London Borough of Waltham Forest

CORONATION SQUARE NEIGHBOURHOOD

Feasibility Study

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EXECUTIVE SUMMARY

WSP has been commissioned by London Borough of Waltham Forest (LBWF) and the GLA under the DEEP framework to carry out an assessment of the feasibility of delivering a heat network for the Coronation Square Neighbourhood (CSN). The CSN consists of three major development sites – the SCORE centre, 9 Osier Way and the Bywaters site. These three developments are referred to in this report as the 'Central Cluster'.

WSP has reviewed the information available at this stage, and recommends that the SCORE site is adopted as the preferred location for an enlarged energy centre serving the developments of the Central Cluster.

This report has been compiled at a stage when the developer (Taylor Wimpey) of the SCORE site is still in the process of changing their outline architectural designs for the development. In the policy context, we are also in a state of change, as a draft New London Plan has recently undergone Examination in Public[1], new emissions factors (SAP10) for Building Regulations have been developed by BRE (but not officially adopted[2]), whilst the GLA has advised[3] that it is encouraging planning applicants to use the new SAP10 factors for referable applications.

WSP has assisted in delivering a review of early stage SAP10-basedenergy centre designs (showing[4] an energy centre floor area of approximately 495sq m) based on air-sourced heat pumps as the main source of low-carbon heat that were produced by Metropolitan (working on behalf of Taylor Wimpey). However, please note that Taylor Wimpey has, subsequent to the drafting of this report, clarified that it will put forward a SAP2012 emissions factor based solution based on gas-fired CHP plant. This SAP2012 design has not been reviewed in this report. The SAP10 scheme initial review of this report highlights several key areas where the SAP10 designs do not appear appropriate for the delivery of energy to the Central Cluster scheme. These areas of concern included:

- The location of the energy centre appeared unsuitable in terms of providing a route for flues to high-level

[1] https://www.london.gov.uk/what-we-do/planning/london-plan/new-london-plan/examination-public-draft-new-london-plan, accessed 17th May 2019
[2] https://www.bregroup.com/sap/sap10/, accessed 17th May 2019
[3] https://www.london.gov.uk/sites/default/files/energy_assessment_guidance_2018.pdf, page 8, accessed 17th May 2019.
[4] As per drawing P3803-SK-040 Rev C, Pinnacle ESP.

- The general space allowance for plant appeared inadequate for suitable access, ventilation, noise attenuation and welfare of operatives
- The space allocation appeared to be insufficient when compared with both the Developer Agreement requirement for an area of 750 sq m, and a notional design developed as part of this report. Further design refinement in subsequent RIBA stages with the appointed ESCo would ascertain if the mechanical and electrical plant could be sufficiently accommodated in an enlarged energy centre of 750m^2.
- There did not appear to be clarity on the demarcation between the ESCo plant and the plant serving retained assets for the SCORE site (e.g. electrical infrastructure)

WSP has developed a notional design for an energy centre to support the Central Cluster, and has created a techno-economic model to reflect the potential performance of this solution from an ESCo perspective. This model assumes:

- That Taylor Wimpey would provide the EC shell, and also fund the installation of plant to a level equivalent to the non-ESCo solution (i.e. a SCORE-only site scheme)
- The ESCo would therefore be responsible for funding the additional cost of plant for the wider-network, including additional EC plant and the district heating network pipework to link the SCORE site with the other developments
- The ESCO would then levy a 'connection charge' per dwelling for the Bywaters and Osier Way sites as they join the scheme (to offset the savings that these developments would make by not having to provide their own central plant).

This model illustrates that the scheme delivers positive whole life cost (WLC), and also delivers an IRR that is anticipated to be attractive to the Private Sector. The scheme as modelled also shows that heat can be delivered at a significantly lower carbon factor than the counterfactual case of gas-fired boilers. This should make connection to the network attractive to the Central Cluster developments under the SAP10 solution presented here.

The table below sets out the key plant capacities included within the WSP assessment:

Table 1 – Key plant attributes

	CAPACITY
Heat pump	1,000 kWth output
CHP (gas fired engine)	250 kWe output
Gas-fired boilers	4 no. 2.3MWth output
Thermal storage	75 cubic metres

The following table shows some of the key WLC model outputs:

Table 2 – Key whole life cost model inputs / outputs

	FIGURE	UNIT
Estimated capital cost	£5,756	£,000
NPV (40yrs, 9% discount rate)	£1,131	£,000
Carbon intensity of heat (full build-out)	0.181	$kgCO_{2e}$ / kWh heat

This table illustrates that the notional solution that WSP has developed delivers a positive whole life cost, and low-carbon heat over the project life based on the assumptions contained within the TEM. We note that an ESCo which delivers the project may select a different design based on their own assumptions. Hence the figures provided in this report can only be indicative at this stage.

Recommendations and next steps

LBWF does not wish to become an ESCo, and is seeking to allow the private sector to deliver the energy provision to the area. This naturally leads to a reduction in control in comparison with a delivery mechanism where LBWF actively were involved in the scheme delivery. The key challenge for LBWF is therefore to establish a suitable framework within which an acceptable scheme is delivered.

WSP would suggest that the planning system is be the key mechanism through which LBWF can ensure an acceptable solution is delivered by the development partners of the Central Cluster scheme. The following actions are recommended:

- Continue to liaise closely with Taylor Wimpey (and their selected ESCo partner) to develop an energy centre and heat distribution network that is acceptable to LBWF to serve buildings in the Central Cluster. This is anticipated to involve technical design meetings as well as strategic discussions.
    - It would be beneficial, for LBWF to have visibility or even influence over the TW procurement of an ESCo, so that LBWF can have confidence that the basis of this procurement is in line with the principles that LBWF expects for the wider development area.
- Continue to require from Taylor Wimpey an area of at least 750sq m for the provision of the district heating energy centre, with suitable flue routes and for access for plant delivery / maintenance.
- Ensure that whichever ESCo partner is appointed by Taylor Wimpey they have provided a clear strategy for the delivery of cost-competitive, low-carbon heat to all consumers in the Central Cluster. This must take into account the imminent ending of the RHI subsidy for heat pumps. This strategy must consider how to deliver a suitable carbon intensity of heat, such that the overall solution for the SCORE site (and wider network) meets planning and Building Regulation requirements, and also incentivises other sites to connect to the network.
- Ensure via Planning Conditions that LBWF has the power to review and approve / amend submitted designs at detailed planning stages, such that LBWF can ensure appropriate compatibility with the technical solutions envisaged.

- Taylor Wimpey are seeking support from LBWF for a SAP2012 solution. However, it is understood that GLA would only support a CHP-based solution if it can be demonstrated that the scheme is 'strategically significant'. It is understood that the following would be required for this:
    - Demonstrate the importance of the scheme in the local and regional context
    - Demonstrate how the initial scheme can be delivered and that the commercial structure is also in place to ensure the development and expansion from the Central Cluster into the strategic-scale project
    - Demonstrate that there is a clear plan to decarbonise the heat supply in the future which is being committed to by key stakeholders.

The next steps for the project for LBWF are therefore:

- Await redesign of the energy centre space from the Taylor Wimpey team, including:
    - Flue strategy – demonstrating how the location of the EC is suitable for the proposed and future plant, given the heights of adjacent blocks
    - Noise assessment – demonstrating how the proximity of potential receptors both at roof level and near ground level have been factored into the EC designs
    - Access and maintenance strategies – demonstrating that there is sufficient space for the safe and efficient upkeep of plant
    - Overall EC design reflecting the above
- Provide technical and architectural feedback on these designs when available
- Continue to liaise with TW and their appointed ESCo on the commercial form of the agreement for the delivery of energy to the SCORE site and the Central Cluster scheme, including the strategic context and potential decarbonisation in the future
- Continue to reinforce planning mechanisms to encourage inter-connection of the neighbouring sites
    - London Heat Map
    - Planning Policy
- Continue to engage with the relevant developers of the key sites at Bywaters and 9 Osier Way to:
    - Ensure that these sites are aware of the expectation of connection in line with planning policy

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INTRODUCTION, PROJECT BACKGROUND AND SCOPE

INTRODUCTION, PROJECT BACKGROUND AND SCOPE

The Coronation Square Neighbourhood (CSN) has been identified as an area of potential opportunity in terms of decentralised energy networks. WSP has been appointed to assist London Borough of Waltham Forest (LBWF) with the identification and development of a decentralised energy system that could be implemented to serve a number of key developments emerging in this area.

There are three key developments that from part of the CSN (referred to as the Central Cluster in this report); these are described briefly below:

- Score – This site is owned by LBWF, and LBWF has selected a development partner (Taylor Wimpey) to construct 550-800 residential units and commercial space on this plot. Currently at pre-planning application stage.
- Bywaters – An existing industrial site, for which Bywaters has already received outline planning permission to construct 730 residential units, a primary school, and 4,500m2 of employment and retail space. However, it should be noted that it is anticipated that a further application will be submitted for this site, with higher residential numbers. For the purposes of this report, an estimated figure of 1,300 dwellings has been modelled.
- 9 Osier Way – Another existing industrial site, which is now anticipated to be developed into around 200 residential units, and circa 550 – 1,000m2 commercial space. Currently at pre-planning application stage.

These three loads form the Central Cluster that is the focus of this study. However, one element of the study scope is also to consider the potential for a system to serve other loads in the vicinity.

The key deliverables required by LBWF for this study are[5]:

- Stakeholder strategy and engagement plan
- The recommended district heating network (DHN) system
- Preferred Energy Centre location and size
- Techno-economic model in MS Excel
- District Heating (DH) network masterplan including network routes, schematics, dimensioning and diagrams
- A zero-carbon transition plan where applicable
- A risk register to identify the key risks and mitigation measures
- Commentary on the next steps

[5] Tender documentation for commission, Section 5 – Specification Requirements, page 6, 'Deliverables'. (NB that this Deliverables list was amended in contractual discussions to remove 'Definition of the commercial framework for developers and ESCOs, including the governance and co-ordination arrangements', as this task will now be taken on by LBWF's appointed advisor (WEC).

POLICY BACKGROUND

This study takes place in the context of a significant policy transition for energy scheme design. This short section summarises some of the key documents and policies that will inform and influence the development of a district heating network scheme and the site developer's own design choices.

NATIONAL POLICY

The Kyoto Protocol lead to the UK's commitment to reducing greenhouse gas emissions to 80% below 1990 levels by 2050. One law that has been put in place to deliver on this commitment is the **Climate Change Act (2008)**, which mandates on the target and requires the government to set binding five-yearly carbon budgets.

The **National Planning Policy Framework (NPPF)** issued by the Department for Local Communities and Local Government in March 2012 sets out the England's Government' planning policies on how to development should occur in the country. This framework has for aim to achieve sustainable development based on three pillars: economic, social and environmental for plan-making and decision making. The definition of sustainable development in the NPPF is "meeting the needs of the present without compromising the ability of future generation to meet their own needs".

The relevant chapter of the framework to the Coronation Square Neighbourhood Energy Centre and decentralised energy network is chapter 10: "Meeting the challenge of climate change, flooding and coastal change". In **Paragraph 148** in this chapter, a framework for local authorities to address the following issues regarding planning applications is set out:

- Secure radical reductions in greenhouse gas emissions
- Provide resilience and minimise vulnerability to the impacts of climate change
- Support the delivery of renewable and low carbon energy sources and associated infrastructure
- Support energy efficiency improvements to existing buildings

Building Regulations (Approved documents, including Part L (2013)) set out the current targets and means of calculation for new buildings to deliver high efficiency new homes (or refurbishments). These documents currently reference the emissions factors set out in SAP2012. These emission factors are widely acknowledged to be out-of-date, in that the factors for the carbon intensity of grid electricity within the SAP2012 document no longer correspond to the carbon intensity of the overall generation mix now seen. In order to respond to this change and other factors, a new version of SAP has been released by BRE *for information only*. This new SAP version is called SAP10, and contains updated carbon emissions factors that significantly reduce the grid carbon intensity.

The GLA has released in its guidance notes for applicants drafting energy statements the following[6]:

1.7. The GLA has decided that from January 2019 and until central Government updates Part L with the latest carbon emission factors, planning applicants are encouraged to use the SAP 10 emission factors for referable applications when estimating CO_2 emission performance against London Plan policies. This will ensure that the assessment of new developments better reflects the actual carbon emissions associated with their expected operation. This approach will remain in place until Government adopts new Building Regulations with updated emission factors. The timeline for this has not been confirmed but Part L is expected to be consulted on by early 2019. See section 5 for further details.

REGIONAL POLICY

The London Plan is the "overall strategic plan for London, it sets out an integrated economic, environmental, transport and social framework for the development of London over the next 20-25 years".

The current London Plan (2016) sets out a target for London (Policy 5.1) of 60% reduction in emissions (over 1990 levels) by 2025. It also sets out the preferred hierarchy for delivering emissions reductions:

- Be lean
- Be clean
- Be green

The New London Plan (which is currently (as at April 2019) undergoing Examination in Public, and anticipated to be published/adopted towards the end of 2019), will be the third London Plan. All Borough of London must comply with the general requirements of the London Plan.

The New London Plan will run from 2019 to 2041. In the Foreword of the document, the current Mayor of London states "I envisage London as a greener city, with high quality open spaces, parks and commons, and one where we lead the way in tackling climate change by **moving towards a zero-carbon city by 2050**."

The following major change points have been identified in the Draft London Plan:

1. Minimising Greenhouse Gas emission (Policy SI2)
2. Zero-carbon City by 2050 (Policy GG6)
3. Development in Heat Network Priority Areas (following **SI3 Energy Infrastructure hierarchy)**
4. Government effort to increase the rate of Heat Network development in London in terms of funding
5. Support the development of low-temperature networks for both new and existing buildings

[6] https://www.london.gov.uk/sites/default/files/energy_assessment_guidance_2018_-_update.pdf, page 9, Energy Assessment Guidance (Oct 2018 version), accessed May 2019.

6. Support using low-grade waste heat
7. Need to consult the Energy Planning Guidance document about the relevance of CHP
8. Not expecting that gas engine CHP will meet the standard within areas exceeding air quality limits with the technology that is currently available – *CHP Phase out*
9. Gasholder de-commissioning program and there may also be a requirement for the provision of new pressure reduction stations - *Impact on CHP supply*
10. Land required for energy supply infrastructure, like EC. Those centres have the possibility to have multi functions: capture, store, generate, supply &/or distribute energy.

Policy SI2 Minimising Greenhouse Gas emissions

"A. **Major development should be net zero-carbon**. This means **reducing carbon dioxide emissions** from construction and **operation**, and minimising both annual and peak energy demand in accordance with the following energy hierarchy:

1) Be lean: use less energy and manage demand during construction and operation.

2) Be clean: exploit local energy resources (such as secondary heat) and supply energy efficiently and cleanly. **Development in Heat Network Priority Areas should follow the heating hierarchy in Policy SI3 Energy infrastructure**.

3) Be green: generate, store and use renewable energy on-site.

B. Major development should include a detailed energy strategy to demonstrate how the zero-carbon target will be met within the framework of the energy hierarchy and will be expected to monitor and report on energy performance.

