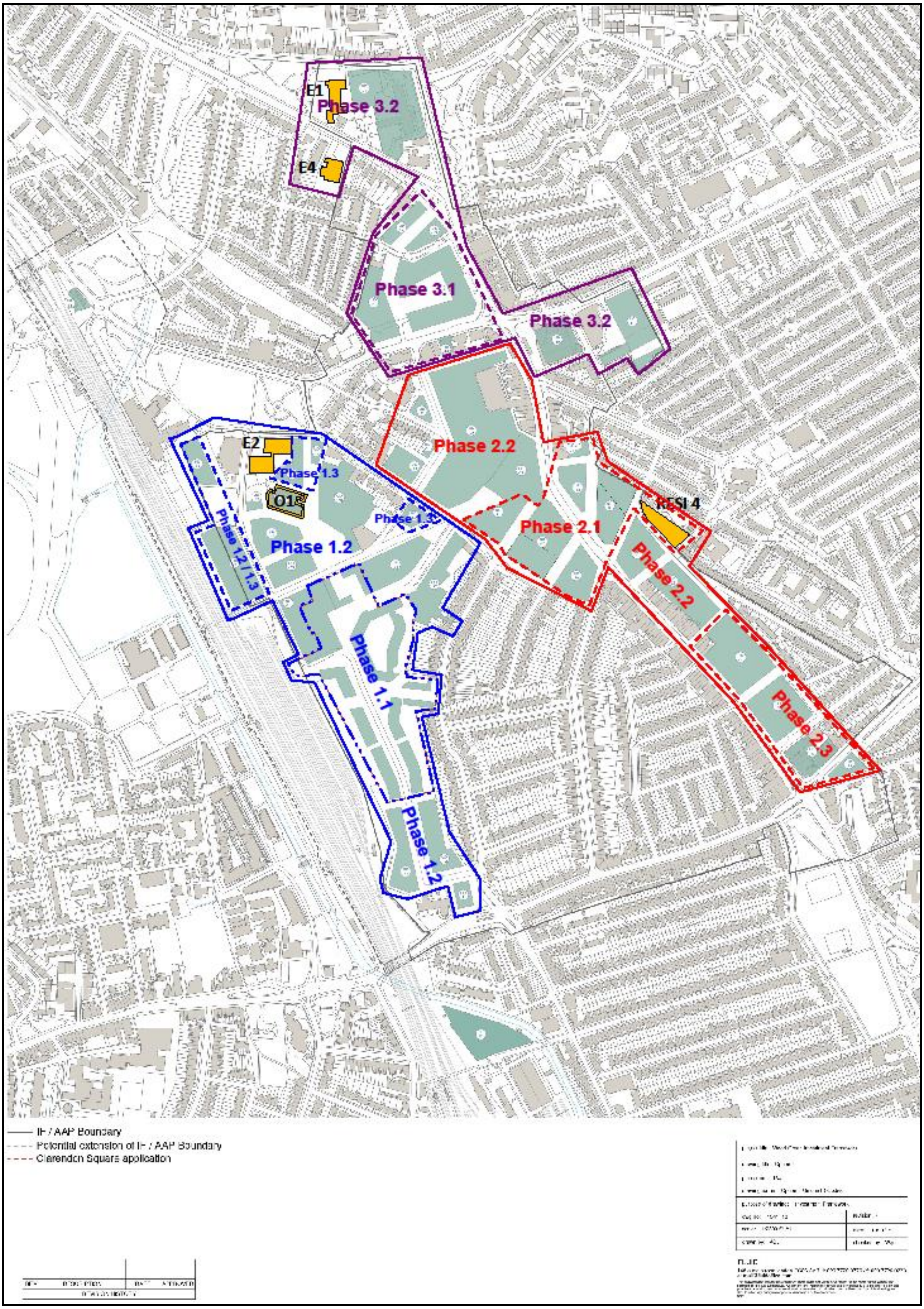


Figure 4: Assumed Phasing for Wood Green Masterplan

Phase 1.1	Phase 1.2	Phase 1.3	Phase 2.1	Phase 2.2	Phase 2.3	Phase 3.1	Phase 3.2
UID - 45a	E2	UID - 16a	UID - 28a	UID - 09a	UID - 36a	UID - 02	E1
UID - 45b	O1	UID - 16b	UID - 28b	UID - 09b	UID - 36b	UID - 03a	E4
UID - 45c	UID - 19a	UID - 17a	UID - 29a	UID - 09c	UID - 37a	UID - 03b	UID - 01a
UID - 45d	UID - 19b	UID - 17b	UID - 29b	UID - 09d	UID - 37b	UID - 04a	UID - 01b
UID - 45e	UID - 20a	UID - 17c	UID - 30a	UID - 09e	UID - 38a	UID - 04b	UID - 08a
	UID - 20b	UID - 18	UID - 30b	UID - 11a	UID - 38b	UID - 05a	UID - 08b
	UID - 21a	UID - 22b	UID - 31a	UID - 11b	UID - 39a	UID - 05b	UID - 49A
	UID - 21b	UID - 22c	UID - 31b	UID - 13	UID - 39b	UID - 05c	UID - 49B
	UID - 22a	UID - 22d	UID - 32a	UID - 34a		UID - 05d	
	UID - 23a	UID - 50	UID - 32b	UID - 34b		UID - 48	
	UID - 23b		UID - 33a	UID - 35a			
	UID - 23c		UID - 33b	UID - 35b			
	UID - 25a		Res4	UID - 52a			
	UID - 25b			UID - 52b			
	UID - 26a			UID - 14			
	UID - 26b						
	UID - 27a						
	UID - 27b						
	UID - 42						
	UID - 43a						
	UID - 43b						
	UID - 43c						
	UID - 44a						
	UID - 44b						
	UID - 55						

Table 3: Development Plots Split by Assumed Phase for Wood Green Masterplan

Energy Supply

03

Energy Supply

In this section heat supply options are considered, together with the potential locations for energy centres, and potential routes to carbon neutrality.

3.1. Technology assessment

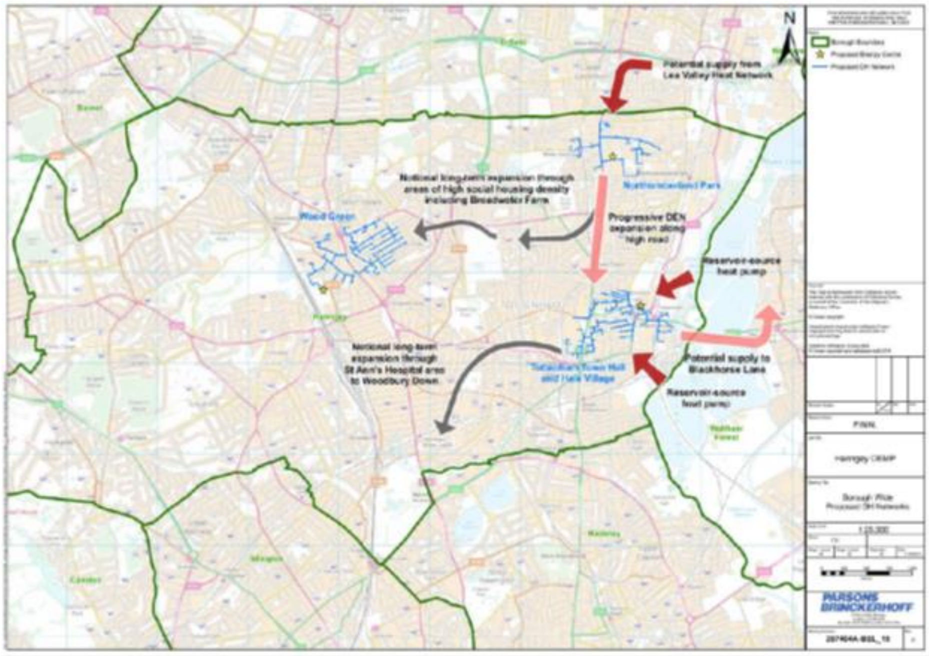
AECOM have reviewed energy supply options for generating heat, and in some cases electricity, for DHNs to identify their suitability in terms of providing a cost effective and reliable heat supply that will also deliver environmental benefits in an urban environment.

Account has been taken of the availability of local resources and opportunities, together with constraints such as traffic, air quality and noise.

Technology	Suitability	Comments
Gas-fired Combined Heat and Power (CHP)	Suitable Option	Gas CHP combines a mature, economic, technology with significant CO_2 reductions. Economic viability is heavily dependent on the revenue stream from the sale of generated electricity.
Community biomass/ biogas boilers	Not suitable	No existing source of biogas was identified within or adjacent to the study area. Significant space is required for new biogas plant together with a suitable source of feed stock such as food waste and this technology is not usually suitable for urban development on a scale suitable to support a district heating system. Biomass requires significant plant space for the biomass boilers, fuel storage, thermal store and gas-fired top-up/back-up boilers. Land prices are high and the space available is restricted. There are risks surrounding future availability and cost of fuel. It is not expected biomass boilers will lead to financial savings unless supported by the renewable heat incentive (RHI). In light of recent announcements it is likely that the RHI will change form in some way, this will probably include a change to tariff levels and the thresholds at which the tariffs change, however it is expected that the RHI will continue to exist in some form until at least 2021. There are issues with air quality as biomass boilers have relatively high NOx and particulate emissions. In addition substantial fuel storage space and regular deliveries are required. Locating the energy centre adjacent to the rail way may offer a suitable bulk supply route. However, delivery by road would cause addition heavy goods traffic in the area and as well as generate further NOx emissions. This technology has therefore not been considered as suitable.
Industrial/ commercial waste heat	Not currently suitable	London Underground Another potential waste heat source is London Underground. The Victoria line runs on the east side of the Wood Green Masterplan area. In order to use this

Technology	Suitability	Comments
		heat a substantial heat exchanger would need to be installed either in a nearby ventilation shaft or within the underground tunnels themselves. A heat pump would then be required to raise the temperature of the heat to a level suitable for use in a heat network. A study carried out for the GLA[4] identified ventilation air from the Underground as a potential low temperature heat source, but also indicated that the actual amounts of heat available at any one point are likely to be relatively small. <u>Heat Recovery from Buildings</u> The GLA study identified heat recoverable from building cooling systems as one of the major sources of low grade heat within London. The current masterplan does include substantial areas of retail, which is likely to have cooling. There may be some potential for this source in the future depending on the actual buildout of the Masterplan. Further investigations should be undertaken into opportunities for heat recovery as sites are developed within the Masterplan. <u>Crossrail 2</u> As with the existing underground heat could be recovered from the proposed Crossrail tunnel. The advantage over the underground is that the infrastructure for heat recovery could be installed during construction. If planned into the Crossrail system heat recovery could be via air to water heat exchangers in ventilation shafts or stations, connected to heat pumps which can upgrade the heat to the temperatures required by the district heating network. Alternatively, if cooling were provided at stations then heat could be recovered from the cooling system(s) in the same way that it could be recovered from buildings. Early discussions with Crossrail to determine plans for providing cooling or to assess opportunities to install heat recovery infrastructure are advisable.
Energy from waste - incineration	Not currently suitable	There are no energy from waste (EfW) plants in the locality of the heat network. However, the Edmonton EcoPark site in Enfield is being developed to supply a new district heating system to the north of Tottenham. Should this heat network expand south and west to Tottenham and Wood Green then it could offer a significant source of low carbon heat in the future. The previous EMP for the wider Haringey area identified this as a potential heat source and indicated a potential expansion scenario.

[4] *GLA, London's Zero Carbon Energy Resource: Secondary Heat, Report Phase 1, January 2013*

Technology	Suitability	Comments
		 While not suitable at the current time this option should be considered when carrying out the more detailed network design to ensure it remains viable to connect should the Edmonton scheme expand to the Wood Green area.
Heat pumps – Water, Ground and air source	Not suitable	Heat pumps take heat from the ambient surroundings (air, ground, or water) and deliver this heat at a higher temperature through a closed process. Air is a diffuse source and so is less suitable for a centralised heating plant for DH. In order to absorb enough energy from the air the collector coil will need to be very large. This size can be reduced somewhat by blowing air across the collector with a fan, however if noise is to be minimised then this fan speed will be limited and the size of the collector increases. Closed loop ground source systems are similarly limited in capacity as a large ground area is required. A closed loop system extracts heat through the use of a secondary medium. A glycol mix is circulated around either a borehole array or a shallow buried coil connected to the evaporator side of the heat pump. Borehole arrays offer more heat extraction for a given area, each borehole provides around 5-8kW of heat output (3.7-6.4MWh/yr), but they are more expensive to install than a shallow buried coil. The main open areas near Wood Green are on the opposite side of the railway to the proposed Wood Green heat network. It would therefore be necessary to install any ground loop(s) in built up areas. There could be issues of ownership and the potential that future development plans could disrupt existing ground loops. While the New River runs on the west side of the Masterplan area, and there is a water treatment works on the west side of the railway, these are not identified as potential heat sources on the National Heat Map.[5]

[5] *http://tools.decc.gov.uk/nationalheatmap/*

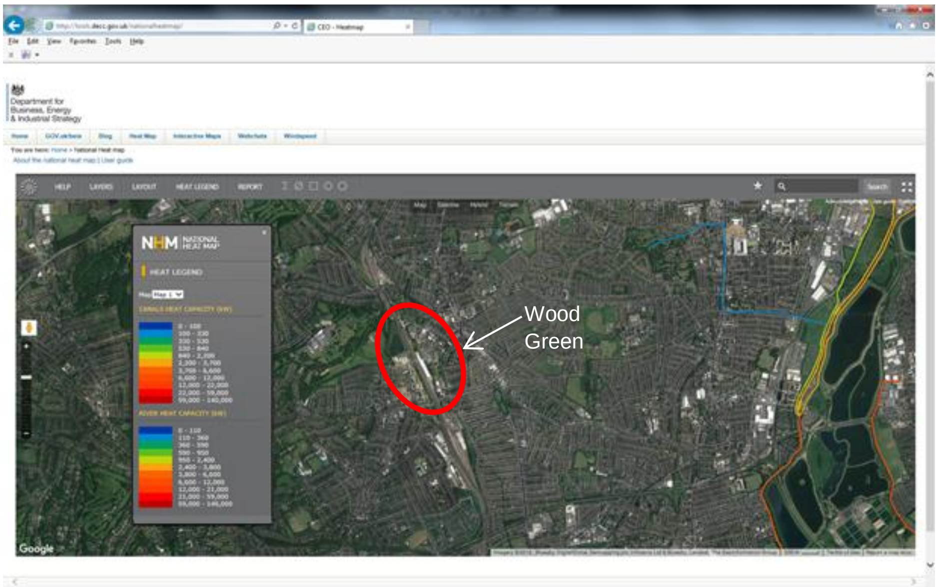
Technology	Suitability	Comments
		 It is therefore assumed that the heat potential from these sources is too small to be worth considering. This technology is therefore not considered suitable.

Table 4: Summary of energy source review

3.2. Electrical Sales

Where electricity is generated as part of a district energy scheme, the revenue from sales of the electricity can be important in ensuring the scheme is financially viable. For gas CHP schemes this is often the most critical factor for viability.

3.2.1. Electricity Sale for Retail Value

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

3.2.2. Electricity Sale for Licence Exempt Generators

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

Licence exempt suppliers can provide power over the existing electrical supply network, but the sale price will be influenced by the use of system charges that need to be paid to the network operator. The supplier will also need to purchase alternative supplies when their generator is unable to meet the demand of their customers. Alternatively a private wire network can be developed, owned by the generator, which enables the system charges to be avoided. However, the network will need to be maintained and the “Citiworks” case (a European

Court of Justice ruling in 2008) has resulted in private wire networks being required to be open to alternative suppliers in an open market to prevent monopoly supply.