C. In meeting the zero-carbon target a minimum on-site reduction of at least 35 per cent beyond Building Regulations117 is expected. Residential development should aim to achieve 10 per cent, and non-residential development should aim to achieve 15 per cent through energy efficiency measures. Where it is clearly demonstrated that the zero-carbon target cannot be fully achieved on-site, any shortfall should be provided:

1) through a cash in lieu contribution to the relevant borough's carbon offset fund, and/or

2) off-site provided that an alternative proposal is identified and delivery is certain.

D. Boroughs must establish and administer a carbon offset fund. Offset fund payments must be ring-fenced to implement projects that deliver greenhouse gas reductions. The operation of offset funds should be monitored and reported on annually.

<u>Paragraph 9.2.10</u> "The Mayor may publish further planning guidance on sustainable design and construction and will continue to regularly update the guidance on preparing energy strategies for major development. Boroughs are encouraged to request energy strategies for other development proposals where appropriate. As a minimum, energy strategies should contain the following information:

[…] c. Proposals to further reduce carbon dioxide emissions through the use of zero or low-emission decentralised energy where feasible, prioritising connection to district heating and cooling networks and utilising local secondary heat sources. (Development in Heat Network Priority Areas should follow the heating hierarchy in Policy SI3 Energy infrastructure)."

Policy SI3 Energy infrastructure

"A. Boroughs and developers should engage at an early stage with relevant energy companies and bodies to establish the future energy requirements and infrastructure arising from large-scale development proposals such as Opportunity Areas, Town Centres, other growth areas or clusters of significant new development.

B. Energy masterplans should be developed for large-scale development locations which establish the most effective energy supply options. Energy masterplans should identify:

1) major heat loads (including anchor heat loads, with particular reference to sites such as universities, hospitals and social housing)

2) heat loads from existing buildings that can be connected to future phases of a heat network

3) major heat supply plant

4) possible opportunities to utilise energy from waste

5) secondary heat sources

6) opportunities for low temperature heat networks

7) possible land for energy centres and/or energy storage

8) possible heating and cooling network routes

9) opportunities for futureproofing utility infrastructure networks to minimise the impact from road works

10) infrastructure and land requirements for electricity and gas supplies

11) implementation options for delivering feasible projects, considering issues of procurement, funding and risk, and the role of the public sector.

C. Development Plans should:

1) identify the need for, and suitable sites for, any necessary energy infrastructure requirements including upgrades to existing infrastructure

2) identify existing heating and cooling networks and opportunities for expanding existing networks and establishing new networks.

D. Major development proposals within Heat Network Priority Areas should have a communal heating system

1) the heat source for the communal heating system should be selected in accordance with the following heating hierarchy:

a) connect to local existing or planned heat networks

b) use available local secondary heat sources (in conjunction with heat pump, if required, and a lower temperature heating system)

c) generate clean heat and/or power from zero-emission sources

d) use fuel cells (if using natural gas in areas where legal air quality limits are exceeded all development proposals must provide evidence to show that any emissions related to energy generation will be equivalent or lower than those of an ultra-low NOx gas boiler)

e) use low emission combined heat and power (CHP) (in areas where legal air quality limits are exceeded all development proposals must provide evidence to show that any emissions related to energy generation will be equivalent or lower than those of an ultra-low NOx gas boiler)

f) use ultra-low NOx gas boilers.

2) CHP and ultra-low NOx gas boiler communal or district heating systems should be designed to ensure that there is no significant impact on local air quality.

3) Where a heat network is planned but not yet in existence the development should be designed for connection at a later date."

Paragraph 9.3.2: "[…] Decentralised energy will become an increasingly important element of London's energy supply and will help London become more self-sufficient in relation to its energy needs."

Paragraph 9.3.3: "Developments should connect to existing heat networks, wherever feasible. Stimulating the delivery of new district heating infrastructure enables the opportunities that district heating can deliver to be maximised. The Mayor has identified Heat Network Priority Areas, which can be found on the London Heat Map website123. These identify where in London the heat density is sufficient for heat networks to provide a competitive solution for supplying heat to buildings and consumers. Data relating to new and expanded networks will be regularly captured and made publicly available."

Paragraph 9.3.5: "To ensure heat networks operate efficiently, effectively and reliably, the Mayor supports standards such as the CIBSE CP1 Heat Networks: Code of Practice for the UK and the Heat Trust standard. These set out principles for good design, specification and operation of networks and can help ensure fairness for customers of heat networks. The Mayor also supports the development of low-temperature networks for both new and existing systems as this allows cost-effective use of low-grade waste heat"

Paragraph 9.3.6: "Further information about the relevance of CHP in developments of various scales will also be provided in the Energy Planning Guidance document, which will be kept updated as technology changes. However, it is not expected that gas engine CHP will be able to meet the standards required within areas exceeding air quality limits with the technology that is currently available."

Paragraph 9.3.10: "National Grid and Southern Gas Networks operate London's gas distribution network. Both companies are implementing significant gasholder de-commissioning programmes, replacing them with smaller gas pressure reduction stations. The Mayor will work with key stakeholders including the Health and Safety Executive to achieve the release of the resulting brownfield sites for redevelopment."

Paragraph 9.3.11:" Land will be required for energy supply infrastructure including energy centres. These centres can capture and store energy as well as generate, supply and distribute it. The ability to efficiently store energy could reduce overall energy consumption, reduce peak demand and make renewable energy more effective."

Chapter 11: Funding the London Plan

Paragraph 11.1.42: "The exception to this approach for utilities infrastructure is heat network infrastructure, the pipework that carries hot water connecting sources of low-cost, low-carbon energy to homes and business to meet their space heating and hot water needs. Heat networks are an emerging class of infrastructure recognised by both the Mayor and the Government as being essential in meeting climate change targets. Heat networks are not a regulated undertaking and therefore not subject to the same restrictions or benefits (in terms of powers) as statutory undertakers. The Mayor is exploring how to increase the rate of their development in London, which will require central government to create a level playing field for the treatment of district heating networks compared to other statutory utilities regarding access rights and business rates."

LONDON ENVIRONMENT STRATEGY 2018

The London Environment Strategy

- Support connections to existing low temperature heat networks
- BOX 26: support local Heat Networks + use energy more flexibly + smart technology/energy storage
- Fuel Poverty Support fund + RE:NEW Programme
- London Plan 2016 = CO_2 emission reduction of 35% on top of Part L (2013)
- Policy 6.1.4 Ensure new developments are zero carbon
- Policy 6.2.1 Delivering more decentralised energy in London ; "District heating networks and renewable energy supply account for approximately half of London's decentralised energy systems, delivering the equivalent of two per cent of total demand. There is the opportunity to increase this type of energy supply to 15 per cent of demand by 2030. There are opportunities for further decentralised energy projects, including large scale solar PV installations and heat networks utilising technologies such as heat pumps in combination with secondary heat sources." -> DEEP
- Low-temperature networks
- Both new & existing buildings to consider DE
- Mayor to investigate London's geology to provide thermal storage and heat source in conjunction with future low temp HN
- Heat from Waste

LOCAL POLICY

The LBWF Local Plan is currently under review, and revised policies are anticipated to be put out to consultation in July 2019.

London Borough of Waltham Forest, Core Strategy (Adopted March 2012)

Policy CS4 - Minimising and Adapting to Climate Change

The Council will tackle climate change locally and promote resource efficiency and high environmental development standards during design, construction, and occupation of new developments by

Reduction of Carbon Emission

A) requiring new developments to minimise on site carbon emissions across their lifetime in accordance with the energy hierarchy by using less energy through responsive design, supplying energy efficiently and using on-site renewable energy;

B) requiring developments to meet high environmental standards of building design and construction, including targets based on standards such as BREEAM and Code for Sustainable Homes;

C) encouraging and where appropriate requiring retrofitting of the existing building stock to become more energy efficient by utilising existing and future programmes to co-ordinate and drive activity;

D) 'leading by example' and seeking to exemplify high sustainability standards and reduced carbon footprint on the Council's and its partner's own development areas and buildings and leading on awareness raising campaigns;

Energy Efficient Supply

E) working with partners and developers to promote and facilitate the delivery of local decentralised energy capacity and networks that are flexible and adaptable, especially district heating systems in appropriate areas of the Borough, in particular in the key growth areas;

F) requiring developers to investigate opportunities for establishing or linking into existing or proposed decentralised energy networks through tools such as the London Heat Map;

G) promoting innovative energy technologies that reduce carbon emissions and use of fossil fuels, such as hydrogen and energy from waste sources;

London Borough of Waltham Forest Development Management Policies Local Plan

(Adopted October 2013)

Policy DM10 Resource Efficiency and High Environmental Standards

The Council will ensure sustainable resource management and high environmental standards by

A. Requiring development of one or more units or greater than 100sqm to be designed with regards to sustainable development principles and to achieve the Council's stepped targets towards zero carbon by 2016 for residential development and by 2019 for non-residential developments, as set out in the table below in accordance with the London Plan; carbon reduction targets can 66 London

Borough of Waltham Forest Development Management Policies Local Plan Adoption Version be met through a combination of on-site and appropriate off-site measures through contributions into carbon fund and the emerging Community Infrastructure Levy (CIL). To assist the Council in the application of this policy, planning applications for relevant developments should be accompanied by the developer's self-assessment quantitatively demonstrating the methods, measures and appliances by which the compliance will be achieved.

B. Requiring residential development of one or more units to achieve Code for Sustainable Homes Level 4 or equivalent standards; encouraging developments to achieve higher standards where feasible;

C. Requiring non-residential development greater than 100 sqm to achieve BREEAM 'very good' or equivalent standards and encouraging major non-residential developments to achieve BREEAM 'excellent' or equivalent;

D. Encouraging high environmental standards in existing development wherever possible through retrofitting; and requiring, where appropriate, simple and cost effective energy efficiency measures to be carried out on the existing buildings when applying for extensions or conversions of more than 100sqm.

Policy DM11 Decentralised and Renewable Energy

The Council will seek to reduce carbon emissions by:

A. Requiring development of one or more units or greater than 100sqm located in the proximity of an existing or committed future Decentralised Energy Network to assess opportunities for, and to implement links into, existing or future committed decentralised energy networks, unless it can be demonstrated that an efficient connection is not feasible in accordance with the following thresholds;

development of one or more units or greater than 100sqm located within 200m of an existing or committed future Decentralised Energy Network, major development located within 500m of an existing or committed future Decentralised Energy Network, and development of more than 50 units located within 1000m of an existing or committed future Decentralised Energy Network;

B. Requiring major developments that have demonstrated that the connection to an existing or committed decentralised energy network is not feasible, to be connection ready for future networks; and to implement a Combined Heat and Power Plant (CHP); and/or where possible, connect into an existing or implement a new small network linking neighbouring developments or buildings unless it can be demonstrated that an efficient connection is not feasible; Connection ready developments will be expected to meet the full carbon reduction targets as set out in DM10;

C. Giving due consideration to air quality impacts in accordance with policy DM24 where CHP or biomass is proposed; and Requiring development of one or more units or greater than 100sqm which seek to reduce the site's carbon emissions through on-site renewable energy to ensure that the proposed renewable system is appropriate to the location and does not significantly adversely affect the development, or local amenity of neighbourhoods, and the environment, including air quality.

STAKEHOLDER STRATEGY AND ENGAGEMENT PLAN

WSP recognises that it is important to have a focussed and targeted plan for the engagement of key stakeholders in a district energy scheme. This is not least, because the 'default' approach for individual developers will be to focus only on their own development plots, ignoring potential synergies with neighbouring sites. In order to avoid a piecemeal and fragmented approach to energy provision, a stakeholder engagement strategy is proposed.

Development context

Both 9 Osier Way and SCORE are in the pre-planning phase and, whilst the Bywaters site already has outline planning consent, it is currently anticipated that a new application will be submitted likely from a new site owner seeking to increase the density of development, which effectively would also put this site back into the pre-planning phase.

Stakeholder mapping

The following parties are currently understood to be the key stakeholders relevant to engagement on energy matters:

Planning / Regulatory

- LBWF planning, regeneration and highways departments
- GLA energy team

Developers

- SCORE site –
    - Taylor Wimpey as developer
    - Metropolitan as primary ESCo advisor for the energy centre at pre-application stage
    - Pinnacle Power as secondary system provider
    - London Energist as energy statement author
- Bywaters site
    - Bywaters as site owner
- 9 Osier Way site
    - Pocketliving as developer
    - GLA housing and land team

Engagement plan

It is understood that the current structure for the delivery of energy to the Central Cluster will be based around the appointment of an ESCo by Taylor Wimpey, with the structure of the planning and commercial framework established to ensure that the ESCo is incentivised to supply heat to all of the three sites of the Central Cluster. Under this arrangement, the technical liaison for ensuring technical compatibility between site designs and the centralised supply system will lie with the appointed ESCo. However, LBWF retains some influence over key aspects of the energy system integration through the planning system. Some of these areas include:

- Location and sizing of on-site energy centres
- Key infrastructure routes on site
- Secondary system designs and return temperatures
- Phasing of development and load growth.

KEY REQUIREMENTS OF PLANNING PROCESS

It is WSP's view that there are certain key requirements that need to be imposed on the developments as part of the detailed planning process, in order to ensure that technical compatibility with the DEN concept is maintained and enhanced throughout the design development process.

Key requirements are:

- Ensuring that construction may not commence prior to approval by LBWF of the technical designs of both the secondary side (e.g. in-building, and on-site distribution) energy systems, and the interface points of the district energy networks. This must include elements such as the selection of Hydraulic Interface Units (HIUs), internal heat emitters, and on-site distribution network specification.

ENGAGEMENT POST AWARD OF PLANNING PERMISSION

It is suggested that LBWF will need to employ specialist advisors at the post-planning stage, in order to evaluate the suitability of the technical designs developed.

RESIDENTIAL - METHODOLOGY

In line with CIBSE Heat Networks Code of Practice (CP1) guidance, multiple methods and benchmark were used to evaluate potential overall demands for dwellings, summarized below:

- Using a reduced space heating demand figure of 25kWh/m^2 for a flat and 28kWh/m^2 for a mid-terrace and 35kWh/m^2 for a detached house; figures derived from WSP's experience of recent developments which illustrate the move toward tighter fabric standards or low levels of typical occupancy or both.
- Hot water demand calculated for each dwelling using the SAP methodology. SAP methodology is based on typical occupancy and an estimated hot water demand per occupant.
- Swedish curve diversity factor for calculating domestic hot water peak loads. This method is mentioned in CP1, slightly less conservative (i.e. resulting in lower demands) than the Danish curve diversity factor method.

The following information was made available for each of the three sites; 9 Osier Way, Bywaters[7] and SCORE:

- Number of dwellings overall
- Dwelling types
- Mix
- Floor area of typical dwelling type

The above information enabled WSP to calculate the residential annual heat demand per year and a peak heat demand for each site, which have subsequently been used to size an energy centre.

This report adopts energy demand figures which are lower than typical published benchmarks but can be considered "realistic" in the context of a new-built metered multi-storey flat scheme. Based on industry experience and analysis of actual metered heat demands, an annual heat consumption rates as highlighted in the bullet points above have been adopted.

For residential hot water demand, SAP provides a methodology for calculating hot water consumption as a product of occupancy, which is determined by floor area. The approach assumes a hot water consumption of 25 litres per person per day, plus an additional 36 litres for the household. It takes account of seasonal variations in demand (slightly higher in winter) and allows for the change in cold water supply temperature across the year (i.e. it is warmer in summer and therefore requires slightly less heating). This approach has been used to calculate hot water demand for the three new build residential developments in Coronation Square Neighbourhood.

[7] NB that the outline planning application figures have been updated to reflect the anticipation that a new application with higher density will be submitted. Based on the notional new total dwellings (1,300), the type of dwellings proposed as part of the outline planning permission have been increased pro-rata.

It has been assumed that the residential areas do not have any cooling demand.

FLOOR AREAS

In order to calculate the per-dwelling heat load, the floor areas of each dwelling type are required.

9 Osier Way

Information on dwellings have been extracted from document titled “9 Osier Way – LBWF Pre – App 2 180815”, screenshot below.

Figure 1 - 9 Osier Way dwelling information

	Apartment type					
Level	1B (38 sqm)	1B A (48 sqm)	2B (61 sqm)	2B A (67.7 sqm)	3B. Dup. (98 sqm)	Units/fl
G					5	5
1	2		2			2
2	25	1	4	1		31
3	25	1	4	1		31
4	25	1	4	1		31
5	25	1	4	1		31
6	20		3			3
7	20		3			3
8	8		2			2
9	8		2			2
10	4		1			2
11	4		1			1
12	4		1			1
Totals:	170	4	31	4	5	

Total units:	214
% 1B units:	81%
% 2B units:	16%
% 3B units:	2%
% Accessible units:	4%

The total residential floor area for 9 Osier Way/PocketLiving is 9,304m^2.

Bywaters site

Information on dwellings have been extracted from document titled “Bywaters Sustainability and Energy Statement”, screenshot below.

Figure 2 - Bywaters dwelling information

Use Type	No. of Units	Floor Area (sqm)
C3 Residential (mid terrace house)	23	126 (each)
C3 Residential (ground floor flat)	34	60 (each)
C3 Residential (mid floor flat)	565	60 (each)
C3 Residential (top floor flat)	108	60 (each)

The total residential floor area for Bywaters as shown here is 45,318m^2.

However, please note that for this site, it is anticipated by LBWF that the applicant will come forward with a new, higher density proposal for redevelopment. On this basis, it has been agreed with LBWF that a figure of 1,300 dwellings will be adopted for the site in terms of modelling of demands and energy supply requirements.

SCORE site

Information on dwellings have been extracted from document titled "Score Accommodation", screenshot below.

Figure 3 - SCORE dwelling information

Residential: Private Bedrooms	NDSS Min. Unit area (m²)	Mix	NIA m2	GIA m2*	No. Units	Total hr
1B2P	50	43%			171	
2B4P	70	43%			172	
3B4P/5P	74/86	13%			52	
4B7P	108	1%			3	
			26076	38871	398	1081

Residential: Affordable Rent Bedrooms	NDSS Min. Unit area (m²)	Mix	NIA m2	GIA m2*	No. Units	Total hr
1B2P	50	24%			29	
2B4P	70	29%			36	
3B4P/5P	74/86	36%			44	
4B7P	108	11%			14	
			9276	13046	123	412

Residential: Shared Ownership Bedrooms	NDSS Min. Unit area (m²)	Mix	NIA m2	GIA m2*	No. Units	Total hr
1B2P	50	40%			92	
2B4P	70	43%			99	
3B4P/5P	74/86	16%			38	
4B7P	108	1%			2	
			15414	22474	231	643

The total residential floor area for SCORE site is 48,862m^2.

Demand calculation

9 Osier Way/PocketLiving

Table 1 below show the breaks down between the space heating using the 25kWh/m^2 reduced benchmark and the Domestic Hot Water (DHW) demand. In the table "access" denotates the accessible flats which have greater floor area than their equivalent non-accessible. The total annual heat demand for residential areas in 9 Osier Way is calculated to be 518,061kWh/m²/yr using the methodology described in the previous section of the report.

Table 3 - 9 Osier Way Residential Annual Heat Demand

				PER DWELLING			OVERALL
Dwelling type	Floor area (m2)	N° of dwellings	Total floor area (m2)	SH - (kWh/p.a)	DHW - SAP (kWh/p.a)	Total - (kWh/p.a)	Total - (kWh/p.a)
1B1P	38	170	6,460	950	1,267	2,217	376,890
1B1P access	48	4	192	1,200	1,393	2,593	10,371
2B3P	61	31	1,891	1,525	1,564	3,089	95,766
2B3P access	67.7	4	271	1,693	1,646	3,338	13,352
3B5P	98	5	490	2,450	1,886	4,336	21,682
TOTAL		**214**	**9,304**				**518,061**

The figures shown in the table above for Osier Way allow us to calculate the average heat load per meter squared - 55.7kWh/m², and per dwelling - 2,421kWh/dwelling. It is noted that 2,421kWh/dwelling is a low value in comparison to typical dwellings, as values are usually around 3,200-3,500kWh/dwelling, but it reflects the small surface area per dwelling of the 9 Osier Way development scheme.

Bywaters

The table below shows the break down between the space heating for flats, mid terrace houses, and the domestic hot water (DHW) demand. The total annual heat demand for residential areas in Bywaters development scheme is calculated to be 4,064MWh/yr using the methodology described in the previous section of the report.

Table 4 - Bywaters Residential Annual Heat Demand

				PER DWELLING			OVERALL
Dwelling	Floor area (m2)	n° of dwellings	total floor area (m2)	SH - (kWh/p.a)	DHW - SAP (kWh/p.a)	Total - (kWh/p.a)	Total - (kWh/p.a)
House	126	40	5,040	3,528	1,961	5,489	219,542
Flat	60	1,260	75,600	1,500	1,551	3,051	3,844,861
TOTAL		1,300	80,640				4,064,403

The Bywater table shows figures that correspond to the following average heat loads per meter square - 50.4kWh/m², and per dwelling - 3,126kWh/dwelling.

SCORE

The table below shows the breaks down between the space heating and the Domestic Hot Water (DHW) demand calculated for the SCORE development site. It is assumed that there is an equal distribution between 3 bed 4 persons flats and 3 beds 5 persons units. It is also assumed that 4 beds 7 persons dwelling are semi-detached terrace houses with a benchmark space heating demand of 35kWh/m^2.

The total annual heat demand for residential areas in SCORE development scheme is calculated to be 2,443MWh/yr using the methodology described above.

Table 5 - SCORE Residential Annual Heat Demand

				PER DWELLING			OVERALL
Dwelling	Floor area (m2)	n° of dwellings	total floor area (m2)	SH - (kWh/p.a)	DHW - SAP (kWh/p.a)	Total (kWh/p.a)	Total (kWh/p.a)
1B2P	50	292	14,600	1,250	1,419	2,669	779,432
2B4P	70	307	21,490	1,750	1,671	3,421	1,050,372
3B4P	74	67	4,958	1,850	1,714	3,564	238,762
3B5P	86	67	5,762	2,150	1,817	3,967	265,780
4B7P	108	19	2,052	3,780	1,924	5,704	108,368
TOTAL		752	48,862				2,442,713

These figures show an average heat load per meter square of 50kWh/m^2 and per dwelling of 3,248kWh/dwelling.

NON-RESIDENTIAL – METHODOLOGY

Benchmarks derived from CIBSE TM46: Energy Benchmarks (2008) (updated for improvements in energy efficiency standards since the time of publishing) have been used to develop non-residential heat demand estimates. CIBSE's TM46 guide contains energy benchmarks for different building usage types in kWh/m^2/yr. It was published in 2008 and the benchmarks refer to existing buildings at that time. As such, it has been assumed those benchmarks are representative of a building that has been constructed to 2006 Building Regulations.

Since 2006, updates to Building Regulations have increased the carbon emissions reduction required from a new building relative to the 2006 baseline. These reductions are achieved as a result of stricter maximum U-values (among other measures). This study has therefore adjusted the TM46 energy benchmarks in line with carbon savings required by each update of the Building Regulations.

Since 2013, the only update to the Building Regulations has been through a set of amendments issued in April 2016, none of which affect the maximum U-values. Nevertheless, it is reasonable to assume that, in keeping with a general move towards low carbon, building materials have continued to evolve and the actual U-values achieved in building fabric have reduced. A 5% improvement has therefore been applied compared to the 2013 Regulations in both 2016 and 2019.

Table 6 - Fabric improvements since the publishing of TM46 energy benchmarks

Fabric Improvement (cumulative)	
2010	25%
2013	34%
2016	39%
2019	44%

The table below indicates the benchmark values for the heat use (a notional boiler efficiency of 85% has been modelled to reflect lifecycle efficiency of a boiler) in kWh/m^2/yr for the building usage types in the three developments. Note that in modifying the benchmark, we have applied the carbon reduction only to the portion of the overall heat demand that is for SH as the HW demand would not be affected by changes in fabric energy efficiency. The split between SH and HW has been derived from industry benchmarks, WSP estimates, and previous project experience.

Table 7 – Annual heat load benchmarks used in analysis

	TM 46 Original Heat Bmark (kWh/m2/yr)	TM 46 Improved Heat Bmark (kWh/m2/yr)	Used Bmark (kWh/m2/yr)	SH proportion of annual load (%)	DHW proportion of annual load (%)	Source of used benchmark & Comment
Office	102	64	50	85	15	Mix of sources (previous modelling, recent tender documentation for London mixed use development), previous projects.
Retail	115.6	75	30	80	20	From previous WSP project (Newcastle)
Dry sport facility	102	71	71	70	30	ECG078, with reduction for taking in consideration the Southern Location of the scheme and the improved fabric since publication + boiler efficiency = 85%
Education	127.5	80	80	85	15	Modified TM46 benchmark to reflect improved fabric + boiler efficiency = 85%

The TM46 benchmark demand figure for dry sport facilities (even taking fabric improvement factors into account) such as the one on the SCORE development, was considered unrealistically high. Therefore ECG078 (2001), a more detailed guide to different types of dry sport facilities, was used as the basis for demand estimation for this element of the scheme (applying fabric improvement factors as appropriate).

The TM46 benchmark figure for office and retail (even taking fabric improvement factor into account) were also considered unrealistically high and therefore lower figures based upon WSP previous projects and experience were used.

Non-residential floor areas

9 Osier Way

9 Osier Way site has 1,300m^2 of non-residential spaces, category B1(C), according to "9 Osier Way – LBWF Pre – App 2 180815" It is assumed that the 50 kWh/m^2/yr of office space is suitable for those spaces accordingly to the definition of B1 spaces.

Reference: https://www.planningportal.co.uk/info/200130/common_projects/9/change_of_use

Bywaters

Information on non-residential spaces have been extracted from document titled "Bywaters Sustainability and Energy Statement", screenshot below.

> RSK Environment Ltd ("RSK") has been appointed by Bywaters (Leyton) Ltd to prepare this Sustainability & Energy Statement in support of an outline planning application to the London Borough of Waltham Forest (LBWF) regarding the proposed Gateway development, Leyton. The proposals comprise a maximum of 730 residential units (including 23 houses), 4,000sqm B1/B1c commercial space, 500sqm flexible A1/A3/D2 space and a circa 2,190sqm second form entry primary school.

The office benchmark has been used for B1 spaces. The retail benchmark has been used for A1/A3/D2 spaces. The education benchmark has been used for D1 spaces.

SCORE

Information on non-residential spaces have been extracted from information provided by LBWF (Carolyn's Seymour email (30/01/2019 10:56)), extract below:

> Non-residential uses (GIA figures, ie, including respective plant areas):
>
> Sports: circa 5000 sqm
>
> Community: circa 1700 sqm (inc. circa 600 sqm nursery)
>
> Health Hub: circa 2700 sqm
>
> Retail: circa 1950 sqm
>
> District Heating Network (DHN): circa 540sqm

LBWF has informed WSP, (Carolyn Seymour's email on 04/02/2019 at 15:49) that the sport centre area includes auxiliary facilities therefore corresponding to a Type 1 sport hall according to the categorization of ECG078, making the Dry sport benchmark in Table 7 is appropriate to use. The community spaces excluding the nursery are assumed to be classroom spaces and therefore the office benchmark is used. The nursery annual heat demand has been calculated with the Education benchmark as recommended by TM46. The health hub spaces are assumed to be GP offices and therefore the office benchmark is used.

SUMMARY OF CENTRAL CLUSTER DEMANDS

Across the core developments of 9 Osier Way, SCORE and Bywaters, the following overall demands have been estimated:

Table 8 – Energy Demand Summary – Central Cluster sites

Sum of three core sites					
			Annual Load (kWh/yr)		Peak Load (kW)
	Area (m2)	Dwellings (no.)	Thermal demand	Electrical demand	Peak Load
Residential	138,806	2,266	7,025,177	-	6,465
Non-residential	19,340	n/a	1,209,454	1,700,350	1,180
Total	**158,146**	**2,266**	**8,234,631**	**1,700,350**	**7,646**

9 Osier Way					
			Annual Load (kWh/yr)		Peak Load (kW)
	Area (m2)	Dwellings (no.)	Thermal demand	Electrical demand	Peak Load
Residential	9,304	214	518,061	-	519
Non-residential	1,300	n/a	65,000	123,500	52
Total	**10,604**	**214**	**583,061**	**123,500**	**571**

Bywaters					
			Annual Load (kWh/yr)		Peak Load (kW)
	Area (m2)	Dwellings (no.)	Thermal demand	Electrical demand	Peak Load
Residential	80,640	1,300	4,064,403	-	3,694

Non-residential	6,690	n/a	411,295	550,100	366
Total	**87,330**	**1,300**	**4,475,698**	**550,100**	**4,059**

SCORE					
			Annual Load (kWh/yr)		Peak Load (kW)
	Area (m2)	Dwellings (no.)	Thermal demand	Electrical demand	Peak Load
Residential	48,862	752	2,442,713	-	2,253
Non-residential	11,350	n/a	733,159	1,026,750	763
Total	**60,212**	**752**	**3,175,872**	**1,026,750**	**3,016**

PREFERRED ENERGY CENTRE COMMENTARY

The aspiration for the CSN district energy system is understood to be to supply market-competitive low carbon energy to the developments of the area. This element of the study considers possible extents of a scheme, suggested means of energy generation to provide low-carbon heat supply, and evaluates the requirements for energy centre space at one of the key sites. In addition, this section of the study also considers the preferred location for a centralised energy centre to serve the developments of the CSN area.