3.2.3. Electricity Sale at Wholesale Value

Perhaps the simplest solution for a small scale generator is to sell electricity to a large licensed supplier who will then re-sell to their own customers under their licence. This means that the small scale generator is effectively competing against large scale generation on the national grid, and only receives a wholesale value for the electricity. Wholesale prices will fluctuate, the price in April 2016 being around 3.3 p/kWh. A higher price may be achieved when electricity sales are made through an aggregator organisation which negotiates with the market on behalf of a large number of small generators, such organisations will take a share of the profit from the sale of power but their business model would be based on the end revenue to generator being higher than direct sale to a large licenced supplier. Such aggregators can also bring added value by negotiating additional revenue from network balancing schemes where generators have the ability to provide power on demand.

3.2.4. Licence Lite

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

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

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

Haringey Council can bid into the Licence Lite scheme set up by the GLA to supply power to TfL (and possibly other users). The GLA have suggested that currently generators are receiving revenues around 10% higher than the wholesale price of power. Based on the April tariffs[6] this would give a unit price of around 3.63 p/kWh.

3.2.5. Wood Green Master Plan Options

At the current time there are no clear indications as to the potential customers for electrical power. The option that has been considered for the base case modelling is the License Lite option with electrical power being sold at 10% above wholesale price. This is a base option that can be achieved regardless of the build out of opportunities in the future.

As the masterplan develops and more detail becomes available, alternative options for electrical supply should be considered. However, CHP may have a limited timeframe where it is the best option for low carbon heat which could limit the viability of private wire networks.

Potential options for private wire include supply to Haringey Council owned buildings in the area or the railway works area.

[6] *www.ofgem.gov.uk/data-portal/wholesale-market-indicators*

3.3. Timeline to Zero-Carbon

The technology most suited to providing low carbon heat at the current time is gas-fired CHP. However, the carbon savings associated with CHP systems are strongly affected by the carbon intensity of the National Grid. When the grid carbon intensity is high then the carbon savings from CHP are enhanced as the carbon benefit of the electrical output of the CHP is enhanced. Conversely when the grid's carbon intensity is below around 0.25kgCO_2/kWh the use of a gas-fired CHP may result in higher carbon emissions than a business as usual scenario based on local gas condensing boilers.

The UK Government has set out its ambitions to reduce the carbon intensity of UK electricity by increasing the amount of low carbon technologies on the Grid. There are a wide range of forecasts of how quickly the carbon factor will fall over the next few decades. The Interdepartmental Analysts' Group (IAG) on Energy and Climate Change publish predictions of future carbon emission factors for both grid average and marginal use. However, in assessing the carbon benefit provided by CHP, emissions factors forecast in a report prepared by Lane Clark and Peacock LLP (LCP) for DECC titled '*Modelling the impacts of additional Gas CHP capacity in the GB electricity market' (December 2014),* and updated in July 2015, have been used. This approach is consistent with other district heating studies being undertaken at the current time.

The LCP forecast is based on the assumption that the operators of a large CHP system will be economically incentivised to operate the CHP at times when the instantaneous electricity price is high; this is generally at times when there is a requirement for more expensive electricity generation (requiring fuel inputs) due to high demands and/or low output of large scale renewable generation. Conversely at times when there is a more limited demand and/or national renewable output is high (e.g. on sunny, windy days) the instantaneous price of electricity will fall and the CHP operators will be incentivised to reduce their power export. On this basis it is calculated that the carbon intensity of the electricity that is being displaced by large CHP systems will remain higher than the grid average carbon intensity. If CO_2 costs were to be increased, this effect would be increased further still.

These two carbon emission factor projections are shown in **Figure** 5. This shows that the prediction of how CHP will operate as part of the UK generating mix has a large impact on the predicted level of carbon saving to be gained from the installation of CHP. The effect of this is that the projected carbon savings from CHP systems will be greater when using the DECC LCP forecast emission factors.

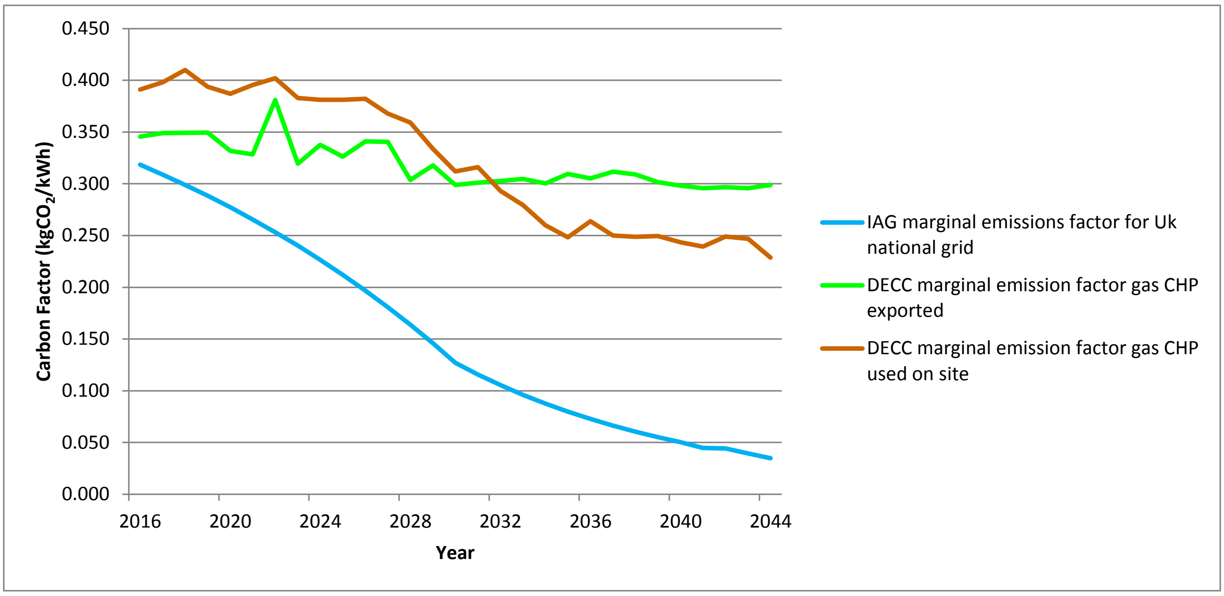


Figure 5: Comparison of IAG marginal emissions factor for UK grid with DECC marginal emissions factor for generation displaced by gas CHP.

In the long term the benefits of gas-fired CHP are likely to reduce or even disappear and therefore an alternative heat source or sources need to be identified for the Wood Green district heating system. From the technology assessment carried out for this study the most likely future source of low carbon heat for Wood Green will be waste heat from the Edmonton energy from waste plant. A more local and secondary option could include heat recovery from buildings with cooling systems.

3.4. Energy centre

3.4.1. Plant sizing

In order to determine the plant space requirements it is necessary to determine the size of the major items of plant.

The CHP plant has been size using AECOM's in-house sizing tool based on the heat demand profile, with thermal stores and electrical substation to match. The monthly heat consumption profile has been determined based on degree days and the total annual energy consumptions set out in Table 1. As the heat consumption will increase over time as more of the new development is complete, assessments have been carried out at each phase of the proposed build out to identify how the CHP plant capacity should be installed. The results of this assessment identify the following CHP units as being appropriate as the scheme develops:

- Phase 1.1: 0.5MWe / 0.6MWth
- Phase 1.2: 1.5MWe / 1.5MWth
- Phase 1.3 – Phase 2.1: Combination of 0.5MWe and 1.5MWe units
- Phase 2.2: 3.4MWe / 3.2MWth
- Phase 2.3 – Phase 3.2: Combination of all three CHP units

Figure 6 shows the amount of heat generated by each CHP unit and the amount required from the gas boilers when all phases of development are complete.

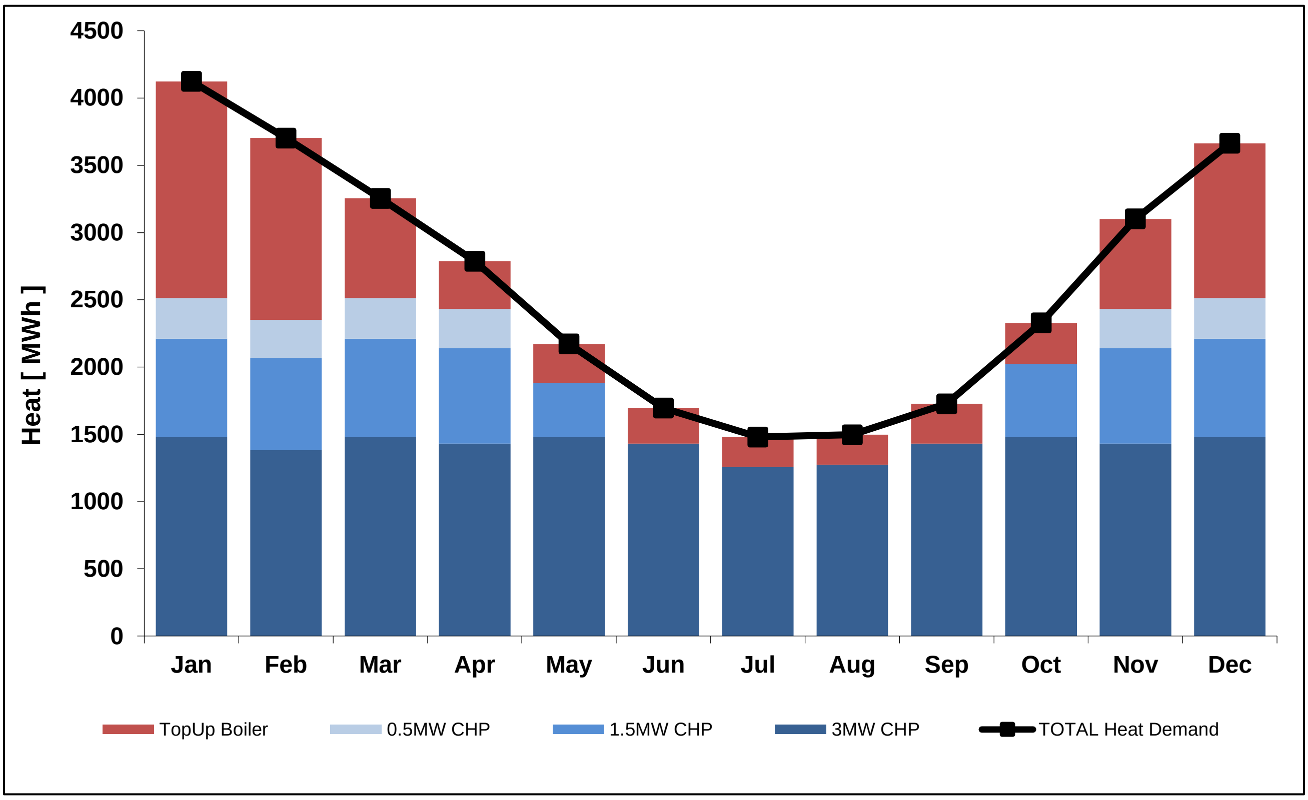


Figure 6: CHP Heat Output at Full Build Out

The thermal storage capacity has been calculated as part of the CHP sizing exercise within AECOM's in-house tool. This is estimated at 430m^3. It should be noted that this is based on monthly energy demands and a more accurate estimate should be undertaken should the scheme be taken to the next level of design based on hourly demands.

The peak boiler plant is sized on on the assessed diversified peak heat demand. This diversified peak demand has been estimated based on the following:

- Dwellings: Allowance of 3kW per dwelling based on a typical 2 bed apartment. Gives peak demand of 19MW.

- Non-domestic buildings: Based on diversified BSRIA Rules of Thumb. Gives peak demand of 8MW.
- Network Heat Losses: Calculated by in-house assessment tool. Gives demand of 1MW.

Total peak boiler capacity is therefore estimated at 28MW at full build out of the scheme.

3.4.2. Space requirements

The size of an energy centre is highly dependent on the heat demand it is designed to meet and the heat-generating technologies used. For the sites identified in the Wood Green masterplan, the foot print is expected to be in the order of 2,700m^2 (dimensions 45m x 60m). In order to accommodate the plant, flues and heat distribution, it is estimated that the free height within the plant room will need to be 10m.

The schematic shown in Figure 7 below shows a plan view of the energy centre layout, based on the following;

- 28MWth boilers[7]
- 5.4MWe / 5.3MWth CHP[8]
- Thermal store inside energy centre
- Electrical switch gear
- Pumps, expansion, controls and ventilation plant
- Allowance for minimum access requirements
- Office and welfare

The energy centre building will probably need to be constructed at its full footprint at the start of the project, especially as it is likely to be part of a larger building. The plant can be installed as required as the scheme is built out. However, in practice the logistics and disturbance caused by installing large pieces of plant mean that there will probably be a few installation dates based around expanding CHP requirements.

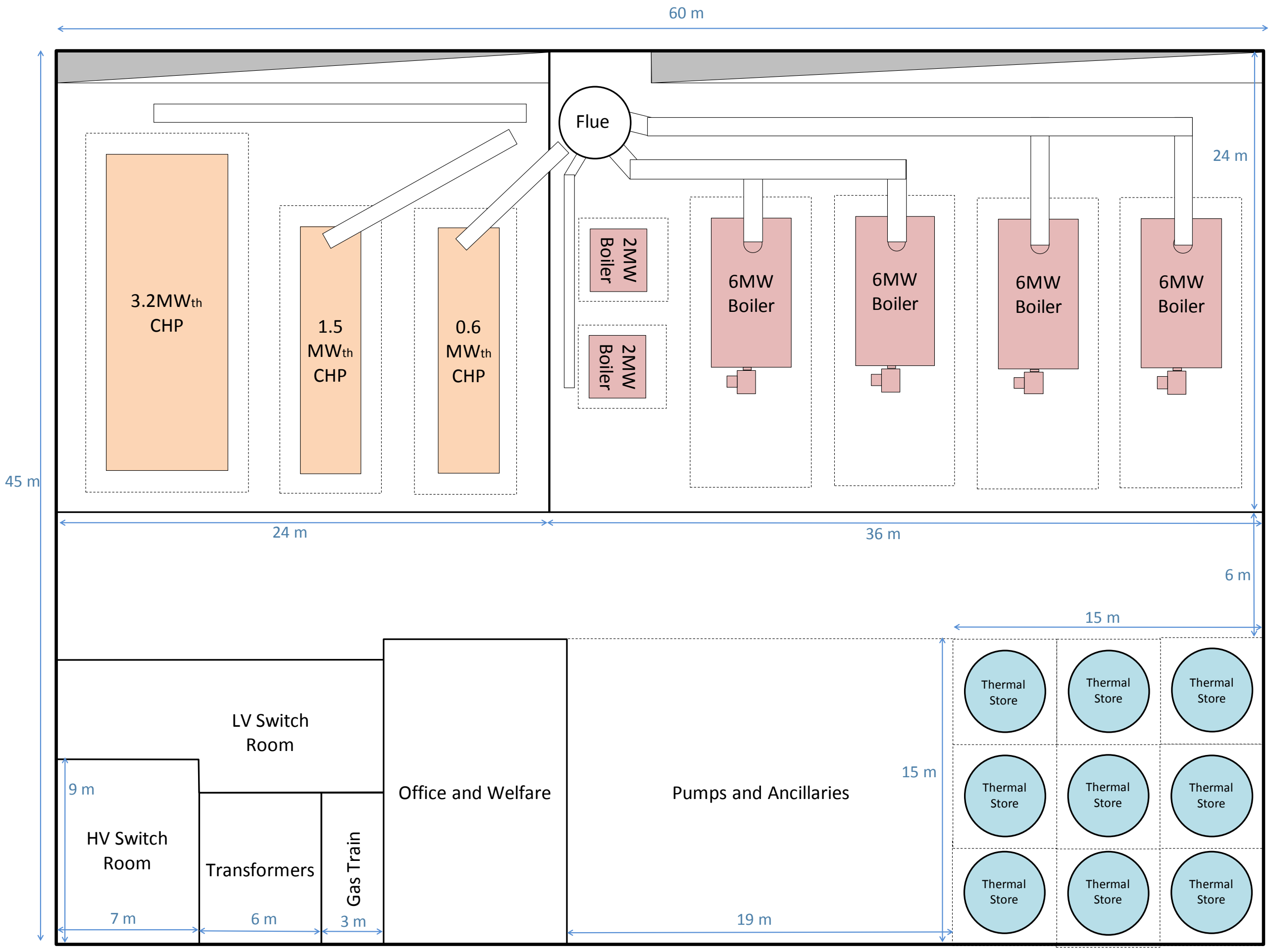


Figure 7: Energy Centre Schematic

[7] *Based on Cochran Thermax and Hoval condensing boiler dimensions*
[8] *Based on Jenbacher containerised systems dimensions*

3.4.3. Energy centre location

There are a number of criteria for locating an energy centre. Most importantly it will require an adequate area of land, and in urban areas, land availability can override other requirements. In a masterplan situation, there may be more flexibility and therefore a wider range of criteria can be considered. These include:

- Phasing. Ideally an energy centre will be located in an early or first phase of the scheme. This means that plant will be in place to provide energy to the early phases of the development. If this is not possible, alternative options may be used such as temporary plant, or even a temporary energy centre buildings.
- Location in relation to energy loads. A central location on the heat network will mean that infrastructure requirements are kept to a minimum, resulting in cost and technical efficiency benefits. If the energy centre is located further away, additional heat network infrastructure will be required to connect to the main network.
- Land value. Sites with a lower land value can be preferred so that the infrastructure costs can be reduced. Low value land is also generally less attractive to development, and may therefore be more suitable for an energy centre use.
- Visual impact. Energy centre buildings can be reasonably large and are often industrial in nature (although architectural treatment can be used). They will also require large flues for exhaust gases if the energy supply is based around a combustion technology. The visual impact of both of these needs to be considered which may favour sites which are less visible or have less impact on neighbouring areas.
- Air quality. Where combustion technologies are used, the air quality impacts need to be considered, and these may impact on the flue height. Where biomass fuels are used, particulates can be an important factor, whilst for gas-fired CHP-based technologies, NOx emission levels are important. The location should therefore identify where sites may have less sensitivity to flue gas pollutants.
- Public visibility and co-location. In some instances, energy centres can be used for education/training, as a show case, and/or for community uses.

Proximity to gas and electrical connections and availability of gas supplies in the area are also important considerations. This issue has not been included in the current analysis as it is anticipated that utility investigations will need to be undertaken to support the development of the masterplan. Any such investigations should include for an energy centre when carried out.

Due to the long term masterplan phasing, the generation plant within the energy centre should be modular, allowing the equipment to be installed in phases to match the growing heat demand. Therefore the initial building and site must be large enough to meet the fully built out demand.

The scheme is not considered large enough to warrant multiple energy centres. This approach could result in technical inefficiencies, and a more complex control and operation strategy. Therefore a single energy centre approach is proposed.

Based on the early masterplanning and heat network analysis, the following areas were identified as potentially suitable locations for the energy centre and are illustrated in Figure 8:

- EC1: Central area within phase 1 with proposed council back of office and retail developments.
- EC2: Area around the household waste site and metropolitan police site, adjacent to railway line.
- EC3: Town centre location within proposed new council front of house, retail and library re-provision.
- EC4: Area adjacent to railway line
- EC5: Within phase 1 area integrated into the Clarendon Square development.

In relation to the above sites, the following points are noted:

- Sites 1, 2, 4, 5 are all located in what is likely to be an early phase of the masterplan, where land is already available, or likely to be available at an early stage.
- Site 1 is most central on the network and so potentially allows for the most efficient network layout.

- Sites 2 and 4 are adjacent to the railway and may therefore be on lower value land where visual impact and air quality are less critical.

A simple assessment of the five sites is presented in Table 5. None of the sites scores well on all the criteria considered.

Criteria	EC1	EC2	EC3	EC4	E5
Within phase 1 of scheme					
Central network location					
Lower land value/lesser potential for alternative uses					
Visual impact					
Air quality					
Co-location and education	Some potential	Some potential	Some potential	Some potential	Some potential

Table 5: Energy Centre Options Assessment

Following the simple assessment further work has been undertaken. This revealed the need for the energy centre to be housed within an integrated building solution due to land restrictions within the Investment Framework area. The proposals at this stage are for an energy centre with a footprint of 2,700 m^2 (roughly 45m x 60m proportionally). This assumes the energy centre is located on the ground floor and allows for a requirement for volume comprising 3 storeys in height which can be sub-divided with internal floors as required.

The integrated building approach is one which is used in heavily urbanised areas due to the scarcity of land and high land values. However this does potentially increase the risk and complexity, and may be viewed as a higher risk item by a potential developer. The integrated approach means the following issues need to be considered:

- Acoustics and vibration: with co-location, there is likely to be a significant requirement for attenuation on air intakes for the energy centre. This is manageable but does take space and increases cost.
- Access: ground floor with level access is best to enable easier installation of plant (a CHP engine may weigh 20 – 30 tonnes).
- Façade: it is proposed that the façade surrounding the energy centre is de-mountable to allow access to the plant for maintenance and replacement. This may have an impact on the architecture and it is likely that a large part of the façade will need to be devoted to the energy centre at lower levels. There may also be a need for a large area of louvers to allow ventilation for the plantroom and heating plant.
- Roof access: it is likely that there will be heat rejection equipment required, usually located on the roof. There will therefore need to be access to the roof to install and maintain this. The visual impact of roof-top plant will also need to be assessed.
- The flues may be significant in terms of height and cross section. This need to be taken into account in terms of lost footprint.
- Any flues for the energy centre will need to be taller than the building itself and adjacent buildings.

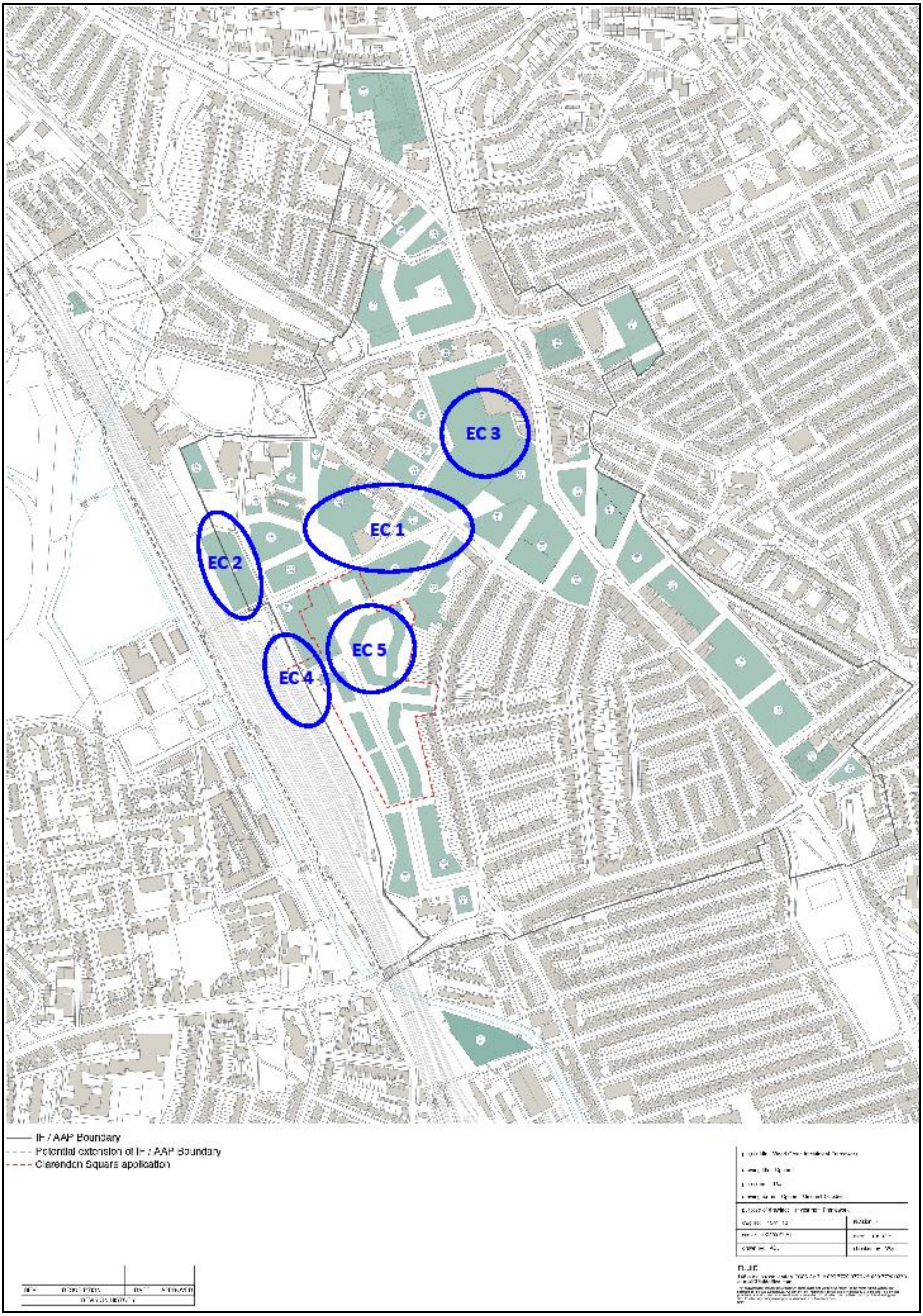


Figure 8: Energy Centre Location Options

Further considerations are:

- EC1 - Bittern Place (the only viable site within EC1) has emerged as a key location for potential new Council accommodation due to its proximity to the town centre placing a high demand on space. In addition, one of the key principles of the Investment Framework is to provide better east-west connections between the High Road and Cultural Quarter. The key method of achieving this is by providing active uses that will encourage footfall and exploration along this key threshold, a quality not well suited to an energy centre. The demands on space for accommodation and the requirement for active frontages has led to EC1 being considered as unsuitable for an energy centre and therefore discounted.
- EC2 – Land values are likely to be lower than other sites considered and there are likely to be fewer issues with noise and visual impact. However, there is a risk associated with working so closely to the railway embankment. Network Rail may express concerns about any works (piling, etc.) which may have an impact on the embankment. This is not an energy centre specific issue, but a more general one, which may be managed. The site is also furthest from the centre of the masterplan area. EC2 is considered a potential option for development of an energy centre.
- EC3 – Although the Site Allocations DPD makes reference to SA16 Wood Green Library as forming part of the decentralised energy network, the spatial demands of providing Council front of house accommodation, a new library, a sizable new public square and re-provision of retail or active town centre uses has resulted in this location becoming unviable. This is further compounded by the assumption that air quality should be better here due to the increased residential density. EC3 has therefore been discounted.
- EC4 – Further to more detailed analysis by the design team, it was concluded that whilst EC4 offered many benefits there is limited land availability in this area and the constraints posed by the railway would prove too problematic. This option has therefore been discounted.
- EC5 –Clarendon Square is likely to be one of the early phases of development at Wood Green and is reasonably central to the masterplan area. Further, an existing planning permission for the site includes a biomass boiler led energy centre and the developer has expressed an interest in supplying heat to additional sites in the area. The Clarendon Square site is currently being replanned and is likely to reapply for planning permission. This offers an opportunity to incorporate and energy centre suitable to serve the wider Wood Green masterplan area into the Clarendon Square scheme design. EC5 is considered the preferred option for the development of an energy centre.

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Energy Distribution

04

4. Energy Distribution

In this section the network constraints and opportunities are identified, including consideration of pipework routes.

4.1. Network design considerations

The development of DHNs requires suitable routes to be found to install the pipework. The installation of pipes and associated equipment is expensive and disruptive and therefore the routing needs to be carefully considered to ensure the network is as efficient as possible, so that the largest amount of heat possible is sold over the shortest length of pipework.

Key opportunities and influencing factors considered for the network routing include:

- The use of existing roads and pathways where public ownership enables development.
- The use of landscaped / pedestrian areas to reduce disruption to transport routes and allow lower cost installation.
- The use of minor roads where utility congestion may be less and where traffic disruption could be minimised.
- Provision of connections from the energy centre to other buildings, keeping the network length low to minimise capital cost and heat losses;
- Provision for future expansion – e.g. designing the network to facilitate expansion or connection to other networks.

4.2. Network Constraints

Within the masterplan area the main barriers to the installation of a heat network are the Piccadilly underground line and the High Road on the eastern side of the area. While routes exist that avoid running down the High Road if required, it will still be necessary to cross this route, which runs above the Piccadilly Line. This may limit the network expansion depending on how deep the Piccadilly line is in this area.

To the south of the masterplan area Turnpike Lane is a major traffic route and the over-ground railway line to the west are the other major constraints to expansion of the network in the future.

4.3. Basis of Network Design

The network designs assume an operating delta T of 30°C, representing a flow temperature of 70°C and a return temperature of 40°C. The limiting maximum flow velocity is assumed to be 2.5m/s, and the limiting pressure is assumed to be 250Pa/m of pipe length.

The network temperatures are in line with the Heat Network Code of Practice and given the large proportion of new build development are anticipated to be achievable.

A more detailed investigation will be required however, at the next stage to determine how the existing buildings proposed to be connected to the network may need to be adapted, or auxiliary top-up plant retained, to enable them to continue to operate satisfactorily.

4.4. Network Development

The initial phase of development is assumed to be at Clarendon Square. As this will be a new build site the development of a heat network to serve this site should be included in the planning permission. Provision should also be included for serving the development to the south of Clarendon Square. It will be necessary to develop the energy centre building at the same time and install plant to serve the initial development phases.

As the masterplan is built out, the heat network can be developed through the Cultural Quarter to the Mall and then extends south down the High Road and north through the bus station site to the Civic Centre.

Figure 10 shows the indicative route for the fully developed network with the energy centre being located on the Clarendon Square site. Based on this route, together with the design criteria set out above, the diameters and total lengths of pipe have been calculated and these are shown in Figure 9.