SCHEME EXTENT

IDENTIFICATION OF POTENTIAL LOADS IN CSN AREA

In addition to the core demands of the three key sites (Score, Bywaters, 9 Osier Way), the following sites have been considered as part of this study:

Leyton Mills – This area is currently owned by 2 separate landowners, and is a retail park with large outlets including B&Q and Asda. LBWF has stipulated that the site must be brought forward as a single unified development. It is currently thought that the earliest emergence of a unified proposal of this nature is several years away. The site could be developed as a mixed-used site (residential / retail). Earliest anticipated date for a start on site is around 2024. However, as part of the development proposals, LBWF would also require that a bridge crossing is developed to link the site with the Queen Elizabeth Olympic Park. This could be specified and designed to have sufficient structural strength to support district heating pipework, and hence this route could allow the Leyton Mills site to access the heating supply of the 'Olympic Park' energy centres (King's Yard and Stratford). On this basis, it is possible that this development could be served either from an extension to the CSN DEN or from the 'Olympic Park' energy centres. It is not possible to say which is likely to be the more attractive or realistic proposition at this stage, as the balance of costs and carbon intensity of heat between the two potential sites could change significantly between now and the time of potential heat connection. On the basis of this uncertainty, it would seem to be a potentially risky investment to expand the CSN energy centre to cater for this potential load that may or may not decide to connect. The potential loads of the Leyton Mills site have not been included in the calculation of energy demands / energy centre sizing at this stage.

Housing development at Leyton Orient football ground – LBWF has advised WSP that the heating systems in these blocks (located at the four corners of the football club ground) are incompatible with a district heating solution, and hence these are not considered further as part of this study.

New Spitalfields Market – The redevelopment of the New Spitalfields Market site is anticipated in an approximately 10-year timeframe. This will be a significantly sized scheme delivering a new mixed neighbourhood, but similarly to the uncertainty surrounding Leyton Mills, this site could equally (or even more straightforwardly) be served by the Olympic Park Network than an extension to the CSN DEN. The Olympic Park network already extends under the A12 and currently serves the hockey centre. On this basis, it would seem risky to make allowance within the CSN scheme to cater for this demand, and the New Spitalfields Market site has not been included within scheme sizing at this stage.

The following sites have been considered on the basis of desktop evaluation of the area using mapping tools (e.g. OS Mapping / Google Earth / Streetview). Commentary is also given on heat network connection potential

- Leyton Fire Station – assumed to have centralised boiler system (see linear heat density (LHD) analysis below).
- Former Oliver Close estate (Oliver Road) – understood to have individual gas boilers currently – not considered as a potential connection given high costs and disruption associated with conversion from individual boiler system.
- Twist House – as above – individual gas boiler system understood to be current means of heat provision
- Leyton Grange Estate – at greater distance (additional approx. 175m) from the Central Cluster than the Fire Station, and currently it is uncertain what the existing heat supply arrangement is.
- Ive Farm Fields – understood to be a small load, at a distance of > 600m from the SCORE energy centre. Not considered to be a viable potential connection (even in combination with other loads identified above)
- Developments on Ruckholt Road (NEST and Rookery Court) (see LHD analysis below)

LINEAR HEAT DENSITY ANALYSIS OF POTENTIAL LOADS

In addition to the qualitative analysis above, linear heat density analysis has also been carried out.

This modelling is based around the understanding that commercial viability is a product of the relationship between the length of pipework and the connected load for a potential heat network. Essentially it is quantifying the balance between potential income (linked to heat sales volume) that could be generated through connection to a load, against an indicator of the cost to make that connection (network length).

The approach adopted to linear heat density testing has been to take the 'core loads' as a basis for analysis, and consider the potential expansion connections, as listed out in the sections above.

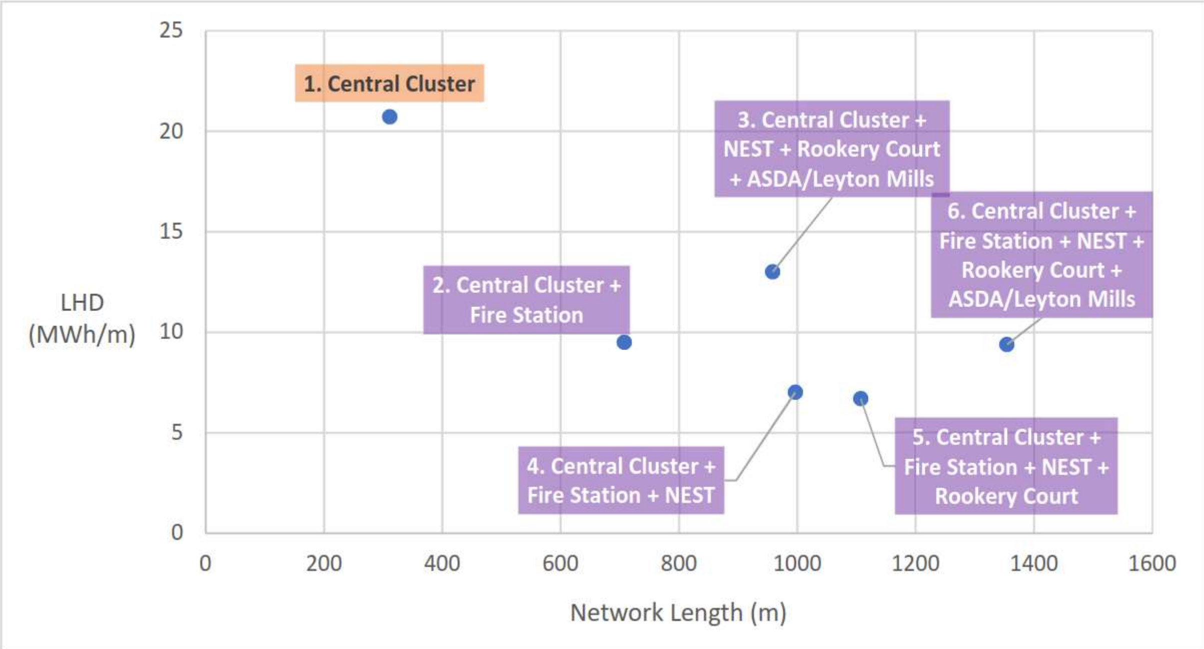
It is assumed for the purposes of this analysis that all development sites are fully built-out – i.e. the analysis of potential linear heat densities of connections for new developments is based on the heat load at completion.

Figure 4 - Network links for LHD analysis

The results for the LHD analysis are shown in the figure below. The model provides a LHD figure of 21 MWh/m for the Core Network (Point 1 in the Figure below) which includes Score, 9 Osier Way and Bywater developments. Expanded network pipe connections are connected to the nearest feasible section of the core DH network pipework. The routing of the DH network is preliminary in this exercise and is subject to revision later in the delivery of the design.

There are two areas of expansion for the DH network. The north section of the core network, near 9 Osier Way would need to be extended to deliver heat to Leyton Fire Station. The southern section of the network could be expanded to serve the NEST, Rookery Court and ASDA/Leyton Mills heat demands. The expansion of the north section to connect the Fire Station results in a reduced LHD of 9.5 MWh/m (Point 2). This is because there is a small annual heat demand (265,000 kWh) for a large increase in network pipework (400m). Removing the North Section from the network and expanding the Southern section to connect NEST, Rookery Court and ASDA/Leyton Mills results in a LHD of 13.5 MWh/m. The large increase relative to the Fire Station expansion comes from the connection of the ASDA/Leyton Mills heat load. This is significantly larger than any of the other estimated heat demands (5,000,000 kWh) and requires an equivalent trench length for pipework (400m). Expansion to the loads of Option 3 is likely to generate most benefit of the options presented here as the LHD is highest of the expansion options. Other combinations of expanded loads, Points 4, 5 and 6 gives lower or equivalent LHD values to the Fire Station.

Figure 5 - Linear Heat Density results



Overall, the linear heat density analysis above illustrates that the Central Cluster alone has the highest heat density, indicating that this core selection of loads is likely to give the best balance between network expense and income. On this basis, it is recommended at this stage that feasibility options focus primarily on this selection of core loads (9 Osier Way, Bywaters, SCORE).

It must be noted, that LHD is not the only metric of scheme performance. It is also critical for most district heating networks that a size threshold is reached (in terms of annual heat demand served), to allow scheme operators sufficient margin in operation to cover fixed cost elements (both operational and capital), that may not vary significantly with scale. There is not a fixed rule for the required threshold. However, it is WSP's recommendation at this early stage that the scheme progresses on the basis of the Central Cluster which has an annual estimated heat demand at end-users of approximately 8.2GWh p.a.

MEANS OF ENERGY GENERATION

The objective of the CSN DEN is to produce market competitive, affordable low carbon heat. In the currently policy context, LBWF has advised that the primary assessment of carbon performance for this study should be based upon compliance with the draft London Plan policies, and based upon the carbon factors of SAP10. However, please note that Taylor Wimpey has, subsequent to the initial drafting of this report, clarified that it will put forward a SAP2012 emissions factor based solution based on gas-fired CHP plant. This SAP2012 design has not been reviewed in this report

The objectives of the DEN will be met if low-carbon and cost competitive heat can be generated within the constraints of the energy centre (constraints in terms of location, scale, urban environment, status of current technology, etc.). There is only a relatively limited palette of technologies available for heat generation at the scale and market-ready phase of development that meet these criteria.

This study does not attempt to catalogue the full range of low and zero carbon technologies available for all contexts. Instead, this study focusses upon the key low-carbon technologies that are considered to be both suitable for the site and sufficiently market-mature to be realistic options for the scheme.

The key technologies that are considered here are:

- Heat pumps
- Combined heat and power (gas-fired)
- Solar PV and hot water

The assumption is made that for all schemes, top-up and standby heat would be provided by gas-fired boilers. WSP understand that there are no life-critical functions that need to be supported by the scheme, and hence dual-fuel boilers and oil storage areas are not incorporated in designs / commentary.

HEAT PUMPS

Heat pumps can derive their source-side heat from several sources:

- Waste heat (from processes)
- Ambient air
- The ground
- Water in the ground

The focus of this study will be on heat pumps based on ambient air – i.e. 'air-source heat pumps'. This is primarily due to the current proposal from the ESCo design advisors at pre-application stage for the SCORE development site, which utilises this technology. The scope of WSP's appointment also does not currently cover investigation into ground conditions, and hence the potential for a ground source system in this location remains unknown at this stage.

The overall seasonal performance of air source heat pumps depends on multiple factors, including plant efficiency, ambient temperatures, approach temperatures, network / output temperatures. For the purposes of comparison in this section, a seasonal COP (or seasonal performance factor – SPF) of 2.6 is assumed.

The following graphs illustrate the potential performance of a heat pump against the counterfactual option of a gas boiler.

Figure 6 - ASHP cost saving

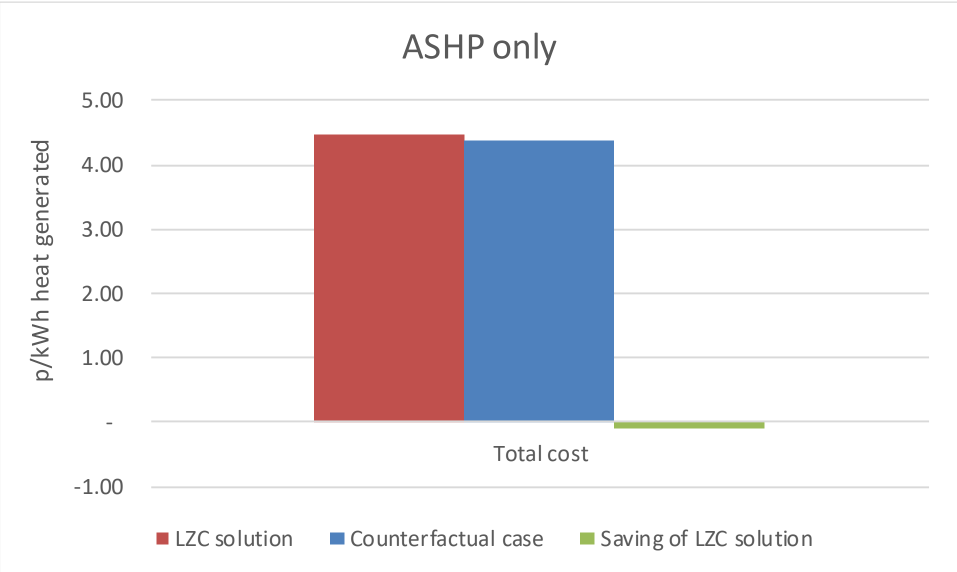
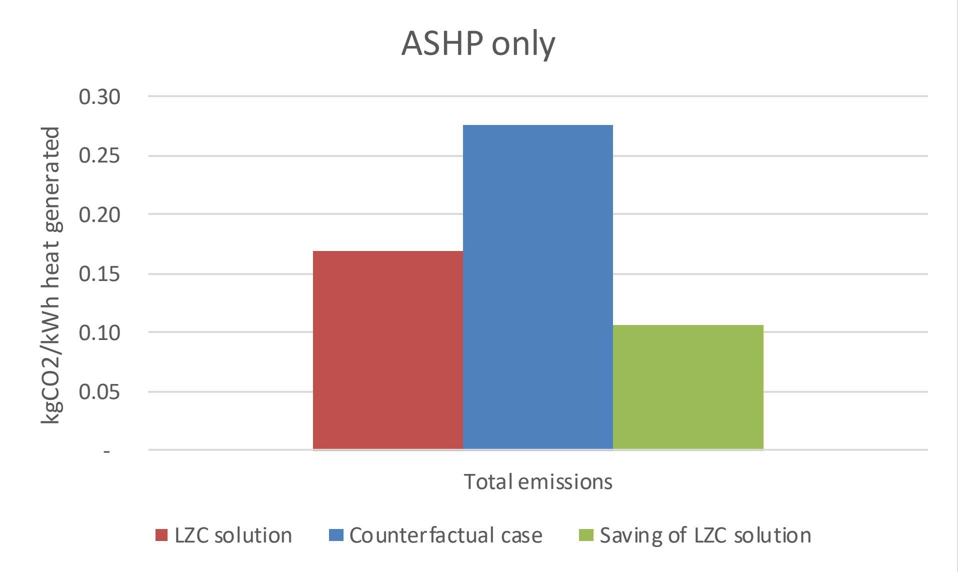


Figure 7 - ASHP carbon saving



There are a number of assumptions implicit within these graphs which are listed below:

Table 9 – Calculation assumptions – carbon and cost savings (ASHP)

INPUTS		UNIT / SOURCE / NOTES
Heat demand (site)	1	kWh - Notional basis for comparison
Electricity demand (site)	0.1	kWh - Representing notional landlord / parasitic requirements of site
Boiler efficiency	83%	GCV basis (seasonal)
Distribution losses (as percentage of site heat demand)	20%	Notional as per CP1 best practice
Percentage of heat met by ASHP	80%	Notional
ASHP COP	2.60	Notional – to meet ASHP RHI threshold of 2.5 COP
ASHP maintenance cost	0.40	p/kWth (based on rough supplier advised figure (4% of capex, assuming 5,000hrs operation per year)
Cost of gas	2.23	p/kWh (excl CCL) (QEP, Dec 2018, table 3.4.1, small consumer, average of most recent four quarters)
Cost of electricity	12.86	p/kWh (excl CCL) (QEP, Dec 2018, table 3.4.1, small consumer, average of most recent four quarters)
Value of exported electricity	4.00	p/kWh - estimate