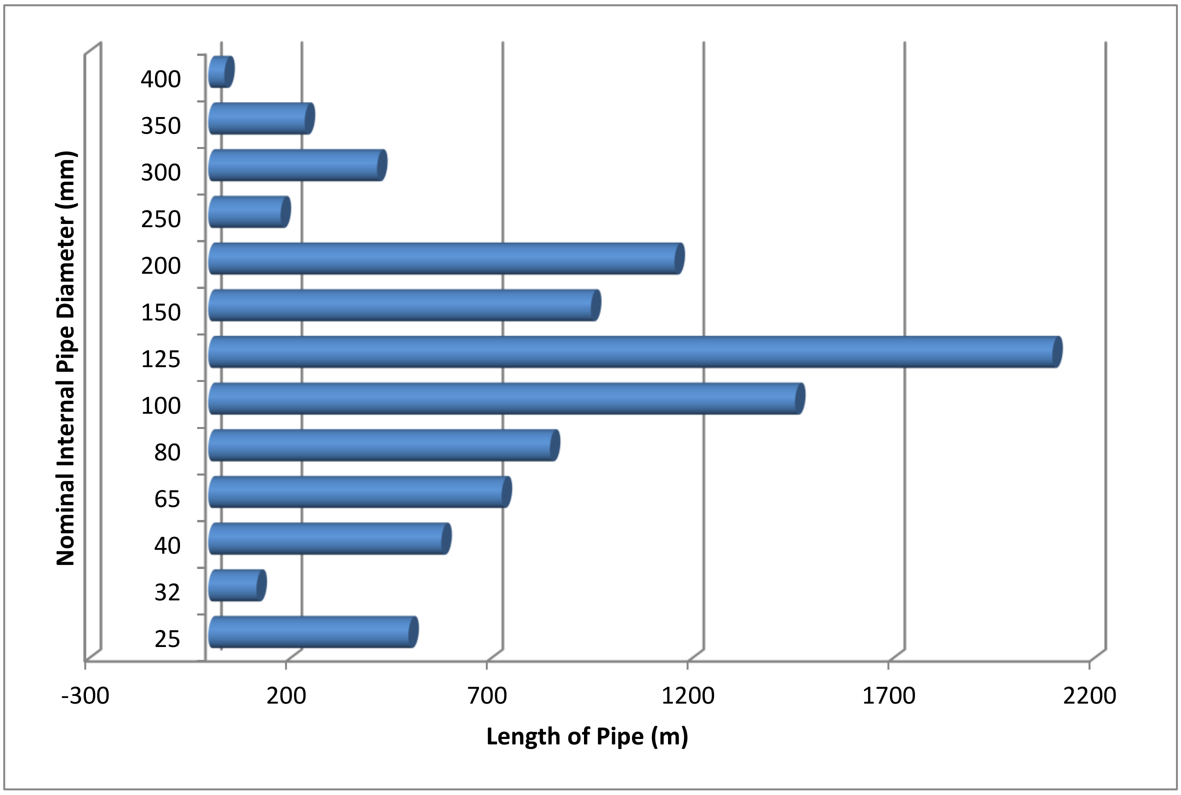

Figure 9: Wood Green Heat Network Pipe Lengths

A check has been carried out on the effect of the energy centre being located near the waste depot adjacent to the railway (Location 2 identified in section 3) on the heat network layout and pipe sizing. This shows that the while pipe sizes vary, overall pipe length is similar to the above option and the overall cost of pipework is within 0.5% of the chosen route.

In the future heat may be supplied from the Edmonton EfW plant to the north east of Wood Green. No specific pipe route has been proposed for any extension of the Edmonton heat supply to the Wood Green area. Therefore an assessment has been carried out into the impact of designing the Wood Green scheme to take a supply from Edmonton at the north east end of the Wood Green network (the opposite end to the proposed energy centre). The assessment increases the length of large diameter pipes (400mm – 300mm), while reducing the length of 250mm – 100mm pipe. This results in an overall increase in capital cost for the pipework of around 7% (£0.4 million). Further comment on the impact of this on the predicted project financial performance is given in section 5.

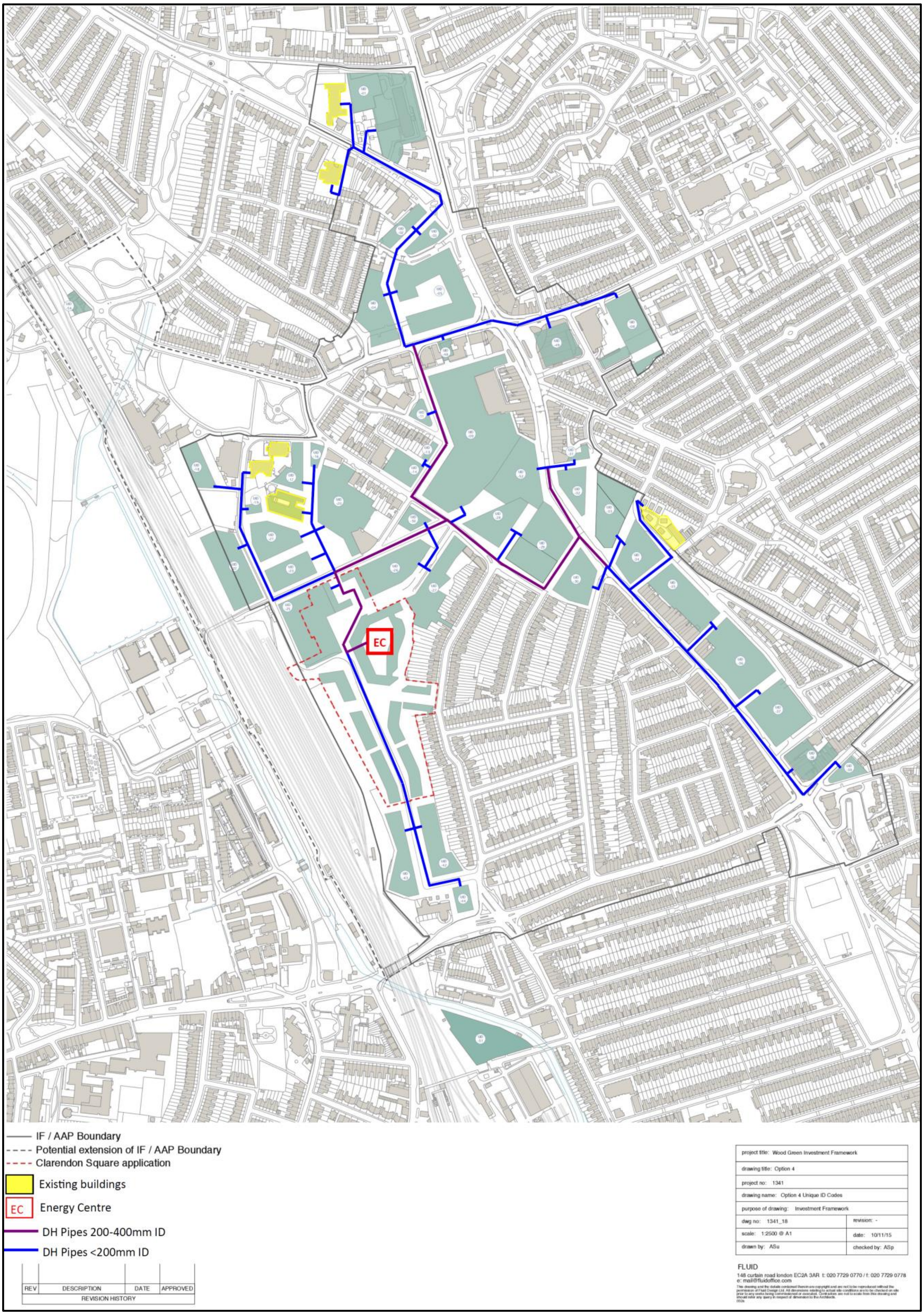

Figure 10: Heat Network Route for Wood Green

Techno-economic Assessment

05

5. Techno-economic Assessment

A technical and financial assessment has been undertaken of the outline network design. This section sets out the results of this assessment and predicted carbon savings achieved.

5.1. Assessment Overview

For each building a monthly heat demand profile was created based on the information available.

To assess the commercial viability of the network options, estimates have been made of the total capital costs associated with the network and plant, the costs associated with operation and maintenance and the revenue from the sales of heat and electricity. These estimates are based on recent quotes from suppliers and AECOM's previous experience of delivering district heating projects. The costs have been run over 25 and 40 year periods to determine the cash flows and calculate the following:

- **Total capital cost.**
- **Net Present Value (NPV)** – this is the yield of the investment based on the capital investment and the costs and returns over time together with the discount factor. We have reviewed the NPV for a 3.5% discount rate, based on the Government's recommendations for public sector funded projects, 6% as a mixed public sector / private funded project and a 10% discount, considered reasonable for the assessment of a private funded scheme. The NPV is a useful indicator as it shows, for any given discount factor and length of contract, how much gap funding may be required (if any) in order to make a project viable.
- **Internal Rate of Return (IRR)** – this shows the rate of return on the investment. A public sector funded project would typically look for a IRR of 6%, while a private funded project is likely to look for something between 9% and 12% depending on the approach to investment.

The techno-economic assessment includes a sensitivity analysis. The economic model has several key inputs, to undertake the sensitivity analysis, each of which was adjusted individually (whilst keeping all other inputs on their base values). This process was repeated for each of the following model inputs:

- **Electricity revenue price –** The average price at which electricity can be sold (higher prices require a greater proportion to be sold to private consumers).
- **Heat sale price –** Average price at which heat is sold to customers. Linked to offering a discount over business as usual.
- **Capital cost –** The capital cost of the heat network and energy centre.
- **Gas costs –** Price of gas purchased by the energy centre to fuel CHP units and top-up boilers.
- **Connection Charges –** Price paid by developers to connect to the network which offsets the need for plant to be installed on the individual site.

5.2. Assumptions

The scheme has been assessed based on gas-fired CHP, backed up by gas boilers. It is assumed that the energy centre building and initial heating plant will be installed in 2019 with heat supplied to the first buildings in 2020. The heat network is assumed to be developed following the phasing and heat load build up set out in section 2, with heat generation plant being added to the energy centre as required. Figure 11 shows the assumed capital expenditure profile, while Figure 12 shows the assumed build-up of income and operational expenditure over time.

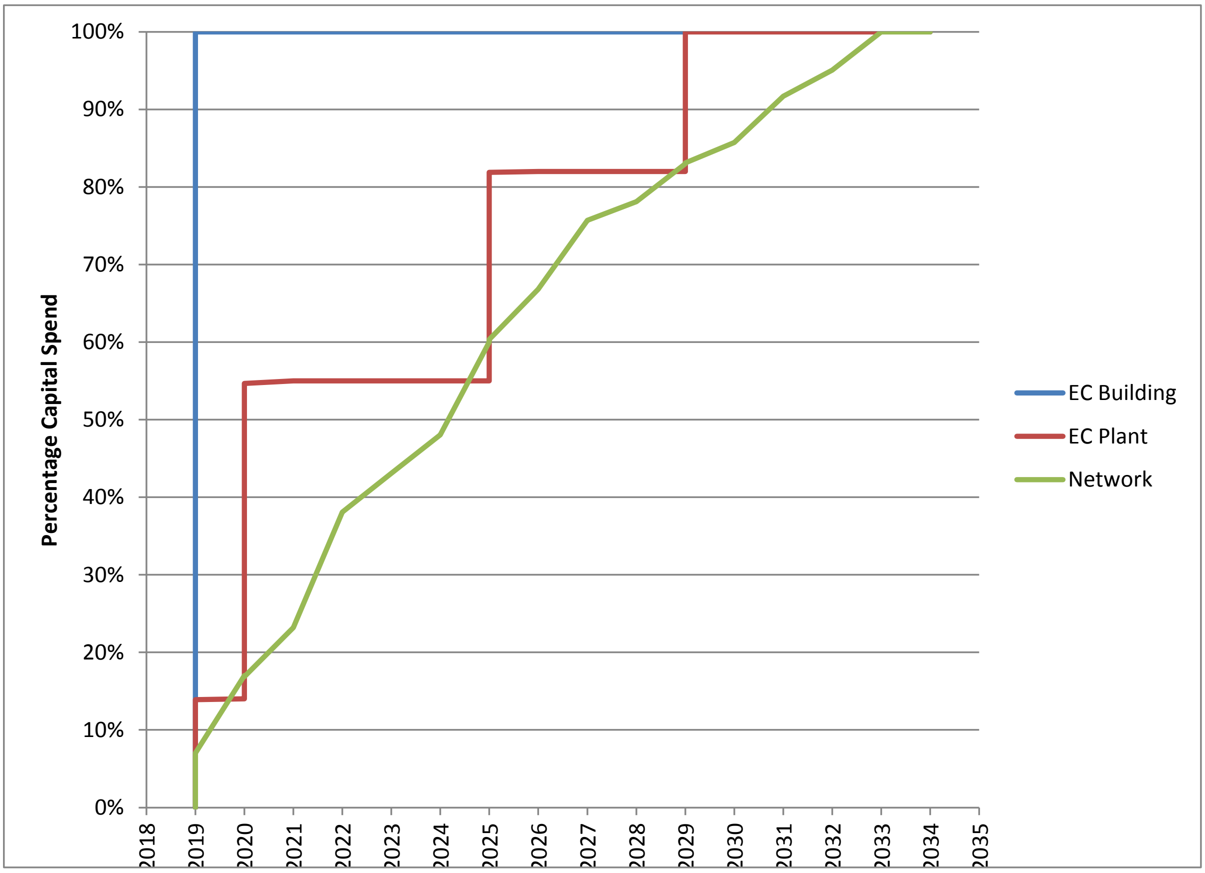

Figure 11: Capital Expenditure Over Time

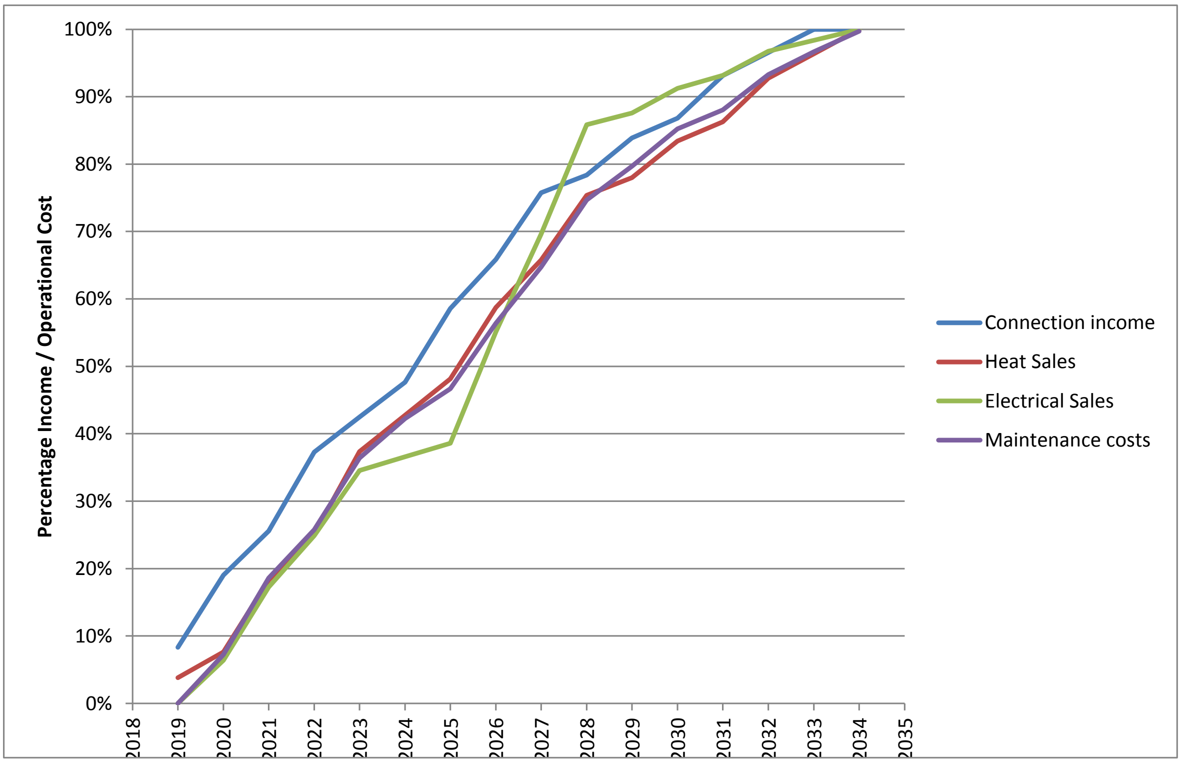

Figure 12: Operating Costs and Income Build-up Over Time

The proposed district heating system has been compared with a Business as Usual (BAU) case. This has been taken as individual gas boilers for each dwelling or commercial property.

Most of the sites that are assumed to connect are new build and therefore are anticipated to pay a connection charge. This charge is set below the cost of installing plant on each individual site to provide a financial incentive to developers to connect while providing income to the heat network.

Retained sites that are assumed to connect will not pay a connection charge as they do not have any plant costs to offset at the time of connection.

Similarly heat exchangers and pipework on new development sites are assumed to be a cost to the developer not the heat network, while heat exchangers required for existing sites are assumed to be paid for by the heat network.

The heat price has been set based on offering a 10% discount compared to the BAU case of individual gas boilers. This is based on the cost of gas plus maintenance and capital replacement over the project life.

Energy costs (gas and electricity) have been taken from the DECC (now Department of Business, Energy & Industrial Strategy) quarterly energy statistics, while the export price of electricity generated by the CHP has been taken from as the wholesale price of electricity plus 10%. All these prices are assumed to vary over the life of the project in line with IAG energy cost projections.

Energy emissions factors are taken from the Government's IAG figures and are based on the consumption based grid-average. Emissions associated with exported electrical power from the CHP are taken from the LCP model developed for DECC.

For the calculation of the Net Present Value (NPV), Initial Rate of Return (IRR), and other economic indicators, a lifecycle of 40 years has been modelled with a discount rate of 3.5%, reflecting the "Green Book" public sector investment rate.

5.3. Results

The capital cost of the fully built out scheme is estimated to be around £30.9M. Table 6 indicates the estimated costs of the major items of plant. An allowance has been added to cover the cost of design fees and other development costs to the capital items of plant. Note that the costs identified are intended to be installed costs not the just the cost of purchasing the items of plant.

	Unit Rate		Amount		Cost (£ Millions)
CENTRAL PLANT					
Building	2000	£/m^2	2700	m^2	£5.4
Utility connections					£1.4
Boilers	50	£/kW	28	MW	£1.4
CHP					
(Installed cost including CHP unit, M&E connections. Ventilaiton. Heat rejection and controls)	1000	£/kWe	5.4	MWe	£5.4
Ancillary plant					
(Includes M&E works, ventilation, pumps, pressurisation and controls)	290	£/kW	28	MW	£8.1
Thermal Stores	1000	£/m^3	430	m^3	£0.4
HEAT NETWORK					
Pipework (installed)					£4.8
Site Sub-stations	17,200	£/connection	92	nr.	£1.6
Customer connections (HIUs) - Only for existing buildings					£0.4
Development costs					£2.0
TOTAL					**£30.9**

Table 6: Capital Cost Breakdown for Full Scheme

The assessment shows that the project returns a positive IRR of around 2.6%, with an NPV over 40 years and 3.5% discount factor of around -£1.8M. Figure 13 shows the sensitivity of the predicted IRR to changes in capital costs, gas costs, connection charges, heat price and electrical sale price. This shows that the scheme is very sensitive to heat price; if heat is sold at the same price as the counterfactual then the project is predicted to deliver an IRR of 6%. To a less extent the project is sensitive to capital costs and electrical sale price. If electricity can be sold at around £65 / MWh then the predicted IRR rises to around 10%. This suggests that the scheme could be made financially attractive if a private wire network could be developed to sell the electricity generated at a discounted commercial price.

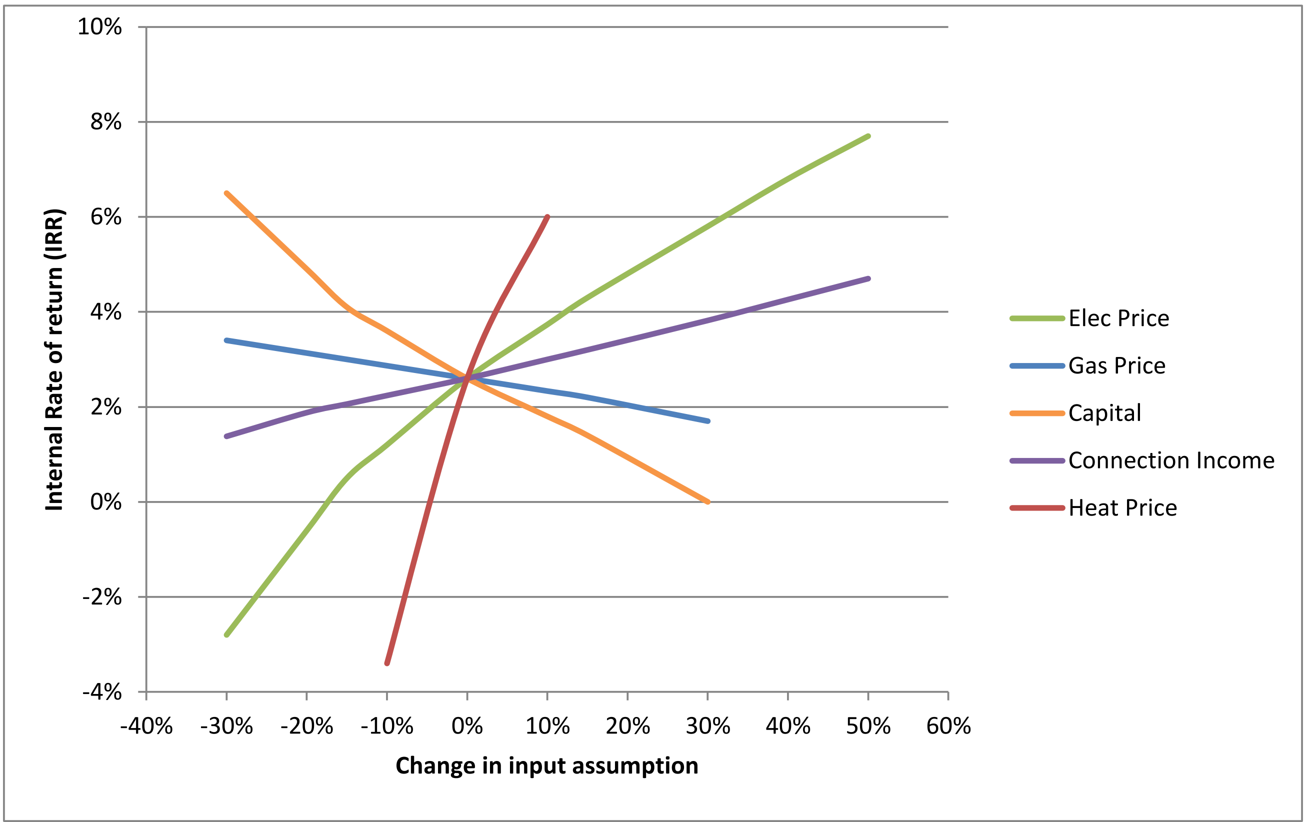

Figure 13: Financial Sensitivity Analysis

Table 7 shows the influence of the discount rate and length of assessment term on the NPV.

Discount	(%)	3.5	6	10	3.5	6	10
Period	(Years)	40	40	40	25	25	25
NPV	**(£ million)**	**-£1.8**	**-£5.1**	**-£7.3**	**-£4.0**	**-£6.1**	**-£7.6**
IRR	**(%)**	**2.6%**	**2.6%**	**2.6%**	**0.8%**	**0.8%**	**0.8%**
Discount on Counterfactual	(%)	10%	10%	10%	10%	10%	10%
Electric sales price	(p/kWh)	3.63	3.63	3.63	3.63	3.63	3.63
Connection charge	(£/kW)	400	400	400	400	400	400
Energy Centre Gas Price	(p/kWh)	1.87	1.87	1.87	1.87	1.87	1.87
Counterfactual Gas Price	(p/kWh)	3.9	3.9	3.9	3.9	3.9	3.9
Capital cost	(£ million)	£30.9	£30.9	£30.9	£30.9	£30.9	£30.9
CO_2	(Tonnes)	15,495	15,495	15,495	11,211	11,211	11,211
	(Tonnes pa)	387	387	387	448	448	448

Table 7: Financial Results

Figure 14 shows the breakdown of income for the scheme. Heat sales dominate, hence the sensitivity of the financial performance on the heat sale price. It should be noted that the heat sales include both fixed and variable charges and represent a level of income the offers a 10% reduction compared to business as usual.

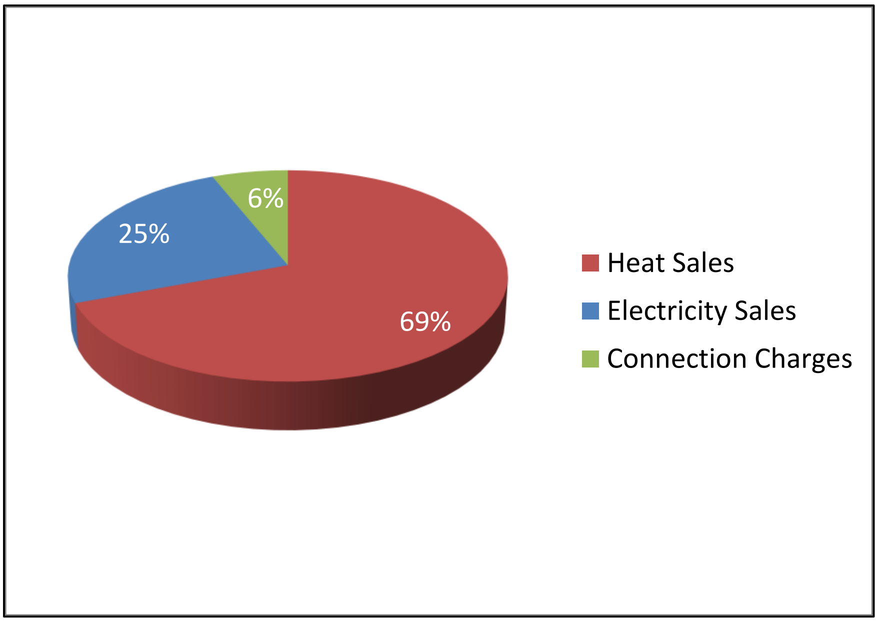

Figure 14: Revenue Split Over 40 Scheme Life

Carbon savings have been estimated for the scheme taking account of the projected reductions in emissions associated with the electricity grid. The savings over 40 years are around 15,495 tonnes, 387 tonnes pa, while the savings over 25 years are around 11,211 tonnes, 448 tonnes pa based on CHP technology being used throughout the project life.

A calculation has been carried out to estimate the potential CO_2 savings possible if the proposed Wood Green network could be supplied by heat from the EfW plant from day one to meet around 90% of the schemes heat needs. The result suggests that around 166,000 tonnes could be saved over the 40 year life of the scheme. In reality the actual savings would be less if gas fired CHP were used as the low carbon heat source for the first 15 to 20 years of the scheme.

A further analysis has been undertaken to determine the effect of alternative energy centre and pipe route options. Changing the location of the energy centre within the master plan will have a minimal impact on costs (less than 1% of the total project cost) and hence predicted financial return of the scheme. Designing the Wood Green network to connect onto a future heat supply from Edmonton at the opposite end of the network to the preferred energy centre location would only increase the overall capital costs by around 1%. This is likely to lead to a very slight reduction in IRR from 2.6% to 2.5%, with a reduction in NPV from –£1,8 million to -£2.1 million.

5.4. Risk Register

Risk	Impact	Mitigation
Heat loads are lower than predicted due to changes to masterplan	Viability of scheme reduced due to reduced heat sales	Assess volume of development as masterplan updates and check impact on techno-economic assessment
Phasing of development requires significant amounts of temporary plant		Include changes to capital and reductions in operational income in sensitivity analysis of techno-economic assessment. Look for routes to link sites that would not put district heating pipe at risk from future construction activity.
Longer time frame for development reduces viability of scheme	Viability of scheme reduced due to delayed income	Carry out sensitivity assessment at the next feasibility stage on changes to delivery timescale
Land costs for energy centre high		Include changes to capital in sensitivity analysis of techno-economic assessment. Investigate potential costs and identify site that will reduce these.
Noise, pollution control or visual impact of energy centre plant	Scheme less viable due to increased capital cost	Include changes to capital in sensitivity analysis of techno-economic assessment. Carryout investigation into measures that might be required and include these in cost assessment at next stage of feasibility.
Low IRR	Lack of interest for private investment	Investigate measures to improve income from electrical sales. Investigate measures to publicly fund parts of the system, such as funding from the Heat Network Investment Project and / or Community Infrastructure Levy.
Opportunities for local heat recovery do not delivery required heat loads	Long term CO_2 savings lower	Investigate opportunities for heat recovery further at next feasibility stage. Include clauses in AAP and planning that encourage developments to investigate and include heat recovery.
Heat network from Edmonton EfW not extended to Wood Green area	Long term CO_2 savings lower	Investigate measures that will improve likelihood of heat from Edmonton being made available at Wood Green in the next feasibility stage.

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Delivery Options

06

6. Delivery Options

This section sets out the potential approach to delivery that could be used to take a district heating scheme forward within Wood Green.

There are a number of routes to delivering the proposed heat network for the Wood Green AAP area. The predicted IRR is too low to be attractive to a private investor or ESCO unless a private wire network can be used to raise the electrical sale price or heat revenue is set at a level equal to providing heat from individual gas boilers.

6.1. Private Concession Agreement

A concession area could be offered within which a private company would provide heating supplies via a heat network, with developers being obliged to connect schemes over a specified size to the network and the concessionaire being obliged to supply heat. The concessionaire would be responsible for developing the heat network, making connection and supply agreements, supplying heat and billing customers.

This arrangement removes the need for public funding beyond the appointment of a concessionaire. However, once appointed the Council will have limited ability to interfere with / or influence the operation of the scheme. A strong concession agreement is required that sets out the terms of contract and level of service customers can expect and puts in place controls on prices. The scheme should be registered with the Heat Trust for domestic customers and similar provisions should be in place for non-domestic customers.

One of the main issues with this approach to delivering a scheme is the certainty with which developments can be obliged to connect to the scheme where the Council do not necessarily own all the sites to be developed. Planning policy is one mechanism that can be used to encourage connection. The confidence of the private sector in the ability of planning policy, and a favourable commercial offer, to ensure connections will determine the interest in this type of contact.

The Queen Elizabeth (Olympic) Park scheme is an example of this arrangement.

6.2. Private Energy Supply

The Council could offer a private company an energy supply agreement, although such an offer is likely to be limited to those areas and buildings under their control. This can act as a kick start to the network and generally requires a concession agreement that enables the network operator to expand the system over a given concession period.

This gives operators a greater level of certainty around which they can build a business case, but generally requires the Council to have control over a reasonably large proportion of the AAP area, either as existing retained buildings or development sites.

The Coventry Heatline project is an example of a scheme operating in this way.

6.3. Public Private Partnership / JV Company

There are a wide range of options that could be adopted depending on the Council and private sector appetite for the scheme.

The Council could own specific assets in the scheme (parts of the network or energy generating plant) or could part fund the scheme with the private sector part funding, designing, constructing and operating the scheme.

Developers may be interested in a JV partnership where they see commercial advantage in developing an area wide heat network through reducing development costs on individual sites, by not including an energy centre on each site, or through generating an income while the scheme is built out.

This approach offers potential returns on investment but with shared risk as well as offering the Council a higher level of influence regarding how the scheme operates.

6.4. Public Sector Scheme

The Council could decide that the scheme offers an investment opportunity and could fully fund a scheme through a combination of public borrowing, infrastructure levy payments, Section 106 payments and grants.

This approach offers the Council control of the scheme operation and a higher potential return than a public / private partnership, but places all the risk with the Council.

A public sector scheme could use private company(s) to carry out specific tasks (design, build or operate the network) on their behalf, while managing the scheme in-house. Islington is an example of this approach. Alternatively the Council could set up a wholly owned special purpose vehicle to develop and operate the heat network, returning an income stream back to the Council. An example of this approach is Nottingham.

6.5. Separate Heat Generation and Delivery

The operating models discussed in the preceding paragraphs can be modified by separating heat generation from heat delivery. Coventry Heatline is an example of this approach where heat is generated by an EfW plant and sold to the pipeline owner / operator who then sells to end customers.

6.6. AAP and Planning Requirements

Planning policy will be a major driver for connection to a heat network in Wood Green regardless of which option is taken forward.