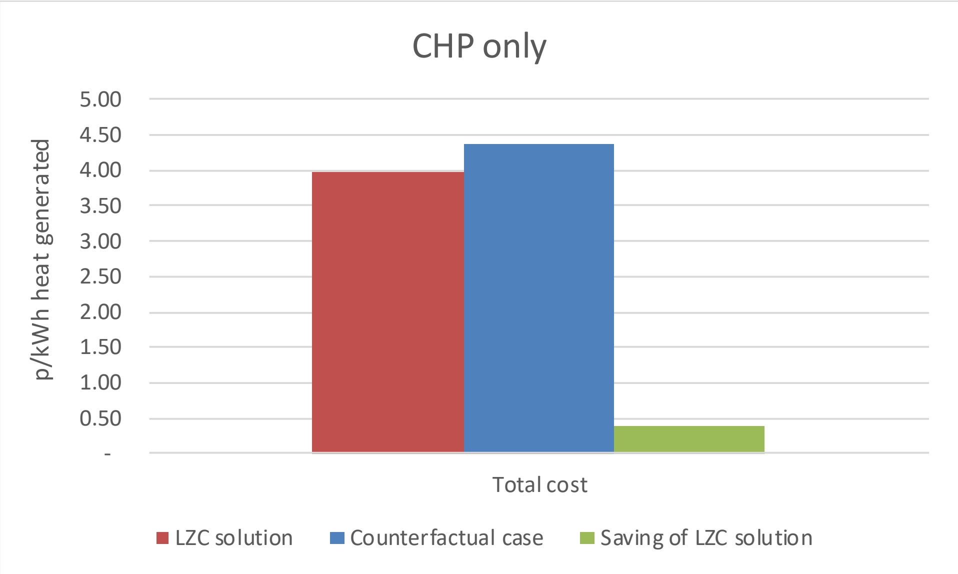
INPUTS		UNIT / SOURCE / NOTES
RHI on ASHP output	2.69	p/kWh – as per non-domestic RHI rate for installations accredited after 1st Jan 2019[8]
Carbon intensity of gas	0.210	kg/kWh (SAP 10)
Carbon intensity of electricity	0.233	kg/kWh (SAP 10)
CCL gas	0.339	p/kWh – HMRC – rate from 1/4/2019

GAS-FIRED COMBINED HEAT AND POWER

The use of gas-fired combined heat and power has for many years been one of the key preferred options for delivering low-carbon energy. This was due to its ability to deliver both significant cost reductions against a grid-import and gas-boiler only option, and also carbon savings against the same alternative scenario. However, as described in the policy section of this document (see page 13), the reduction in the carbon intensity of electricity now means that the ability of gas-fired CHP to deliver carbon savings is eradicated or vastly curtailed. However, its ability to deliver cost savings remains, and hence the technology remains a viable component of potential energy configurations.

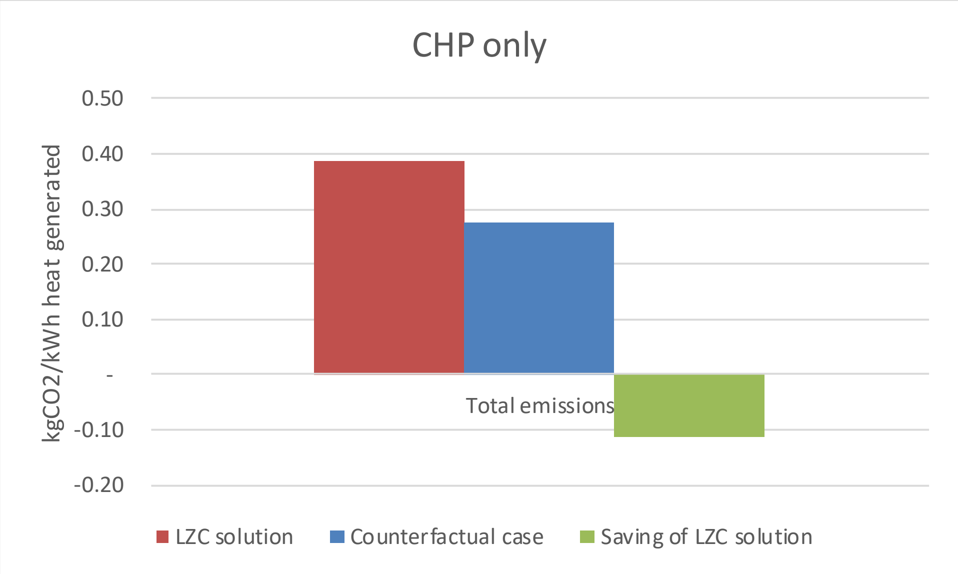
The following graphs illustrate gas-fired CHP's ability to generate savings against the counterfactual case of gas-boilers and power import from grid under SAP10 emissions factors.

Figure 8 - CHP only cost savings



[8] Please note that the RHI scheme is currently due to end with the last opportunity for qualification of schemes being the end of March 2021 (schemes should be commissioned by this date). The Government has not to WSP's knowledge of April 2019, announced if another framework support mechanism will be put in place to replace the RHI for heat pumps.

Figure 9 - CHP only emissions savings



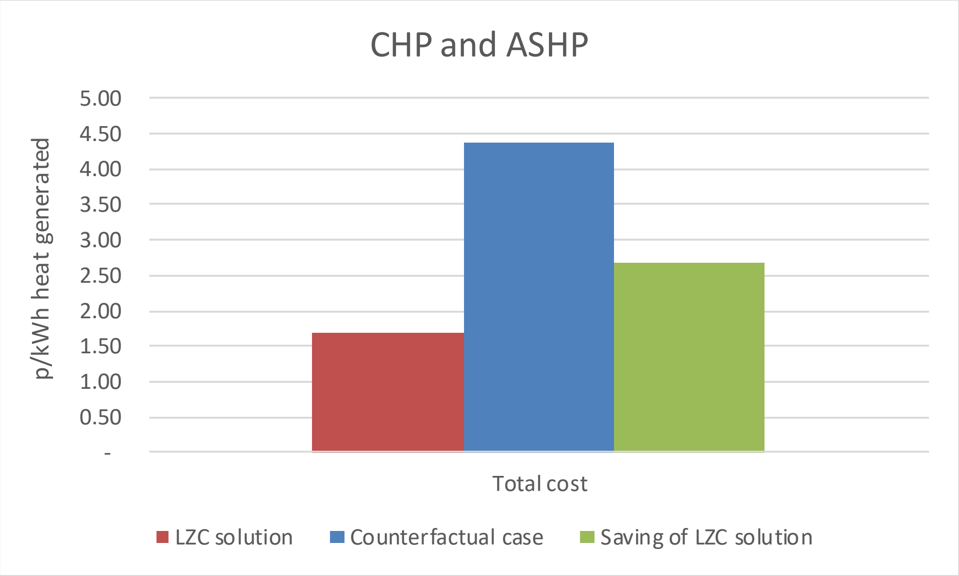
These figures are based on the same assumptions as listed above, with the following CHP specific assumptions:

Table 10 – CHP specific assumptions

INPUTS		UNIT / SOURCE / NOTES
CHP electrical efficiency (GCV)	37%	Notional (GCV)
CHP heat efficiency (GCV)	39%	Notional (GCV)
Percentage of heat demand met by CHP	80%	Notional
CHP maintenance cost	1.2	p/kWh (notional)

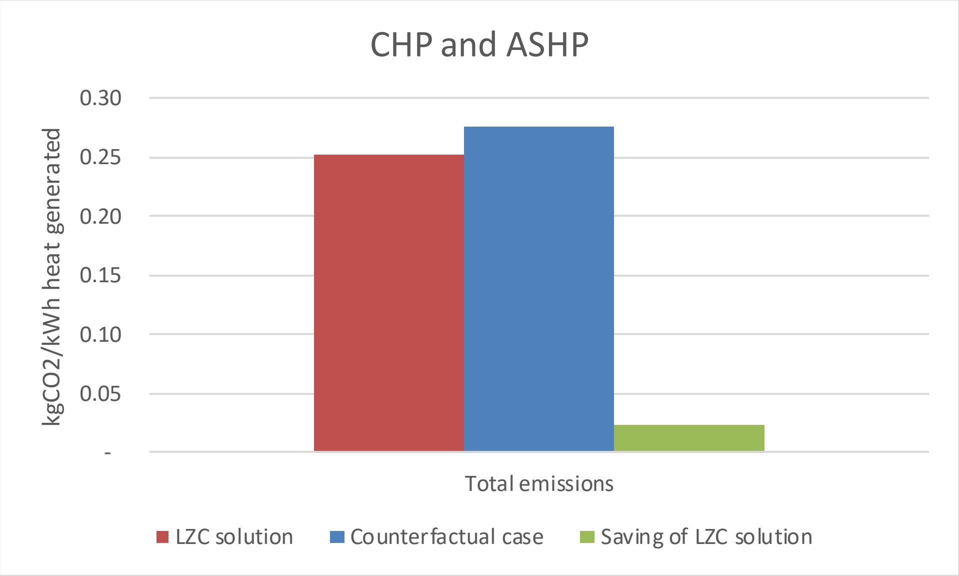
A comparison of performance against the counterfactual is also illustrated for a mix of ASHP and CHP generation, where the CHP is assumed to generate 30% of the overall heat demand and the ASHP 50% of the heat demand, the remainder being met by gas-fired boilers.

Figure 10 - CHP and ASHP combination cost comparison



Please note that these figures should not be taken to be indicative of the cost of heat generation, as these do not take an capital cost elements into account, and also assume that all heat is generated through the primary plant sources (whereas in reality a significant portion of overall heat demand would normally be generated by gas-fired boilers).

Figure 11 - CHP and ASHP combination emissions comparison



It can be seen from the analysis above that the combination of ASHP and CHP delivers both cost and carbon savings against the counterfactual case under the assumptions listed. This contrasts with the technologies operating on an individual basis, where the CHP unit delivers cost savings, but increases carbon emissions, and the ASHP delivers carbon savings, but at higher cost than the counterfactual. For this reason, the combination of CHP and ASHP is pursued as the preferred lead technology selection for the scheme.

As stated above, please note that these figures only address operational costs, and do not take the capital costs of the various systems into account, nor the potentially varying contributions that gas-boiler heat might make to any actual overall annual supply mix.

PV AND SOLAR THERMAL ARRAYS

The available roof space for PV or solar thermal panels is not yet known, as the M&E designs and other competing uses for the space have not yet been established. However, it is noted that the area of roof available on a multi-storey development of this nature will always be limited, and that as a result, the contribution that PV or solar thermal panels can make towards decarbonising energy provision will be relatively small. The use of these solar technologies should only, in WSP's view, be considered as a complementary approach to the proposed ASHP / CHP combination that is identified above.

From an operational perspective, solar thermal arrays would operate effectively in competition with the ASHP and CHP, in terms of trying to meet the available on-site heat demand. On this basis, this technology is not recommended.

The use of PV arrays, however, could offer some benefit in the summer periods in particular, when both solar generation is likely to be more significant, and when the heat demands are relatively low. During these periods, depending on plant sizing and base-load demands, it may be that the ASHP operates to meet heat demands, and that PV output could contribute towards reducing the required import of power for the heat pump (and any landlord supplies).

At this stage, therefore, it is suggested that PV arrays are considered as part of the overall strategy. It is noted, however, that there may be both limited roof space (particularly given the need for large dry-air coolers or similar to source heat for the heat pumps), and that below a certain scalar threshold, the additional system complexity of integrating the PV will outweigh the benefits that this type of system might deliver. At this stage, the technology is recommended as a potentially complementary solution, but PV has not been included in proposals at this stage, given the uncertainty over roof areas and capital cost of initial installation.

ENERGY CENTRE SPATIAL REQUIREMENT

WSP has carried out an assessment at high level to evaluate a suitable spatial requirement for an energy centre to serve the combined loads of the three core developments sites of the CSN, i.e. the Central Cluster. .

A number of options for plant were considered, on the basis of the overall estimated demands. The following summarises the options considered and the approximated basis for the plant selections:

Overall thermal output of low carbon plant was initially approximated on the rule-of-thumb basis that approximately 70% of overall heat demand should be met by the low-carbon plant, assuming full-load operation for around 5,500 hours p.a..

Numerically, this approach delivered the following approximate output:

Table 11 – LZC initial technology sizing assessment

	APPROX LZC SIZING	
Heat demand (exl losses)	8,235,000	kWh p.a.
Losses	20%	%
Losses	1,647,000	kWh p.a.

	APPROX LZC SIZING	
Total demand	9,882,000	kWh p.a.
% met by LZC	70%	%
Hours run by LZC	5,500	Hours p.a.
LZC heat output	1258	kWth

The peak demand of the core loads is estimated to be as follows:

Table 12 – Peak demand estimate

	ESTIMATED PEAK DEMAND	
Heat demand (peak, excl losses)	6,800	kWth

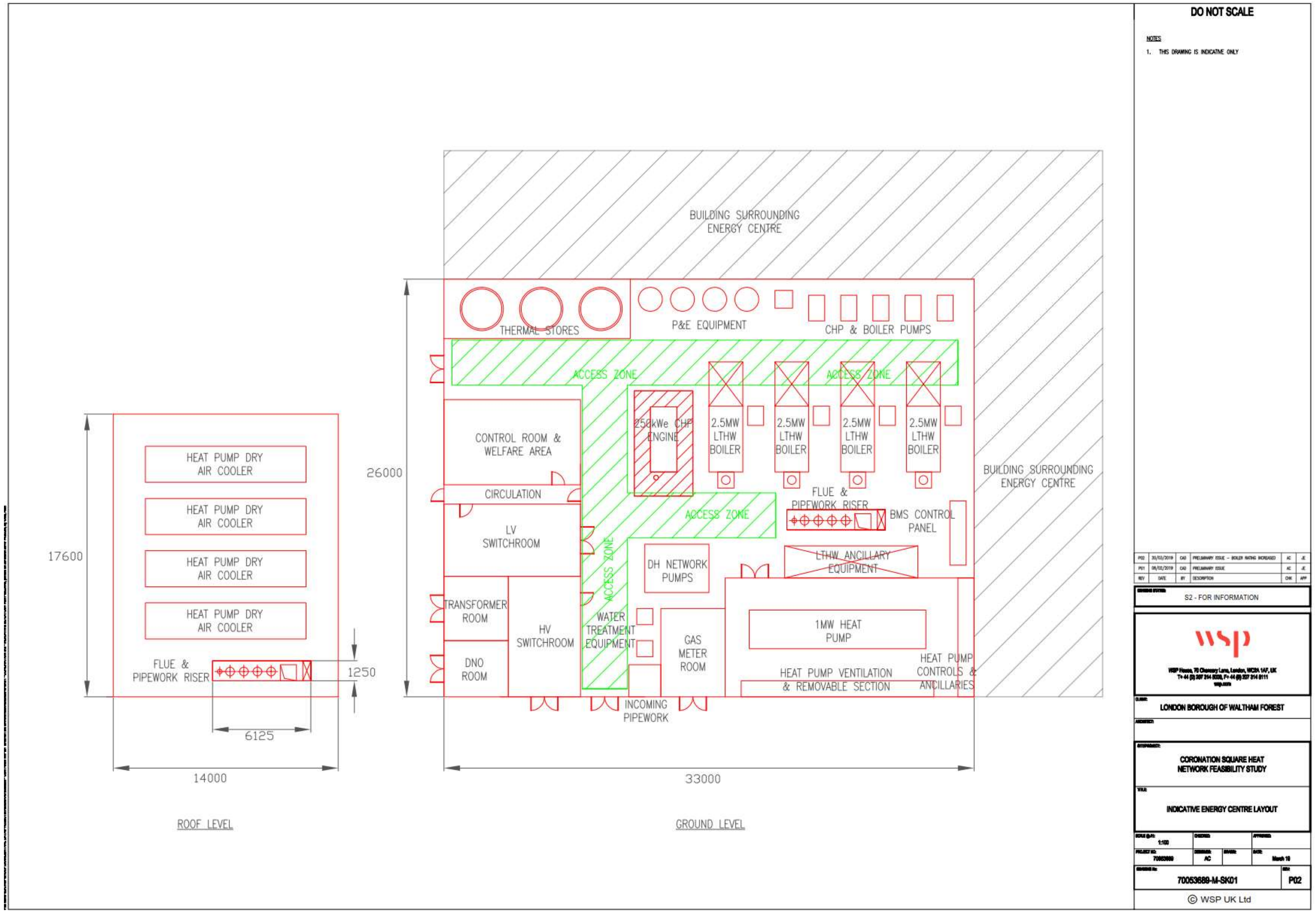
From this approach, the following notional plant selection was developed, in order to assess the spatial requirement for a solution that is considered suitable for the delivery of heat to the three Central Cluster development sites;