The AAP can also support the development of district heating by including:

- Requirements for all new sites to connect to a district heating network. Where it is not possible in the initial years, new developments should be required to include the following:
  - Provide space for a heat exchanger
  - Safeguard routes for installation of the network connection route
  - Design the space heating as a low temperature system (70ºC flow / 40ºC return) to allow the building to be connected to the heat network in due course.
- Identify the preferred location for an energy centre within the Clarendon Square site.
- Identify the potential pipework route and safeguard this where it does not run through existing adopted roads.
- Require developers and encourage Crossrail to look for opportunities for recovering heat where cooling is required. This could be facilitated by the use of central water cooled chillers (rather than VRV or split unit

cooling). Also opportunities for serving several closely linked buildings from central chillers should also be investigated as part of the design development options.

These requirements should also be set out in the planning policy developed for the site on the basis that a viable DHN scheme has been identified and can be delivered.

Current planning policy in London supports connection to heat networks, but resistance can be met even where networks already exist in an area. One advantage of having a network developer in place would be a proactive approach from the supply side to connections.

Early discussions with developers and information packs setting out the advantages of connection could also be advantageous. On the Olympic Park the concessionaire's employer often acts as an initial point of contact for developers, although the final connection and supply agreements are negotiated directly between the concessionaire and developer.

Conclusions

07

7. Conclusions

A masterplan is under development for the Wood Green Investment Framework area to support the development of an Area Action Plan. As part of this work an assessment has been undertaken of a heat network for the Wood Green area.

Energy demands have been estimated based on the current masterplan and benchmark data and an initial development programme has been identified which is in line with the anticipated development and operation of Crossrail 2, which is seen as a major driver for regeneration of the area. The estimated total annual heat demand on full build out of the masterplan is 28.2 GWh.

The initial source of low carbon heat is anticipated to be gas-fired CHP, but in the longer term a connection to the energy from waste plant in Edmonton could become the major heat source. Other low carbon heat may be available from heat recovery from building cooling systems and Crossrail. Opportunities would need to be investigated as the masterplan is developed in more detail.

An assessment of potential energy centre sites has identified a site integrated into the proposed Clarendon Square development that has been used in the techno-economic analysis of the proposed heat network. An energy centre area of around 2700m^2 is estimated to be required to serve the fully built out district heating scheme. Due to pressures on land use the energy centre is anticipated to need to be integrated with other building uses regardless of which site is chosen. Heating plant can be installed as required to meet the growing heat load but the energy centre building will need to be fully built at the start of the project. The fully built out DHN is estimated to require around 28MW of gas boiler plant and 5.3MWth of gas-fired CHP.

A techno-economic assessment of the scheme has been carried out and shows that the scheme returns an IRR of 2.6%. The scheme has been tested against a number of parameters and show particular sensitivity to heat sale price, electrical sale price and capital cost.

The current analysis is based on sale of electricity via a Licence Lite agreement at a current price of £36.3 per MWh, varying over the life of the scheme according to IAG projections on energy prices. If some or all of the electricity generated could be sold over private wire then a higher value could be realised and the scheme would return a higher IRR. If a sale price of around £65-£66 per MWh can be achieved then the scheme would return an IRR of around 10%. Potential private wire customers include Haringey Council or the rail works to the west of the scheme.

The IRR could also be improved by increasing the heat price. The current analysis is based on selling heat at a 10% discount compared to the cost of providing heat from individual gas boilers. If the heat price were raised to be equal to the cost of heat from individual gas boilers (ie no discount compared to business as usual) then the IRR could be increased to around 6%.

The relatively low IRR is unlikely to be attractive to private investment unless developers within the Wood Green AAP area see other advantages to a single area wide network and are interested in supporting such a scheme. In addition to or instead of improved revenue from electrical sales, it may be possible for the Council to improve the IRR by funding and owning specific assets such as the energy centre or heat generation, as part of a JV delivery model. A further option is for gap funding from the Heat Network Investment Project or Community Infrastructure Levy to improve the IRR, possibly to a level acceptable to the private sector.

Recommendations

The following recommendations are made regarding next steps and further feasibility work:

1. Integrate information and recommendations into the AAP to ensure a district heating network can be developed. This should include:
    - All new developments should be required to connect on to the district heating network. Where it is not possible in the initial years, new developments should be required to include the following:
        - Provide space for a heat exchanger

  - Safeguard routes for installation of the network connection route
  - Design the space heating as a low temperature system (70ºC flow / 40ºC return) to allow the building to be connected to the heat network in due course.
- Identify the preferred location for an energy centre within the Clarendon Square site.
- Identify the potential pipework route and safeguard this where it does not run through existing adopted roads.
- Require developers and encourage Crossrail to look for opportunities for recovering heat where cooling is required. This could be facilitated by the use of central water cooled chillers (rather than VRV or split unit cooling). Also opportunities for serving several closely linked buildings from central chillers should also be investigated as part of the design development options.

2. During discussions with Crossrail determine:
   - Plans for providing cooling to stations (water cooled chillers would facility heat recovery if mechanical cooling is proposed) and where cooling assets are likely to be located.
   - Potential for incorporating heat recovery into stations and / ventilation shafts - integration of air-to-water heat exchangers in ventilation shafts, fan coil units at stations?
   - Locations of ventilation shafts.

3. Any Stage 2 feasibility investigations should include:
   - Update heat loads and timing based on masterplan current at the time and review the potential for connecting heat loads outside but in close proximity to the AAP area.
   - Investigate further opportunities for heat recovery from buildings and other sources,
   - Investigate potential for heat being taken from Edmonton EfW – Development plans already being considered, ambition for expansion, potential timeframes for expansion, potential heat sale price and carbon intensity.
   - Given updated masterplan confirm preferred location for energy centre and need for temporary energy centre(s).
   - Obtain information on potential utility supplies and connections for an energy centre.
   - Size plant and design energy centre to RIBA Stage C to ensure energy centre has space for major items of plant and the necessary ancillary equipment.
   - Identify whether the existing buildings proposed to be connected can operate at 70 / 40oC and if not whether modifications can be made or whether top up heating plant should be retained. This will enable an estimate of connection costs for the existing buildings to be made.
   - Identify all major utilities (trunk sewers or water mains, national grid gas and electrical assets) and other potential barriers to heat network development. Where possible identify depth of these together with depth of Victoria tube line.
   - Update the pipe route and sizing based on revised masterplan, network constraints and energy centre location.
   - Investigate opportunities for private wire connections, identifying potential customers and volume of electrical sales possible.
   - Carryout techno-economic analysis, including a sensitivity analysis.
   - Based on the results from the techno-economic analysis identify the preferred business structure for developing the scheme.

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Glossary

Glossary

AAP: Area Action Plan

BAU: Business as usual

Biomass: Fuel derived from organic material such as wood, energy crops, food waste or agricultural residues.

CHP: Combined Heat and Power: a method of power generation which produces both heat and electricity.

CO_2: Carbon Dioxide.

DE: Decentalised Energy: broadly refers to energy that is generated off the main grid. It can refer to energy from waste plants, combined heat and power, district heating and cooling, as well as geothermal, biomass or solar energy.

DECC: UK Government Department for Energy and Climate Change.

DH(N): District Heat (Network): a system where a centralised heat generating plant (using any one of a range of technologies) provides heat to surrounding buildings in the area by means of a network of insulated pipes carrying hot water or steam.

DNO: Distribution Network Operator

Energy Centre: Location of the energy generating plant for a district heat network.

EfW: Energy from waste - the generation of electrical power from the burning of municipal waste.

EMP: Energy Master Plan.

ESCO: Energy Service Company: A commercial entity which typically operates and maintains the plant associated with a DHN (or potentially also other forms of generation). They would also normally bill any user of the DHN.

GIS: Geographical Information Systems: software and tools for managing, analysing and presenting geographical data.

GLA: Greater London Authority

Heat density: Measure of the heat demand in an area: mapped in this report as $MWh/year/m^2$.

IAG: Interdepartmental Analysts' Group

IRR: Internal Rate of Return: the discount rate at which an investment breaks even. i.e. the discount rate required for an NPV of zero.

kWh: Kilowatt-hour: a unit of power (energy conversion). 1 Kilowatt = 1,000 Joules per second; 1 Kilowatt-hour = 3,600,000 Joules.

MWh: Megawatt-hour: equal to 1,000kWh or 3.6×10^9 Joules.

NPV: Net Present Value: the equivalent value of an investment today, taking into account cashflows and discount rates over the lifetime of the investment.

Payback Period: The amount of time taken for an investment to break even.

RHI: Renewable Heat Incentive.

Special Purpose Vehicle (SPV): A subsidiary corporation designed for high risk investments.

TfL: Transport for London

UKPN: UK Power Networks

Appendices

Appendix 1 – Energy data

Plot Unique Identification Number		Plot Footprint - msq	Plot description	Number of Storeys	Approx. Residential GEA - msq	Approx. Retail GEA - msq	Approx. Workspace GEA - msq	Approx. Education GEA - msq	Approx. Community / Community GEA - msq	Approx. Transport GEA - msq	Approx. Healthcare GEA - msq	Approx. Pubs/Restaurants GEA-msq	Approx. Leisure GEA - msq	Character Area	Site Allocation
UID - 01		10,409	Education on GF with residential above	6	26,073	NA	NA	2575.5	NA	NA	NA	NA	NA	Civic Centre &	SA10 / Additional allocation A
UID - 02		1,604	Residential development	5	4,812	NA	NA	NA	NA	NA	NA	NA	NA	High Street Nor	SA11
UID - 03		1,419	Residential development with retail on GF/1F	6	3,406	2,129	NA	NA	NA	NA	NA	NA	NA	High Street Nor	SA11
UID - 04		4,534	Retail on GF with residential above	4 to 6	12,864	923	NA	NA	NA	NA	NA	NA	NA	High Street Nor	SA12 / 13
UID - 05		8,313	Reconfigured bus depot with x2 storey retail on	3 to 18	39,613	2,053	2,714	NA	NA	NA	NA	388	NA	High Street Nor	SA12
UID - 06															
UID - 07															
UID - 08		5,335	Leisure / Retail	6	NA	12801.6	NA	NA	NA	NA	NA	NA	6045	High Street Nor	SA14
UID - 09		19,213	Residential, retail, healthcare and community s	25	78799.2	7,938	4,550	NA	1400	NA	1750	NA	NA	High Street Nor	SA15
UID - 10															
UID - 11		795	Residential development and mosque/communi	6	1,908	NA	NA	NA	1,193	NA	NA	NA	NA	Parkland & Mo	SA15
UID - 12															
UID - 13		332	Residential development	3	747	NA	NA	NA	NA	NA	NA	NA	NA	Parkland & Mo	Additional allocation C
UID - 14		2,018	Resi	3	3,632										
UID - 15															
UID - 16		580	Community facilities and offices	5	NA	1,305	NA	NA	870	NA	NA	NA	NA	Creative Quart	SA23
UID - 17		1,816	Early years/residential/offices	7	1,350	NA	4,219	1,553	NA	NA	NA	NA	NA	Creative Quart	SA23
UID - 18		2,045	Education	5	NA	NA	NA	7,669	NA	NA	NA	NA	NA	Creative Quart	Additional allocation D
UID - 19		352	Workspace / creative (5 floors) with residential	8	1,056	NA	792	NA	NA	NA	NA	NA	NA	Creative Quart	SA24
UID - 20		7,321	Workspace / creative (5 floors) with residential	8	11,369	NA	25,946	NA	NA	NA	NA	NA	NA	Creative Quart	SA23 / 24 / 25
UID - 21		3,294	Workspace / creative (5 floors) with residential	8	5,929	NA	12,353	NA	NA	NA	NA	NA	NA	Creative Quart	SA24
UID - 22		6,077	Energy centre, resi, restaurant, leisure and work	8 to 12	18,231	NA	3,762	NA	NA	NA	NA	1,895	9,116	Creative Quart	SA29
UID - 23		2,674	Cultural, Retail and Resi	8 to 15	11,231	808	NA	NA	9,890	NA	NA	NA	NA	Creative Quart	SA24
UID - 24															
UID - 25		3,146	Employment and Resi	5	7,550	NA	2359.5	NA	NA	NA	NA	NA	NA	Creative Quart	SA5 (Clarendon Sq) / SA28
UID - 26		4,722	Council back of house and resi	7	3,944	NA	14,934	NA	NA	NA	NA	NA	NA	Creative Quart	SA5 (Clarendon Sq) / SA26
UID - 27		4,760	Retail on GF with residential above	5	13,546	734	NA	NA	NA	NA	NA	NA	NA	Clarendon Squa	SA26 / Additional allocation E
UID - 28		3,419	Retail on GF with residential above	20	22,565	5,129	NA	NA	NA	NA	NA	NA	NA	The Mall	SA17
UID - 29		6,845	Retail on GF with residential above	15	36,963	10,268	NA	NA	NA	NA	NA	NA	NA	The Mall	SA17
UID - 30		3,435	Retail on GF with residential above	6	8,244	5,153	NA	NA	NA	NA	NA	NA	NA	The Mall	SA17
UID - 31		466	Retail on GF with residential above	5	1,118	350	NA	NA	NA	NA	NA	NA	NA	The Mall	SA17
UID - 32		2,194	Retail on GF with residential above	6	5,266	3,291	NA	NA	NA	NA	NA	NA	NA	The Mall	SA17
UID - 33		4,684	Retail on GF with residential above	6	11,242	7,026	NA	NA	NA	NA	NA	NA	NA	The Mall	SA17
UID - 34		3,806	Retail on GF with residential above	6	9,134	5,709	NA	NA	NA	NA	NA	NA	NA	The Mall	SA17
UID - 35		5,010	Retail on GF with residential above	6	12,024	7,515	NA	NA	NA	NA	NA	NA	NA	High Street Sou	SA18
UID - 36		7,256	Retail on GF with residential above	6	17,414	10,884	NA	NA	NA	NA	NA	NA	NA	High Street Sou	SA19
UID - 37		5,681	Retail on GF with residential above	6	13,634	8,522	NA	NA	NA	NA	NA	NA	NA	High Street Sou	SA19
UID - 38		2,902	Retail on GF with residential above inc. a tower	4 to 10	10,447	2,177	NA	NA	NA	NA	NA	NA	NA	Turnpike Lane	SA20
UID - 39		1,177	Retail on 1st & GF with residential above inc. a	4 to 7	2,825	883	NA	NA	NA	NA	NA	NA	NA	Turnpike Lane	SA21
UID - 40															
UID - 41															
UID - 42		3,556	Primary School	3	NA	NA	NA	8,001	NA	NA	NA	NA	NA	Clarendon Squa	SA27
UID - 43		3,530	Workspace, Education and Early Years	9	9,792	NA	2,720	1,215	NA	NA	NA	NA	NA	Clarendon Squa	SA27
UID - 44		970	Resi and Community	5	1,455	NA	NA	NA	2,183	NA	NA	NA	NA	Clarendon Squa	SA27
UID - 49		4,080	Resi & Leisure	6	9,792								4896	Vue Cinema	
UID - 48		540	Office space	6	NA	NA	2,430	NA	NA	NA	NA	NA	NA	Parkland & Morrisons	
UID - 50		1,022	Resi	3	1,840	NA	NA	NA	NA	NA	NA	NA	NA	Creative Quarter	
UID - 51		5,445	Resi	6	19602	NA	NA	NA	NA	NA	NA	NA	NA	North of Nornsey Rail Depot	
UID - 52		5,822	Resi/Retail	3 to 35	32,160	10,480	NA	NA	NA	NA	NA	NA	NA	The Mall	
UID - 54		701	Resi/Retail	4	1,577	525.75	NA	NA	NA	NA	NA	NA	NA	Creative Quarter	
UID - 55		1,865	Resi	2	2,238	NA	NA	NA	NA	NA	NA	NA	NA	Creative Quarter	
Clarendon Square															
UID - 45			Clarendon Square Development		25,176	700	700	NA	550	NA	NA	550			