Table 13 –Notional plant selection for spatial planning

	NOTIONAL SELECTION FOR SPATIAL PLANNING	UNIT
ASHP	1,000	kWth
CHP	250	kWth
Gas boiler	2,300	kWth
Gas boiler	2,300	kWth
Gas boiler	2,300	kWth
Gas boiler	2,300	kWth
Total resilient supply (boilers, assuming N+1)	6,900	kWth
Thermal storage inputs		
Thermal storage size	75	cubic metres
Temperature differential	30	deg C
CP of water	4.2	kJ/kg/deg C
Density of water	987	kg/cubic metres
Capacity of store (kWh)	2,591	kWh
Hours of LZC operation @ 50% output)	4.15	hours

This selection was later confirmed as a suitable selection through the techno-economic modelling undertaken as part of this commission. The following layout was developed to suit this selection of plant.

Figure 12 - Notional Energy Centre Layout



This layout assumes the following:

- Access on two adjacent sides of the development
- Availability of a double-height space
- Roof space for dry air coolers
- Suitable facades for air-intake and extract

The layout has been developed on the basis of indicative plant selections for a SAP10-based scheme. The area currently indicated by this layout is 858sq m (ground floor, not including the roof space required for dry-air coolers or similar).

This area is somewhat in excess of the allowance made (750sq m) in the Developer agreement for the SCORE site, however, it should be noted that it is possible that not all of the elements shown on this layout will be required as part of the DHN energy centre provision (for example the HV room may not be required depending on the electrical arrangement that is developed).

A number of comments apply to this layout:

- The area required for dry-air coolers will be influenced by the acoustic (noise breakout) criteria specified for the location, and hence this is only indicative at this stage
- The boiler selection and desired resilience is also subject to discussions with the developers and energy services provider for the scheme
- The layout assumes a double-height space, and hence if required, in some areas it may be possible to introduce mezzanine housing of plant if there is sufficient height (e.g. approx. 7m). However, this sketch does not currently integrate the ventilation (natural and mechanical) requirements for the various plant elements, and this will significantly curtail the available space for mezzanine floor installation. Further detailed design development would be needed to evaluate to what degree the use of mezzanine installation could reduce the overall footprint requirement of the space.
- The preferred thermal storage capacity requirement has not yet been tested in by energy modelling, and hence this capacity should be considered indicative.

The following is a summary of the estimated louvre requirements for the plant illustrated above, where a mix of mechanical and natural ventilation is assumed.

- Indicatively, on the 'southern' (e.g. the bottom edge of the drawing) façade, a louvre area of $23m^2$ has been calculated as a requirement for general plant ventilation (intake), heat pump room ventilation (intake), and CHP inlet ventilation.
- The extract ventilation requirement in terms of louvre area for the plant room is calculation indicatively as $7.5m^2$ on the 'western' side of the plantroom drawing (CHP extract, and general plant room extract). The heat pump extract is assumed to be via ductwork to roof level such that in the event of ammonia leakage that sufficient dispersion to high level can take place.

PREFERRED ENERGY CENTRE LOCATION

It is the aspiration of LBWF to create a decentralised energy network for the CSN Central Cluster. This will best be accomplished by an energy centre that has a number of key attributes:

- Sufficient physical space to house required plant (including ventilation / access / connectivity / etc)

- Early completion in the development timeline of the area, such that the other plots to be connected do not have to install their own plant as an interim measure
- A central location to increase the efficiency of heat distribution
- Flexibility to cater for changes in development quanta and phasing
- A site where LBWF has sufficient influence to ensure the development serves the energy requirements of neighbouring plots as well as its own needs.

There are multiple unknown factors in the overall future development of the Central Cluster scheme as addressed by this report. This is both normal at this stage of development, and fundamentally unavoidable given the design progression that all new developments go through. The key 'unknowns' for the selection of an energy centre include:

- Timings – when will heat be required for the different plots?
  - The different plots have an anticipated timetable for emergence (as outlined below), but this is subject to change, and cannot be guaranteed at this stage.
- Quanta – what demands will emerge as plans change over the design development process?
  - It is possible that the site owners / developers may wish to come forward with alternative designs that they consider to offer greater return on investment (even when a site already has an existing outline planning permission). This normally corresponds to an intensification of the development, and hence greater demands for heat. The degree to which change in this direction is possible is normally constrained by the limits imposed by the planning system.
- Whether the developments really will proceed or not, given the current turmoil in the political system (Brexit) and the impacts that this might have on markets for housing and goods.

The overall recommendation for the scheme is that an energy centre is pursued on the SCORE site as the preferred location. This recommendation is made based on the following reasons:

- Whilst the 9 Osier Way site is currently anticipated to be the first to be constructed, it is LBWF's view that this site is too small both to house the energy generation facility required, and to bear the costs and loss of development space that the enlarged energy centre implies.
- There is little to differentiate the Bywaters and SCORE sites in terms of location – both sites could house energy facilities that are close to the centre of the combined development area of the three development plots.
- The council (LBWF) is the land-owner of the SCORE site, and has already entered into a development agreement that requires an area of 750sq metres be allocated for primary energy centre plant. On this basis, the SCORE site is the default preferred location for the energy centre for the Central Cluster scheme assuming there are no other technical reasons for an alternative preference.
- The topology / proposed building heights of the current developments and the neighbouring buildings do not suggest any particular advantage to either site in terms of minimising air quality impacts from flue gases. WSP has only been able to use indicative drawings for this assessment of overall building heights.
- The SCORE site is currently assumed to emerge earlier than the Bywaters site, and hence it would be advantageous to have the energy centre at the SCORE site, such that the Bywaters site can be supplied from the outset from the SCORE site, and would not need to house any temporary plant for the provision of heat before a permanent energy centre emerges.

ANTICIPATED DEVELOPMENT TIMETABLE (CURRENT ASSUMPTIONS)

The following image illustrates the overall modelled growth of loads that is current assumed for the different development sites.

Figure 13 - Site development timetable

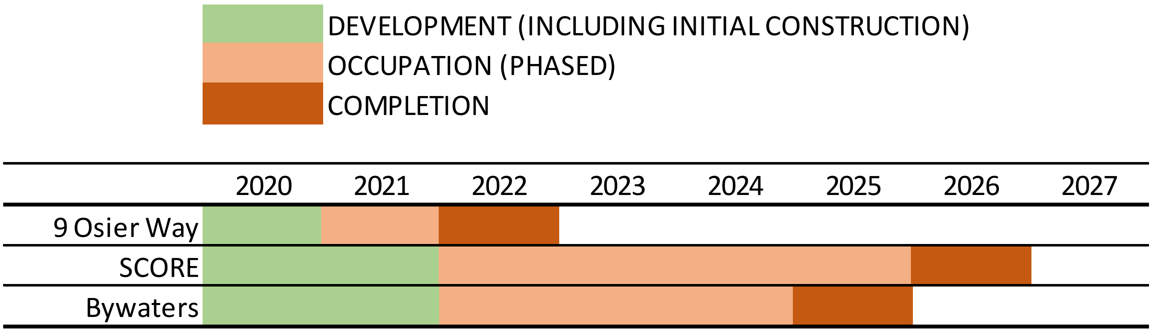
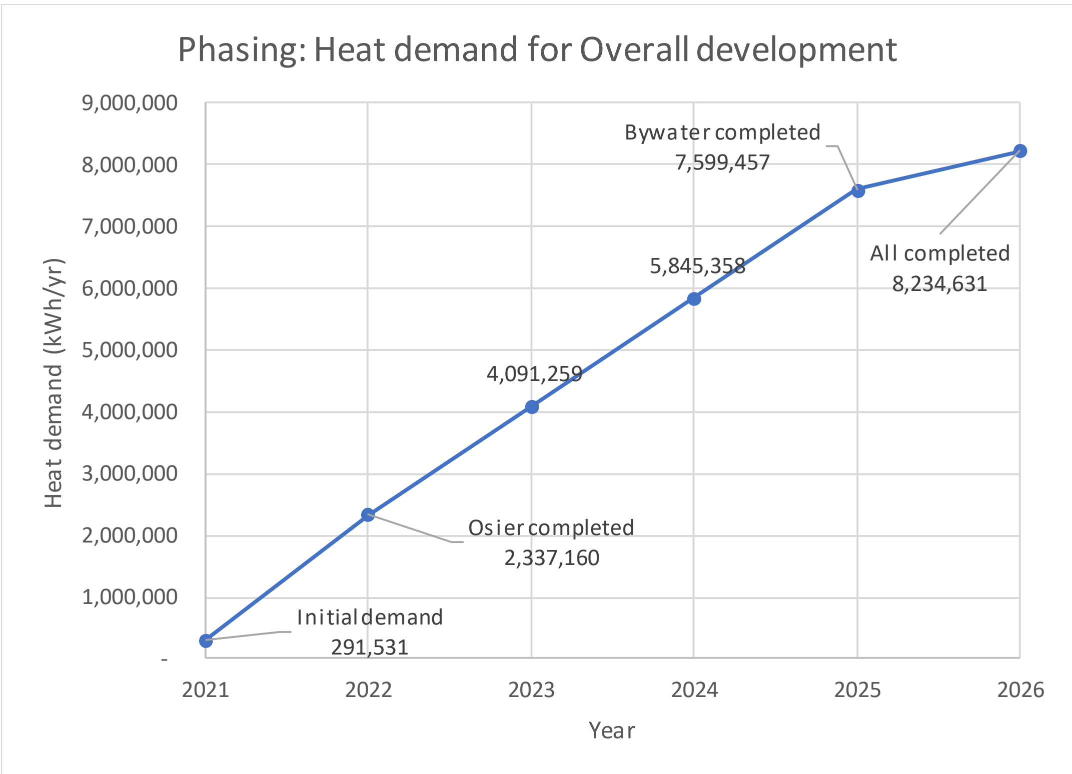


Figure 14 - Load growth chart



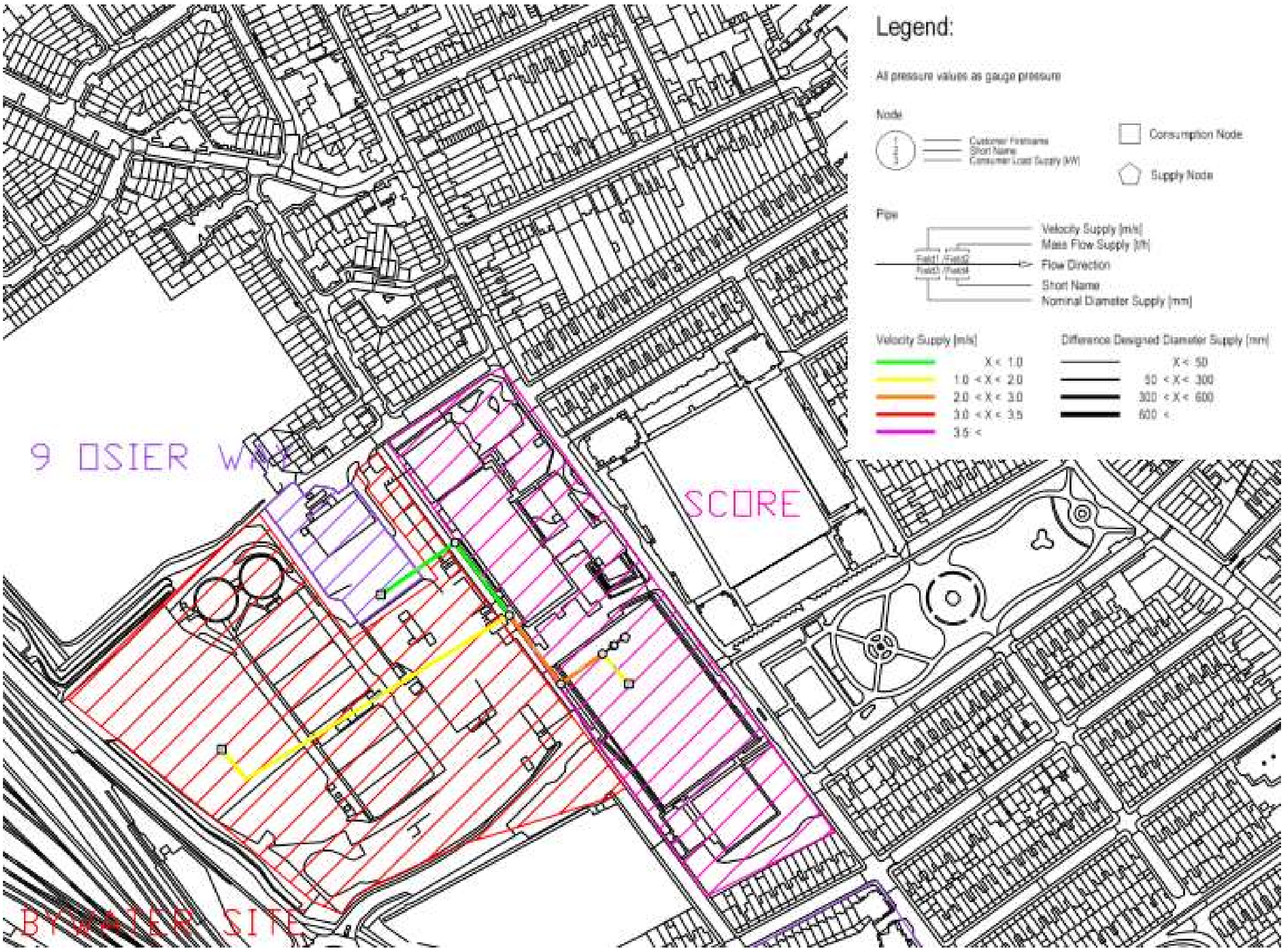
This chart illustrates the linear assumption in terms of unit completions across the different development areas in the absence of more detailed phased development plans.

NETWORK ROUTING AND DESIGN

The exact locations of the proposed energy centre for the development sites of the key development areas is not yet confirmed through the granting of full or detailed planning permission on the sites. Hence at this stage, notional locations within each development plot have been assumed for energy centre / substation locations using information from the outline or pre-application submissions.

The following network analysis has been undertaken for the Central Cluster;

Figure 15 - Network analysis output (Central cluster, non-futureproofed)



This network analysis undertaken in Bentley hydraulic network modelling software) indicates that the maximum diameter for the network (in the section leaving the SCORE energy centre) would be around 125mm diameter.

The following assumptions have been made in the hydraulic calculation of the network dimensions:

The model operates with the following parameters:

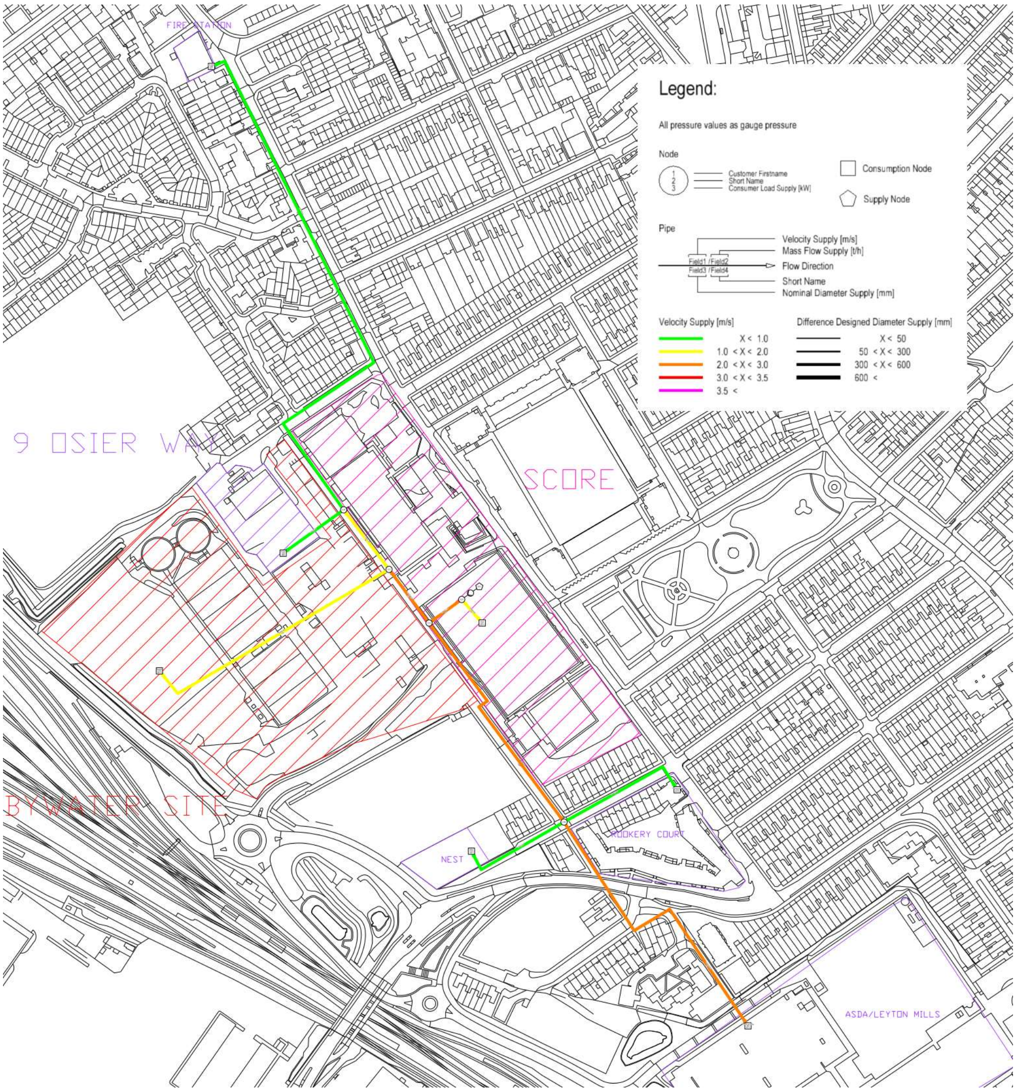
- 75% diversity on branches with 3 or more connections (only applies to expanded network)
- 70/40°C flow/return
- Sizing to logstor design guidance

Table 14 – Pipework velocity limits assumed

Type of Pipe	Diameter (*AS INTERPRETED FROM LOGSTOR GUIDANCE*)	Maximum Velocity (m/s)
Transmission	>DN150	3.5
Main	DN125 - DN80	2.5
Branch	<DN80	1

The same approach has also been applied to an estimation of potential pipe sizes for an 'expanded' network that also serves the load points identified in the linear heat density assessment for the scheme. This analysis shows the following output:

Figure 16 - Network diameters (Expanded scheme)



A higher resolution image of this network is provided in the appendices to the report. However, the largest diameter on this iteration of network design is 200mm. This could provide an indication of the potential ‘future-proofing’ that could be applied to the network to ensure that future loads could also be served by the SCORE energy centre. The value of this ‘future-proofing’ is linked to both views of the likelihood of the various connections emerging, and ability of the SCORE energy centre to house the plant sufficient to serve these demands.

DESIGN REVIEW OF PROPOSED ENERGY CENTRE

WSP prepared the following commentary memo on the indicative SAP10 emission factor designs developed by Metropolitan. This is replicated here for ease of reference, and constitutes WSP's design review of the SAP10 designs developed to this point, particularly as no updated design information has been provided to WSP..

MEMO (copy of version issued)

TO	CSN project team	**FROM**	James Eland, WSP
DATE	**21 March 2019**	**CONFIDENTIALITY**	**Confidential**
SUBJECT	**CSN Energy Centre design issues for expanded system**		

WSP has drafted a set of initial comments on the developing CSN Energy Centre design with a view to testing whether the proposed area appears to offer a suitable solution for the supply of heat to the wider area. These comments cover a number of topics, and there are clearly a number of design issues to be resolved as the designs develop. Currently, WSP's overall view is that adopting an energy centre floor area of 750 sq m would provide a means of mitigating many of the risks and issues that are highlighted.

The following comments were provided to Metropolitan on 18th March 2019.

WSP has been asked to provide comments / queries on the design of the energy centre as currently proposed by Metropolitan (on behalf of the Taylor Wimpey development team). The comments below have been compiled in advance of a technical workshop discussion that is due to be held on the 22nd March 2019.

The comments have been compiled with reference to the drawings developed by Metropolitan with the following designations, as provided to WSP on 21 Feb 2019[9]:

- #####[10]-DH-M-10-02-001-C-P Energy Centre GA (New London Plan)
- #####-DH-M-10-02-002

Please note that the comments below focus on the SAP10 solution (i.e. heat pumps and CHP).

WSP has been appointed to provide technical support to LBWF, who are acting in partnership with TW to develop a suitable solution for the site. Hence these comments have been prepared in the spirit of hopefully constructive queries to help ensure that the developing designs meet the needs of all parties.

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[9] Email from D Kakalopoulos to J Eland, 21/2/2019 15:15.
[10] NB that the "#####" were part of the drawing numbers as provided to WSP.

The aim of the approach from the perspective of LBWF is to ensure that the spatial allocation and initial proposed arrangement is fit for purpose both for the initial scale of *scheme and the enlarged network.* Further, it is also critical to note that LBWF needs to consider the lifespan of the project in terms of energy supply, and build in contingency (in terms of space) to allow for a number of potential changes that might include:

- Changes to legislation
  - It is noted that within the current Development Agreement with Taylor Wimpey, that there is potential for the actual build-out of the site to be delayed by up to 4 years. There may be significant policy shift within this period, and even if outline planning permission for the SCORE site is obtained under the current legislation / planning framework, the other neighbouring developments may come forward under an updated framework, which might require, for example, greater carbon savings. Therefore, the spatial allowance within the SCORE site should have sufficient flexibility to cater for this type of change.
- Change of operator
  - Whilst it is our hope that an operator of the energy system would continue to operate throughout the lifecycle of the building and the length of a concession agreement (or similar), it is always possible that unforeseen circumstances (potentially wholly unrelated to this scheme) give rise to change. In order to cater for this, LBWF would like to ensure that a different company, with a potential alternative approach could also accommodate its preferred solution in the space available.
- Market changes (utility price shifts)
  - The shifts in market pricing of utilities could give rise to different technology preferences in the future. If, for some reason, electricity becomes significantly cheaper than currently predicted, a greater component of heat pump provision might become desirable. It would be beneficial if designs can accommodate this.

Some initial comments/ queries on the drawings provided are as follows:

- Demands
  - It was agreed at the meeting held on 28th February 2019, that the basis of the extended scheme needs to be confirmed, given the potential for the Bywaters site to come forward with a new, higher density scheme. However, WSP notes the need to establish the differences in demand estimates between the Metropolitan figures and the preliminary figures that WSP has developed in this report. WSP and Metropolitan have agreed to assume 1,000 dwellings for the Bywaters site, although it is acknowledged that this is an approximate estimate at this stage.
- Energy Centre location
  - It appears that the energy centre is located under a part of the development that is 12 storeys tall, with the block to the south-east on the same block proposed with 15 storeys. We would normally expect an energy centre to be located under the tallest block to simplify the flue strategy and assist with dispersion (of both boiler NOx emissions and heat pump refrigerant). Is there potential to relocate the energy centre to the base of the 15 storey

tower or alternatively to reconfigure the scheme such that the 15 storey tower is over the energy centre?

- Ventilation air flow
  - The louvre areas that have been calculated by WSP for the anticipated requirements of a similar selection of equipment and general plant room ventilation appear to be significantly larger than can easily be accommodated on the facades currently indicated for ventilation on the Metropolitan GA drawing. The existing proposed arrangement for CHP air intake (drawing from the sports hall space) will not be possible. What is the current proposal for ventilation?
  - The noise breakout levels for the energy centre are currently a cause for concern. There are residential properties in close proximity, and given that heat pumps are often 'noisy' pieces of equipment, careful consideration of appropriate attenuation strategies will be required. This might involve, for example, acoustic louvres that are deeper than currently indicated on the Metropolitan GA. What is the current strategy in terms of acoustic performance?
  - Could additional air flow be achieved by introducing attenuated louvres to the cycle parking areas and perhaps the refuse areas?
  - Will the gas intake room include high and low level louvres?
  - The area containing the district heating pump set and LTHW substation appears to be fairly enclosed. How will high temperatures be prevented in his area? Can additional ventilation be provided?
- Network diameters
  - WSP welcomes the approach to network design indicated on #####-DH-M-10-20-002, in terms of illustrating multiple risers that will hopefully reduce lateral lengths and thereby distribution heat losses (and risk of overheating). WSP would recommend reducing lateral lengths as far as possible.
  - Why is the heat distribution network effectively doubled on the south-western edge of the scheme? i.e. there appear to be two sets of flow and return pipework in this area?
  - What allowance has been made in terms of network diameters to serve the additional sites (Bywaters / 9 Osier Way)?
- Heat pumps
  - It is not clear from the current drawings whether the areas shown incorporate enclosures, or whether these are only the heat pump units themselves. WSP would suggest that enclosures for each unit are required, both from a noise breakout perspective, and also for the containment and evacuation of refrigerant in the event of a leak.
  - If the heat pump is housed within and enclosure, the supply air may need to be ducted with suitable acoustic attenuation, unless the attenuation can be accommodated within the enclosure and air is drawn directly from the space. The current space provision does not look sufficient to accommodate the required vent/acoustic treatment.
  - What is the refrigerant proposed? (the drawings indicate ammonia).
  - As above – the strategy for the dispersion / evacuation of refrigerants in the event of a leak needs to be established. Achieving sufficient dispersal may be difficult to achieve if adjacent parts of the building extend to a higher level than the discharge point.

- The emergency extract system (including duty/standby extract fans) for removal of refrigerant may be quite large. There doesn't appear to be sufficient space to accommodate this within the layout shown. Ammonia scrubbers/absorbers can be used; however, these can be costly and would require additional plant space.
- Where will the heat pump heat recovering circuit and LTHW shunt pumps be located? Can these be accommodated within the footprint shown?
- What is the approach to design in terms of heat resilience – i.e. do the heat pumps contribute to 'resilient heat supply' alongside the boilers? If so, what is the assumption of their output during peak winter conditions and design outside air temperatures?
- The current designs shown three units, with two proposed for the first phase. Would it perhaps be possible to combine these first two units (e.g. provide a single unit at approx. 700kWth capacity) in order to deliver greater space efficiency (and at lower cost)?
- Will the roof mounted dry air coolers require acoustic treatment? Has this been considered when determining the required roof space?

- Electrical
  - Where are the electrical requirements to be housed? Incoming DNO supply / transformer / switchgear etc…
  - Have current designs included for the power requirements of the heat pumps?
  - What level of power supply resilience does the current proposal offer? If sharing equipment with the main building, who would be responsible for maintaining this equipment and ensuring the availability of heat can be maintained? Would sharing this equipment be acceptable to Metropolitan?
  - How would the PV be connected into the electrical distribution system? Would this be used to offset the energy centre parasitic loads only or would this be available for the landlord's supplies to the main building?

- Roof level / risers
  - Has allowance been made for connection to the dry-air coolers at roof level in terms of riser space?
  - Has allowance been made in risers for potential extract air from the heat pumps (see above related to leakage)
  - Has the potential conflict between PV area and the dry-air coolers been explored?
  - Has the potential interaction between the PV output and the CHP output been explored? i.e. if sufficient space and output fo PV panels can be accommodated, might this reduce the CHP capacity required (or potential remove need for it altogether? Perhaps in combination with larger thermal storage, and based on trying to maximise ASHP output during periods of solar PV generation?)

- Boilers
  - The current boiler selection appears partially to have been made on the basis of the space available. However, WSP would argue that (certainly within the agreed 750sq m that should be made available to the DHN plant) that the ESCo should select the most suitable type of boiler module available. The use of shell-and-tube boilers could be considered, for example.

- The peak capacity of the boilers needs to be considered in the context of the view of resilience of supply of the ASHPs as noted above.
- Where will the boiler shunt pumps be located? Space to rear of boilers looks limited.
- Is there a proposed disaster recovery plan to maintain the supply of heat in a failure scenario (e.g. loss of gas supply, works to network distribution pipework) such as spare connection points and planned location for temporary oil fired boiler plant?