Table 8: Fluid Masterplan Schedule

WOOD GREEN DH

28,923,946

LIST OF SITES INCLUDED IN SCOPE FOR DISTRICT HEATING MODELLING AND CONSUMPTION AND AREA DATA WITHIN SCENARIO ONE MASTERPLAN OPTION

		OPTION 1	Data source	kWh Gas	kWh Heat	kWh Electricity	m2 Area	Heating kWh Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
EXISTING RETAINED BUILDINGS																				
E1	Trinity Primary Academy (2)	✓	Existing consumption	486,859	413,830	159,159		72,804	64,218	49,241	39,057	25,178	14,794	0	0	15,493	28,673	46,046	58,327	413,830
E2	Alexandra Infants and Junior School	✓	Existing consumption	298,771	253,955	113,959		44,678	39,408	30,218	23,968	15,451	9,079	0	0	9,508	17,596	28,257	35,793	253,955
E3	Heartlands High School (2)		Existing consumption	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
E4	St Michaels CoE Primary School (2)	✓	Existing consumption	164,435	139,770	36,236		24,589	21,689	16,631	13,191	8,504	4,997	0	0	5,233	9,684	15,552	19,700	139,770
C1	LBH Civic Centre		Existing consumption	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
O1	Chocolate Factory	✓	Existing consumption	761,926	647,637	746,927		105,131	91,068	75,442	59,504	37,784	21,534	15,283	15,908	22,627	43,253	70,442	89,661	647,637
O4	Chocolate Factory 2			0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
O2	Parma House		Existing consumption	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
Res 1	Council owned houses north of Parkland Road			0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
			Data source	N. Dwellings	kWh Heat	kWh Electricity	m2 Area													
NEW DEVELOPMENTS																				
UID - 01	Education on GF with residential above	✓	Residential Benchmarks	298	863,479	844,505	26,073	111,885	100,910	88,715	76,276	59,325	46,642	41,764	42,252	47,495	63,593	84,812	99,812	863,479
UID - 01	Education on GF with residential above	✓	D1.Edu	0	79,841	157,106	2,576	13,275	11,829	9,307	7,592	5,255	3,506	0	0	3,624	5,844	8,769	10,837	79,841
UID - 02	Residential development	✓	Residential Benchmarks	55	159,363	155,861	4,812	20,649	18,624	16,373	14,077	10,949	8,608	7,708	7,798	8,766	11,737	15,653	18,421	159,363
UID - 03	Residential development with retail on GF/1F	✓	Residential Benchmarks	39	112,786	110,307	3,406	14,614	13,181	11,588	9,963	7,749	6,092	5,455	5,519	6,204	8,306	11,078	13,037	112,786
UID - 03	Residential development with retail on GF/1F	✓	A1-A2	0	70,241	134,096	2,129	9,414	8,435	7,348	6,239	4,727	3,596	3,161	3,204	3,672	5,108	7,000	8,337	70,241
UID - 04	Retail on GF with residential above	✓	Residential Benchmarks	147	426,026	416,665	12,864	55,202	49,787	43,770	37,633	29,270	23,012	20,606	20,846	23,433	31,376	41,845	49,246	426,026
UID - 04	Retail on GF with residential above	✓	A1-A2	0	30,443	58,118	923	4,080	3,656	3,185	2,704	2,049	1,558	1,370	1,389	1,591	2,214	3,034	3,613	30,443
UID - 05	Reconfigured bus depot with x2 storey retail on GF, residential above (height varies)	✓	Residential Benchmarks	453	1,311,899	1,283,072	39,613	169,989	153,314	134,786	115,887	90,133	70,864	63,452	64,194	72,161	96,618	128,857	151,646	1,311,899
UID - 05	Reconfigured bus depot with x2 storey retail on GF, residential above (height varies)	✓	A1-A2	0	67,741	129,323	2,053	9,079	8,135	7,086	6,017	4,559	3,468	3,048	3,090	3,541	4,926	6,751	8,041	67,741
UID - 05	Reconfigured bus depot with x2 storey retail on GF, residential above (height varies)	✓	B1	0	59,714	260,568	2,714	8,760	7,720	6,564	5,385	3,779	2,577	2,115	2,161	2,658	4,184	6,194	7,616	59,714
UID - 05	Reconfigured bus depot with x2 storey retail on GF, residential above (height varies)	✓	A3-A5	0	26,367	67,081	388	3,819	3,373	2,878	2,373	1,684	1,169	971	991	1,204	1,858	2,719	3,329	26,367
UID - 08	Leisure / Retail	✓	A1-A2	0	422,453	806,501	12,802	56,620	50,733	44,192	37,521	28,429	21,627	19,011	19,272	22,085	30,719	42,099	50,144	422,453
UID - 08	Leisure / Retail	✓	D2	0	501,735	810,030	6,045	77,767	67,883	56,902	45,701	30,436	19,015	14,623	15,062	19,784	34,280	53,388	66,895	501,735
UID - 09	Residential, retail, healthcare and community spaces	✓	Residential Benchmarks	901	2,609,651	2,552,307	78,799	338,145	304,974	268,118	230,524	179,294	140,963	126,220	127,695	143,543	192,194	256,324	301,657	2,609,651
UID - 09	Residential, retail, healthcare and community spaces	✓	A1-A2	0	261,954	500,094	7,938	35,109	31,459	27,403	23,266	17,628	13,410	11,788	11,950	13,694	19,048	26,105	31,094	261,954
UID - 09	Residential, retail, healthcare and community spaces	✓	B1	0	100,100	436,800	4,550	14,685	12,941	11,004	9,028	6,335	4,320	3,545	3,623	4,456	7,013	10,384	12,767	100,100
UID - 09	Residential, retail, healthcare and community spaces	✓	D1.Oth	0	46,200	133,000	1,400	7,103	6,209	5,215	4,202	2,821	1,788	1,390	1,430	1,857	3,169	4,897	6,119	46,200
UID - 09	Residential, retail, healthcare and community spaces	✓	D1.Hea	0	119,000	213,500	1,750	17,561	15,460	13,125	10,744	7,498	5,070	4,136	4,230	5,234	8,315	12,378	15,249	119,000

UID - 11	Residential development and mosque/community space	✓	Residential Benchmarks	22	63,189	61,800	1,908	8,188	7,384	6,492	5,582	4,341	3,413	3,056	3,092	3,476	4,654	6,206	7,304	63,189
UID - 11	Residential development and mosque/community space	✓	D1.Oth	0	39,353	113,288	1,193	6,050	5,288	4,442	3,579	2,403	1,523	1,184	1,218	1,582	2,699	4,171	5,212	39,353
UID - 13	Residential development	✓	Residential Benchmarks	9	24,739	24,195	747	3,206	2,891	2,542	2,185	1,700	1,336	1,197	1,211	1,361	1,822	2,430	2,860	24,739
UID - 14	Resi	✓	Residential Benchmarks	42	120,297	117,653	3,632	15,587	14,058	12,359	10,626	8,265	6,498	5,818	5,886	6,617	8,860	11,816	13,905	120,297
UID - 16	Community facilities and offices	✓	A1-A2	0	43,065	82,215	1,305	5,772	5,172	4,505	3,825	2,898	2,205	1,938	1,965	2,251	3,131	4,292	5,112	43,065
UID - 16	Community facilities and offices	✓	D1.Oth	0	28,710	82,650	870	4,414	3,858	3,241	2,611	1,753	1,111	864	889	1,154	1,969	3,043	3,803	28,710
UID - 17	Early years/residential/offices	✓	Residential Benchmarks	15	44,709	43,727	1,350	5,793	5,225	4,593	3,949	3,072	2,415	2,162	2,188	2,459	3,293	4,391	5,168	44,709
UID - 17	Early years/residential/offices	✓	B1	0	92,813	405,000	4,219	13,616	11,999	10,203	8,371	5,874	4,006	3,287	3,359	4,131	6,502	9,628	11,837	92,813
UID - 17	Early years/residential/offices	✓	D1.Edu	0	48,128	94,703	1,553	8,002	7,131	5,610	4,577	3,168	2,114	0	0	2,185	3,522	5,286	6,533	48,128
UID - 18	Education	✓	D1.Edu	0	237,731	467,794	7,669	39,529	35,223	27,713	22,607	15,647	10,441	0	0	10,791	17,400	26,111	32,269	237,731
UID - 19	Workspace / creative (5 floors) with residential above	✓	Residential Benchmarks	12	34,972	34,204	1,056	4,532	4,087	3,593	3,089	2,403	1,889	1,691	1,711	1,924	2,576	3,435	4,043	34,972
UID - 19	Workspace / creative (5 floors) with residential above	✓	B1	0	17,424	76,032	792	2,556	2,253	1,915	1,571	1,103	752	617	631	776	1,221	1,807	2,222	17,424
UID - 20	Workspace / creative (5 floors) with residential above	✓	Residential Benchmarks	130	376,509	368,236	11,369	48,786	44,000	38,683	33,259	25,868	20,338	18,211	18,423	20,710	27,729	36,981	43,522	376,509
UID - 20	Workspace / creative (5 floors) with residential above	✓	B1	0	570,818	2,490,840	25,946	83,739	73,796	62,749	51,481	36,125	24,636	20,217	20,659	25,409	39,992	59,214	72,802	570,818
UID - 21	Workspace / creative (5 floors) with residential above	✓	Residential Benchmarks	68	196,362	192,047	5,929	25,444	22,948	20,174	17,346	13,491	10,607	9,497	9,608	10,801	14,461	19,287	22,698	196,362
UID - 21	Workspace / creative (5 floors) with residential above	✓	B1	0	271,755	1,185,840	12,353	39,866	35,133	29,873	24,509	17,198	11,729	9,625	9,835	12,097	19,039	28,190	34,660	271,755
UID - 22	Energy centre, resi, restaurant, leisure and workspace	✓	Residential Benchmarks	208	603,769	590,502	18,231	78,233	70,559	62,032	53,334	41,481	32,613	29,202	29,543	33,210	44,466	59,303	69,791	603,769
UID - 22	Energy centre, resi, restaurant, leisure and workspace	✓	B1	0	82,764	361,152	3,762	12,141	10,700	9,098	7,464	5,238	3,572	2,931	2,995	3,684	5,798	8,586	10,556	82,764
UID - 22	Energy centre, resi, restaurant, leisure and workspace	✓	A3-A5	0	128,826	327,749	1,895	18,659	16,481	14,061	11,593	8,229	5,712	4,744	4,841	5,882	9,076	13,286	16,263	128,826
UID - 22	Energy centre, resi, restaurant, leisure and workspace	✓	D2	0	756,587	1,221,477	9,116	117,268	102,364	85,804	68,914	45,896	28,674	22,050	22,713	29,833	51,692	80,505	100,874	756,587
UID - 23	Cultural, Retail and Resi	✓	Residential Benchmarks	128	371,939	363,766	11,231	48,194	43,466	38,213	32,855	25,554	20,091	17,989	18,200	20,458	27,392	36,532	42,993	371,939
UID - 23	Cultural, Retail and Resi	✓	A1-A2	0	26,664	50,904	808	3,574	3,202	2,789	2,368	1,794	1,365	1,200	1,216	1,394	1,939	2,657	3,165	26,664
UID - 23	Cultural, Retail and Resi	✓	D1.Oth	0	326,383	939,588	9,890	50,178	43,862	36,843	29,684	19,929	12,629	9,822	10,103	13,121	22,385	34,597	43,230	326,383
UID - 25	Employment and Resi	✓	Residential Benchmarks	86	250,052	244,558	7,550	32,400	29,222	25,691	22,088	17,180	13,507	12,094	12,235	13,754	18,416	24,560	28,904	250,052
UID - 25	Employment and Resi	✓	B1	0	51,909	226,512	2,360	7,615	6,711	5,706	4,682	3,285	2,240	1,838	1,879	2,311	3,637	5,385	6,620	51,909
UID - 26	Council back of house and resi	✓	Residential Benchmarks	45	130,610	127,740	3,944	16,924	15,264	13,419	11,537	8,973	7,055	6,317	6,391	7,184	9,619	12,829	15,098	130,610
UID - 26	Council back of house and resi	✓	B1	0	328,548	1,433,664	14,934	48,198	42,475	36,117	29,631	20,793	14,180	11,636	11,891	14,625	23,018	34,082	41,903	328,548
UID - 27	Retail on GF with residential above	✓	Residential Benchmarks	155	448,619	438,762	13,546	58,130	52,427	46,092	39,629	30,822	24,233	21,698	21,952	24,676	33,040	44,064	51,857	448,619
UID - 27	Retail on GF with residential above	✓	A1-A2	0	24,215	46,229	734	3,245	2,908	2,533	2,151	1,630	1,240	1,090	1,105	1,266	1,761	2,413	2,874	24,215
UID - 28	Retail on GF with residential above	✓	Residential Benchmarks	258	747,315	730,894	22,565	96,833	87,334	76,780	66,014	51,344	40,367	36,145	36,567	41,106	55,038	73,402	86,384	747,315
UID - 28	Retail on GF with residential above	✓	A1-A2	0	169,241	323,096	5,129	22,683	20,324	17,704	15,031	11,389	8,664	7,616	7,721	8,847	12,306	16,866	20,089	169,241
UID - 29	Retail on GF with residential above	✓	Residential Benchmarks	422	1,224,131	1,197,232	36,963	158,617	143,057	125,768	108,134	84,103	66,123	59,207	59,899	67,333	90,154	120,236	141,501	1,224,131

UID - 29	Retail on GF with residential above	✓	A1-A2	0	338,828	646,853	10,268	45,412	40,690	35,444	30,094	22,802	17,346	15,248	15,457	17,713	24,638	33,766	40,218	338,828
UID - 30	Retail on GF with residential above	✓	Residential Benchmarks	94	273,023	267,023	8,244	35,377	31,907	28,051	24,118	18,758	14,748	13,205	13,359	15,018	20,107	26,817	31,559	273,023
UID - 30	Retail on GF with residential above	✓	A1-A2	0	170,033	324,608	5,153	22,789	20,420	17,787	15,102	11,442	8,705	7,652	7,757	8,889	12,364	16,945	20,183	170,033
UID - 31	Retail on GF with residential above	✓	Residential Benchmarks	13	37,039	36,225	1,118	4,799	4,329	3,805	3,272	2,545	2,001	1,791	1,812	2,037	2,728	3,638	4,281	37,039
UID - 31	Retail on GF with residential above	✓	A1-A2	0	11,534	22,019	350	1,546	1,385	1,207	1,024	776	590	519	526	603	839	1,149	1,369	11,534
UID - 32	Retail on GF with residential above	✓	Residential Benchmarks	60	174,385	170,553	5,266	22,596	20,379	17,916	15,404	11,981	9,420	8,434	8,533	9,592	12,843	17,128	20,158	174,385
UID - 32	Retail on GF with residential above	✓	A1-A2	0	108,603	207,333	3,291	14,556	13,042	11,361	9,646	7,309	5,560	4,887	4,954	5,678	7,897	10,823	12,891	108,603
UID - 33	Retail on GF with residential above	✓	Residential Benchmarks	128	372,296	364,116	11,242	48,240	43,508	38,250	32,887	25,578	20,110	18,007	18,217	20,478	27,419	36,567	43,035	372,296
UID - 33	Retail on GF with residential above	✓	A1-A2	0	231,858	442,638	7,026	31,075	27,844	24,254	20,593	15,603	11,870	10,434	10,577	12,121	16,860	23,106	27,521	231,858
UID - 34	Retail on GF with residential above	✓	Residential Benchmarks	104	302,511	295,863	9,134	39,198	35,353	31,080	26,722	20,784	16,340	14,631	14,802	16,639	22,279	29,713	34,968	302,511
UID - 34	Retail on GF with residential above	✓	A1-A2	0	188,397	359,667	5,709	25,250	22,625	19,708	16,733	12,678	9,645	8,478	8,595	9,849	13,699	18,775	22,362	188,397
UID - 35	Retail on GF with residential above	✓	Residential Benchmarks	137	398,208	389,457	12,024	51,598	46,536	40,912	35,176	27,359	21,510	19,260	19,485	21,903	29,327	39,113	46,030	398,208
UID - 35	Retail on GF with residential above	✓	A1-A2	0	247,995	473,445	7,515	33,238	29,782	25,943	22,026	16,689	12,696	11,160	11,314	12,965	18,033	24,714	29,437	247,995
UID - 36	Retail on GF with residential above	✓	Residential Benchmarks	199	576,725	564,053	17,414	74,729	67,398	59,253	50,945	39,623	31,152	27,894	28,220	31,723	42,474	56,647	66,665	576,725
UID - 36	Retail on GF with residential above	✓	A1-A2	0	359,172	685,692	10,884	48,138	43,134	37,573	31,901	24,171	18,387	16,163	16,385	18,777	26,117	35,793	42,633	359,172
UID - 37	Retail on GF with residential above	✓	Residential Benchmarks	156	451,540	441,618	13,634	58,508	52,769	46,392	39,887	31,023	24,390	21,840	22,095	24,837	33,255	44,351	52,195	451,540
UID - 37	Retail on GF with residential above	✓	A1-A2	0	281,210	536,855	8,522	37,689	33,771	29,417	24,976	18,924	14,396	12,655	12,829	14,701	20,448	28,024	33,379	281,210
UID - 38	Retail on GF with residential above inc. a tower	✓	Residential Benchmarks	119	345,988	338,385	10,447	44,831	40,433	35,547	30,563	23,771	18,689	16,734	16,930	19,031	25,481	33,983	39,994	345,988
UID - 38	Retail on GF with residential above inc. a tower	✓	A1-A2	0	71,825	137,120	2,177	9,626	8,626	7,513	6,379	4,833	3,677	3,232	3,277	3,755	5,223	7,158	8,525	71,825
UID - 39	Retail on 1st & GF with residential above inc. a tower	✓	Residential Benchmarks	32	93,551	91,495	2,825	12,122	10,933	9,612	8,264	6,427	5,053	4,525	4,578	5,146	6,890	9,189	10,814	93,551
UID - 39	Retail on 1st & GF with residential above inc. a tower	✓	A1-A2	0	29,131	55,613	883	3,904	3,498	3,047	2,587	1,960	1,491	1,311	1,329	1,523	2,118	2,903	3,458	29,131
UID - 42	Primary School	✓	D1.Edu	0	248,031	488,061	8,001	41,241	36,749	28,914	23,586	16,325	10,893	0	0	11,259	18,154	27,242	33,667	248,031
UID - 43	Workspace, Education and Early Years	✓	Residential Benchmarks	112	324,289	317,163	9,792	42,020	37,898	33,318	28,646	22,280	17,517	15,685	15,868	17,837	23,883	31,852	37,485	324,289
UID - 43	Workspace, Education and Early Years	✓	B1	0	59,840	261,120	2,720	8,778	7,736	6,578	5,397	3,787	2,583	2,119	2,166	2,664	4,192	6,208	7,632	59,840
UID - 43	Workspace, Education and Early Years	✓	D1.Edu	0	37,665	74,115	1,215	6,263	5,581	4,391	3,582	2,479	1,654	0	0	1,710	2,757	4,137	5,113	37,665
UID - 44	Resi and Community	✓	Residential Benchmarks	17	48,186	47,127	1,455	6,244	5,631	4,951	4,257	3,311	2,603	2,331	2,358	2,650	3,549	4,733	5,570	48,186
UID - 44	Resi and Community	✓	D1.Oth	0	72,023	207,338	2,183	11,073	9,679	8,130	6,550	4,398	2,787	2,167	2,229	2,895	4,940	7,635	9,539	72,023
UID - 48	Office space	✓	B1	0	53,460	233,280	2,430	7,843	6,911	5,877	4,821	3,383	2,307	1,893	1,935	2,380	3,745	5,546	6,818	53,460
UID - 49	Resi & Leisure	✓	Residential Benchmarks	112	324,289	317,163	9,792	42,020	37,898	33,318	28,646	22,280	17,517	15,685	15,868	17,837	23,883	31,852	37,485	324,289
UID - 49	Resi & Leisure	✓	D2	0	406,368	656,064	4,896	62,985	54,980	46,086	37,014	24,651	15,401	11,843	12,199	16,024	27,764	43,240	54,180	406,368
UID - 50	Resi	✓	Residential Benchmarks	21	60,923	59,585	1,840	7,894	7,120	6,259	5,382	4,186	3,291	2,947	2,981	3,351	4,487	5,984	7,042	60,923
UID - 51	Resi	✓	Residential Benchmarks	224	649,174	634,909	19,602	84,117	75,865	66,697	57,345	44,601	35,066	31,398	31,765	35,708	47,810	63,763	75,040	649,174

UID - 52	Resi/Retail	✓	Residential Benchmarks	368	1,065,066	1,041,663	32,160	138,006	124,468	109,426	94,083	73,174	57,531	51,514	52,116	58,584	78,439	104,612	123,114	1,065,066
UID - 52	Resi/Retail	✓	A1-A2	0	345,827	660,215	10,480	46,350	41,531	36,177	30,715	23,273	17,704	15,562	15,777	18,079	25,147	34,463	41,049	345,827
UID - 54	Resi/Retail	✓	Residential Benchmarks	18	52,235	51,087	1,577	6,768	6,104	5,367	4,614	3,589	2,822	2,526	2,556	2,873	3,847	5,131	6,038	52,235
UID - 54	Resi/Retail	✓	A1-A2	0	17,350	33,122	526	2,325	2,084	1,815	1,541	1,168	888	781	791	907	1,262	1,729	2,059	17,350
UID - 55	Resi	✓	Residential Benchmarks	26	74,117	72,489	2,238	9,604	8,662	7,615	6,547	5,092	4,004	3,585	3,627	4,077	5,459	7,280	8,567	74,117
UID - 45	Clarendon Square Development	✓	Residential Benchmarks	1,080	3,129,625	3,060,856		405,521	365,741	321,540	276,456	215,018	169,050	151,370	153,138	172,144	230,488	307,396	361,763	3,129,625
UID - 45	Clarendon Square Development	✓	B1	0	15,400	67,200	700	2,259	1,991	1,693	1,389	975	665	545	557	686	1,079	1,598	1,964	15,400
UID - 45	Clarendon Square Development	✓	A1-A2	0	23,100	44,100	700	3,096	2,774	2,416	2,052	1,555	1,183	1,040	1,054	1,208	1,680	2,302	2,742	23,100
UID - 45	Clarendon Square Development	✓	A3-A5	0	37,400	95,150	550	5,417	4,785	4,082	3,365	2,389	1,658	1,377	1,405	1,708	2,635	3,857	4,721	37,400
UID - 45	Clarendon Square Development	✓	D1.Oth	0	18,150	52,250	550	2,790	2,439	2,049	1,651	1,108	702	546	562	730	1,245	1,924	2,404	18,150
Res4	Lymington avenue, Wood Green	✓	Residential Benchmarks	66	191,255	187,052	4,959	24,782	22,351	19,650	16,895	13,140	10,331	9,250	9,358	10,520	14,085	18,785	22,108	191,255

Table 9: Baseline Heat Data

Appendix 2 – Modelling assumptions

GLA data for Benchmarking– copy of technical note provided for Wood Green

Used for all new build developments

Project:	**Wood Green Infrastructure Framework: DE study**		
Subject:	**Benchmarks used in preliminary modelling of indicative DH network**	Date:	**26 August 2015**

Introduction

AECOM has provided Haringey Council with the results of initial techno-economic modelling of an indicative heat network scheme in Wood Green. As identified in the report issued[9] on 13th August 2015, the heat network modelled is highly indicative with the purpose at this point being to evaluate at a high level whether a scheme appears to be viable.

The Council has requested further information on the benchmarks used in the study. This note summarises the benchmark data used.

The heat network modelled was based on the emerging masterplan for Wood Green and therefore it assumes a number of plots/sites with different use types and areas being redeveloped. The proposed redevelopment plots/sites have all been assumed to be part of the indicative heat network. A number of existing buildings/sites have been assumed to be retained in their current state and to be included as part of the indicative heat network.

For the retained sites, annual consumption data provided has been used to model heat demands (with the exception of Artizan Court, where benchmarks have also been used due to lack of actual consumption data - these are the same benchmarks as those used for new build). For the proposed masterplan plots/sites, the areas and use types have been used to estimate heat demands using a set of benchmarks. The benchmarks for both domestic and non-domestic have been taken from the 2015 GLA study for the London Energy Plan[10]. The benchmark data is presented in the following section.

Benchmarks

The benchmarks used to model the proposed future developments' heat and electricity demands are as follows:

Domestic: all proposed new residential uses are assumed to be flats.

New Flats	Annual kWh/flat
Heating	1442
DHW	1456
Lighting	302
Appliances	2358
Fans / pumps elec	175

[9] *150810 DHN Initial Modelling v2_Issued.pdf*

[10] *AECOM has developed the domestic and non-domestic energy demand model for the Greater London Authority (GLA) to support the London Energy Plan. This will be published later this year.*

Non Domestic: new building benchmarks per use type for Peri-Urban areas are used as follows. Figures are kWh per year per sqm of gross floor area.

kWh/m² Typology	Shops/ Financial and prof. services	Restaurants and cafes/ Drinking establishments/ Food takeaways	Business	General Industrial	Storage and distribution	Hotels	Residential Institutions	Non-residential Institutions – Education	Non-residential Institutions – Health	Non-residential Institutions – Others	Assembly and Leisure
Class	A1-A2	A3-A5	B1	B2 -B7	B8	C1	C2	D1.Edu	D1.Hea	D1.Oth	D2
DHW	15	23	7	0	0	37	39	8	21	8	19
Lighting	37	105	36	31	42	17	15	24	44	36	49
Appliances	14	39	38	9	13	33	28	25	46	38	51
Heating	18	45	15	17	15	32	41	23	47	25	64
Cooling	25	58	41	18	16	19	15	21	58	37	62
Auxiliary	12	29	22	10	9	35	29	12	32	21	34

Comparison of benchmarks

The Energy Masterplan produced for the borough uses its own benchmarks for residential and other uses.

For domestic new build dwellings the following benchmarks were agrees between LBH and Parsons Brinkerhoff:

Table 3-1 Benchmarks for new domestic dwellings

			Note
Assumed dwelling area	70	m^2	
Energy benchmarks:			
For construction period 2015-2020	41.2	$kWh/m^2/yr$	Space heating only
For construction period 2020-2025	28.8	$kWh/m^2/yr$	Space heating only
For construction period 2025-2030	27.4	$kWh/m^2/yr$	Space heating only
DHW demand	1620	kWh/yr	SAP calculation methodology
Electrical demand (pumps, fans and fixed lighting)	543	kWh/yr	Based on previous project data

When compared to the AECOM benchmarks agreed with LBH, the AECOM space heating benchmark is significantly lower than the demand of 2016 kWh/year for a 2020-2025 dwelling in the PB table.

The DHW and electrical demands are more closely matched, with the addition of appliances to the electrical demand in AECOMs calculations.

The other new build benchmarks for commercial properties tend to be lower in AECOM benchmarks than for the ones used in the previous study.

Modeling inputs assumptions

The NPV (Net Present Value) is the profit or loss accrued by the project over the calculated lifetime (in this case, 25 and 40 years), taking into account the cost of borrowing over that period. The formula used to calculate NPV is:

$$\mathrm{NPV} = \sum_{t=0}^{N} \frac{R_t}{(1+r)^t}$$

Where N = the total number of time periods (years), Rt = cashflow at year t and r = the discount rate (the cost of borrowing).

The IRR (Internal Rate of Return) is the percentage return on the original investment over the calculated lifetime of the project (in this case, 25 and 40 years). If the IRR exceeds the cost of borrowing, the NPV will be positive.

The network designs assume an operating delta T of 30°C, representing a flow temperature of 70°C and a return temperature of 40°C. The limiting maximum flow velocity is assumed to be 2.5m/s, and the limiting pressure is assumed to be 250Pa/m of pipe length. At the detailed design stage, the temperature regime will need to be considered in more detail, taking into account the flow and return temperatures of the heating system in each building, and the potential to reduce these as much as possible to allow the network to operate with lower heat losses and flow rates.

Category	Input	Source	Value
Network costs	Year investment commences	Assumed 2019	2019
	Year network becomes operational	Assumed 2020	2020
	Cost per metre of network pipework	Averaged quotes from network installers	See Table 11
	Capital cost per sqm energy centre	Based on AECOM experience of previous projects	£2,000
	Capex of gas CHP per kW	Averaged quotes from installers; plant size/type dependent	£1000/kW
	Opex of gas CHP		£0.93 - £1 /MWh
	Lifetime of gas CHP plant	Averaged quotes from installers and AECOM experience of previous projects	15 years
Energy prices	Retail prices of electricity and gas by sector	DECC 2016: *Prices of fuels purchased by non-domestic consumers in the UK*	Refer to table 3.4.2 of referenced source.
	Export tariff for electricity sold via GLA Licence Lite scheme	Recommendation from GLA	3.63p/kWh

Category	Input	Source	Value
	Tariff for heat sold on network		10% below cost of operating individual gas boilers. Individual gas boiler costs are made up of: Commercial Boilers - Replacement £138 per kW (annualised over assumed life) - Maintenance £4 pa / kW - Life 20 years - Average gas cost 3.41p/kWh Domestic Boilers - Replacement £3,000 per dwelling (annualised over assumed life) - Maintenance £200 pa per dwelling - Life 15 years - Average gas cost 4.3p/kWh
	Gas costs for energy centre	DECC 2016: *Prices of fuels purchased by non-domestic consumers in the UK*	Refer to table 3.4.2 of referenced source.
	Forward projections for retail prices of electricity and gas	DECC/IAG: *2014 energy and emissions projections: projections of greenhouse gas emissions and energy demand 2014 to 2030.*	Refer to tables in Annex M of referenced source.
Carbon emissions	Grid electricity emissions factors	DECC/IAG: *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal* and DECC/LCP: *Modelling the impacts of additional Gas CHP capacity in the GB electricity market.*	Refer to Table 1 of the referenced source (IAG) and Refer to p67 of the referenced source (LCP)
	Forward projections for grid electricity emissions factors		
	Natural gas emissions factor		

Table 10: Modelling inputs.

Spec Pipe Size (DN)	Hard-dig TOTAL	Soft-dig TOTAL	Heat losses per pipe length @ ΔT 65°C		Heat losses per pipe length @ ΔT 60°C	
[mm]	[£/m]	[£/m]	[W/m]	[kWh/m]	[W/m]	[kWh/m]
25	527	381	17.3	151	15.97	139
32	571	425	18.8	164	17.35	151
40	612	481	21.2	186	19.57	172
50	638	500	23.7	208	21.88	192
65	690	537	26.6	233	24.55	215
80	753	565	27.8	244	25.66	225
100	873	630	29	254	26.77	234
125	979	685	33.4	292	30.83	270
150	1099	742	37.8	331	34.89	306
200	1232	802	39.8	349	36.74	322
250	1380	968	38.8	340	35.82	314
300	1430	1018	44.2	387	40.80	357
350	1584	1204	42.6	373	39.32	344
400	1731	1345	44.1	387	40.71	357
450	1827	1462	58.4	511	53.91	472
500	2330	1965	56.5	495	52.15	457
600	3079	2740	68.4	599	63.14	553
700	3939	3553	77.7	681	71.72	629
800	4499	4223	87.3	765	80.58	706

Table 11: Assumed Pipework costs and heat loss values

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