- General
  - What is the slab to soffit height? Would this allow the construction of mezzanine levels if required to accommodate the plant?
  - What is the function of the substations at the top of the drawing (marked with 560kW and 210kW duty)? Are these for the block immediately above the plant room? Is there perhaps a schematic arrangement of supply that might clarify this?
  - Is it acceptable to house the gas meter room within the development itself? Does this need to be designed to be 'explosion -proof'?
  - How has the current selection of thermal storage capacity been derived?
  - How would the thermal stores be removed and replaced if required post construction of the building and fit-out of the other services?
  - Is there potential for recovery of waste heat from the cooling provision to the sports / health facilities?
  - Does the size of the pressurisation unit expansion vessels / spill tanks account for the future network volume?
  - Filtration and chemical dosing equipment not shown on layout
  - Control room not shown. Where will the BMS headend and server equipment be located?
  - Additional means of escape may be required based on the escape distances to external.
  - A number of roller shutter doors have been shown for plant replacement purposes. What with the acoustic performance be of the roller shutters? May be an issue with increased noise breakout from the main plant space to external.
  - Has the provision of welfare facilities been considered (WC, handwashing facilities etc)?

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TECHNO-ECONOMIC MODEL DEVELOPMENT

INTRODUCTION / FUNCTIONALITY

WSP has developed a techno-economic model (TEM) for the Central Cluster scheme, which has the following overall functionality:

- Provides LBWF with a flexible tool (within certain technical limits) to test the impact of the inclusion / exclusion, and change of phasing of Central Cluster scheme loads, and to assess the impact of the sensitivity of the scheme to other cash-flow inputs.
- The model is designed to reflect a single identified scheme solution that has been costed and where various technical parameters are fixed (network diameters, for example). However, the model also allows a user to test the impact of different capacities of plant on scheme performance.

The model has been designed to reflect the following structure, as advised by the commercial advisor to LBWF for the scheme:

- The model is designed to represent the perspective of an energy centre owner / operator (referred to as ESCO here).
- It is assumed that the ESCO would be responsible for all operation and maintenance costs associated with the energy centre.
- That Taylor Wimpey would provide the EC shell, and also fund the installation of plant to a level equivalent to the non-ESCo solution (i.e. a SCORE-only site scheme)
- The ESCo would therefore be responsible for funding the additional cost of plant for the wider-network to serve all developments in the Central Cluster, including additional EC plant and the district heating network pipework to link the SCORE site with the other developments
- The ESCO would then levy a ‘connection charge’ per dwelling for the Bywaters and Osier Way sites as they join the scheme (to offset the savings that these developments would make by not having to provide their own central plant).
- It is further assumed that the distribution networks required within development plots (e.g. within the boundary of Bywaters, for example) would be funded by the plot developers, and hence these capital costs are excluded from this model. I.e. it is assumed that the plot developers would be required to fund and install on-site networks to the specification required by the ESCO. The model allows for the on-going maintenance and replacement of these ‘adopted’ elements that are assumed to be taken over by the ESCo.
- It is assumed that, as for the on-plot distribution networks, that lateral, risers and domestic HIUs would be funded and installed by the plot developers but operated and maintained (and replaced at end of life) by the ESCo.

EXCLUSIONS

The model does not include a flexible hydraulic model of the distribution network. The pipe dimensions for the distribution system linking the major sites have been developed separately for the full build-out loads of the system. The model allows for the costing / inclusion of network elements when the load selection requires them (with associated cost implications), and includes a map so that users can see which elements of pipe are being used at what date in the project cycle.

INPUTS / TESTING

WSP has developed the model and tested outputs of the model with a number of plant selections that vary around the capacities and configuration of those illustrated in the earlier section of the report. The earlier selection was based on initial 'rule-of-thumb' sizing. This section illustrates the outputs from a more rigorous testing approach for potential selections.

The methodology for testing different plant selections and their suitability for meeting overall loads excludes all of the non-primary plant costs, on the basis that these non-primary plant costs would be equal across all options. This approach therefore is carried out on a comparative basis only, and is carried out with a view to the selection of a preferred option, which will then be further developed to reflect appropriate costs for this preferred option (shown later in this report).

On a comparative basis, the following combinations of plant have been tested:

Figure 17 - Plant configurations tested

OPTION	HS1	HS2
OPTION 1	CHP 230kWel	ASHP 1000 kW
OPTION 2	CHP 400 kWel	ASHP 1000 kW
OPTION 3	CHP 600 kWel	ASHP 1000 kW
OPTION 4	CHP 800 kWel	ASHP 1000 kW
OPTION 5	CHP 230kWel	ASHP 500 kW
OPTION 6	CHP 230kWel	ASHP 1500 kW
OPTION 7	CHP 230kWel	ASHP 2000 kW
OPTION 8	0	ASHP 1000 kW
OPTION 9	0	ASHP 1500 kW
OPTION 10	CHP 1.2 MWel	0
OPTION 11	ASHP 1000 kW	CHP 230kWel
OPTION 12	ASHP 1000 kW	CHP 400 kWel

This list illustrates variants both in terms of capacities, and also the priority order of the plant operation, where HS1 (Heat Source 1) is the primary source of heat, and HS2 is the secondary supply plant. It is assumed for all options that gas-fired boiler operate to meet any heat demand not met by either of HS1 or HS2.

The following results have been obtained:

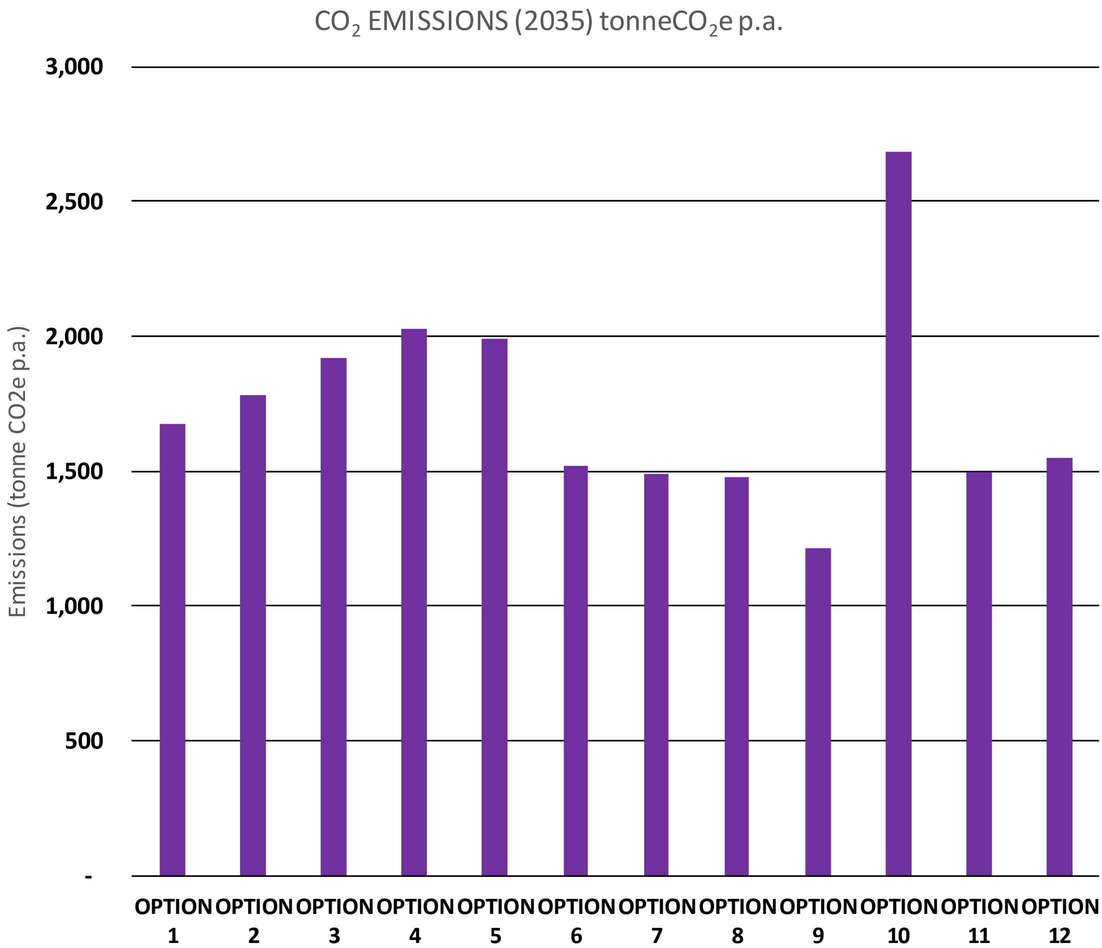
Figure 18 - Plant configuration testing results

OPTION	HS1	HS2	PRIVATE WIRE ON/OFF	TOTAL LOW CARBON SOURCE CAPACITY kW	% OF HEAT MET BY LOW CARBON SOURCE (2035)	ELECTRICITY DEMAND MET BY ELECTRICITY GENERATED	ELECTRICITY EXPORT AS PROPORTION OF TOTAL ELECTRICITY GENERATED %	ELECTRCITY EXPORT KWh	CO2 EMISSIONS (2035) tonne CO2	CARBON INTENSITY OF HEAT (2035) kgCO2/kWh	CAPEX	OPERATING MARGIN (2035)	NPV (25 YEARS, 6% DISCOUNT)
OPTION 1	CHP 230kWel	ASHP 1000 kW	0	1358	77%	58%	32%	518,221	1,677	0.20367	£ 1,799,324	£ 363,692	£ 4,859,106
OPTION 2	CHP 400 kWel	ASHP 1000 kW	0	1428	79%	95%	38%	1,045,031	1,782	0.21645	£ 2,164,992	£ 95,199	£ 4,668,138
OPTION 3	CHP 600 kWel	ASHP 1000 kW	0	1654	82%	96%	56%	1,996,692	1,919	0.23301	£ 2,200,450	£ 58,334	£ 4,537,508
OPTION 4	CHP 800 kWel	ASHP 1000 kW	0	1854	84%	95%	68%	2,879,296	2,027	0.24614	£ 2,267,701	-£ 2,812	£ 4,344,053
OPTION 5	CHP 230kWel	ASHP 500 kW	0	858	60%	96%	32%	582,093	1,992	0.24196	£ 1,460,324	£ 362,893	£ 5,399,026
OPTION 6	CHP 230kWel	ASHP 1500 kW	0	1858	86%	43%	42%	681,261	1,522	0.18479	£ 2,140,324	£ 358,028	£ 4,266,187
OPTION 7	CHP 230kWel	ASHP 2000 kW	0	2358	88%	36%	51%	841,989	1,488	0.18069	£ 2,479,324	£ 353,032	£ 3,719,221
OPTION 8	0	ASHP 1000 kW	0	1000	58%	0%	0%	-	1,480	0.17971	£ 1,609,324	£ 418,373	£ 3,785,122
OPTION 9	0	ASHP 1500 kW	0	1500	75%	0%	0%	-	1,211	0.14712	£ 1,950,324	£ 430,024	£ 3,421,232
OPTION 10	CHP 1.2 MWel	0	0	1191	71%	72%	97%	6,349,520	2,685	0.32607	£ 1,771,390	-£ 237,179	£ 4,043,993
OPTION 11	ASHP 1000 kW	CHP 230kWel	0	1358	76%	43%	2%	17,355	1,494	0.18148	£ 1,799,324	£ 351,047	£ 4,652,806
OPTION 12	ASHP 1000 kW	CHP 400 kWel	0	1428	77%	72%	3%	47,493	1,551	0.18832	£ 2,164,992	£ 91,809	£ 4,591,013

These results show a number of outputs, the key criteria of which are illustrated individually below, and the comparative (ranked) performance of the options is also shown below:

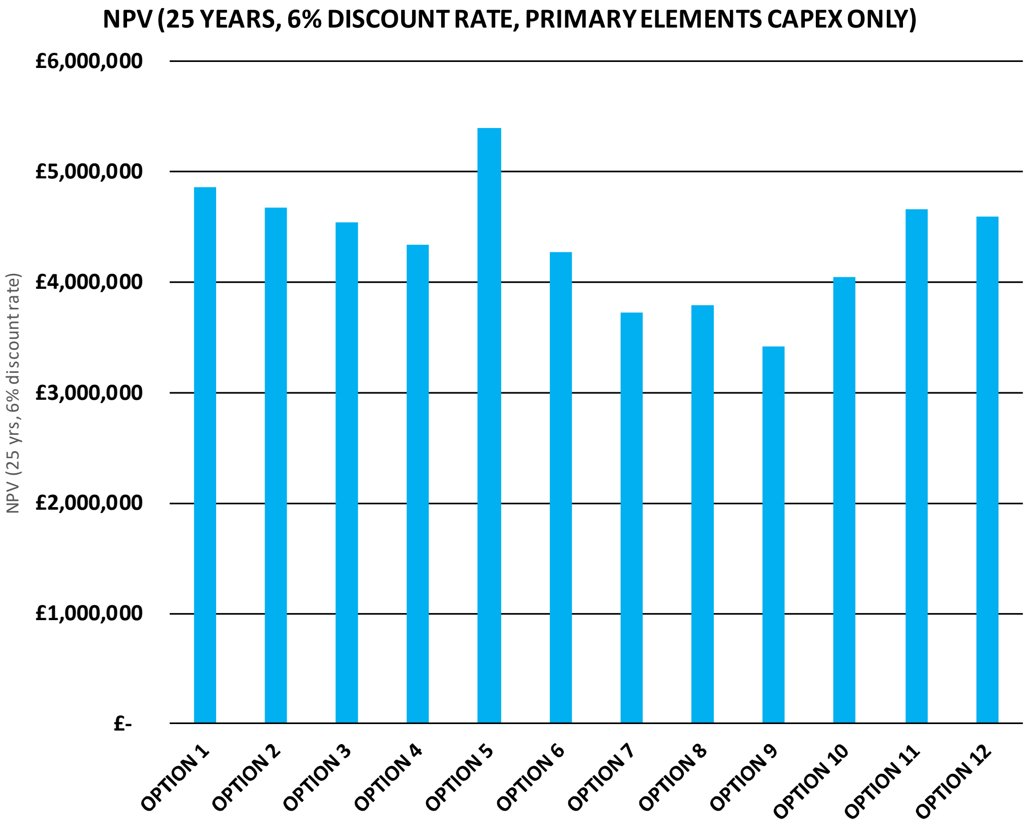
The two key criteria that are shown here in individual graphical format are NPV and carbon savings:

Figure 19 - Carbon emissions of options modelled (least is best)



The graph illustrates that the worst-performing option in terms of carbon emissions is Option 10 (CHP only). The best-performing option is Option 9 (Heat pump only).

Figure 20 - NPV analysis of options (highest is best)



In terms of NPV performance, the best options are Option 5 and Option 1 (combined heat pump / CHP solutions).

Configuration ranked performance:

For a number of metrics, the following ranking has been obtained from the outputs of analysis shown above. The figures within the table show the ranking position from amongst the options analysed – i.e. rank 1 indicates the option performs the best of the group of options selected.

It can be seen that no single option performs overwhelmingly best in all categories.

Figure 21 - Option ranking performance

	% OF HEAT MET BY LOW CARBON SOURCE (2035)	CO2 EMISSIONS (2035) tonneCO2	CARBON INTENSITY OF HEAT (2035) kgCO2/kWh	CAPEX	OPERATING MARGIN (2035)	NPV (25 YEARS)
OPTION 1	7	7	7	4	3	2
OPTION 2	5	8	8	8	8	3
OPTION 3	4	9	9	10	10	6
OPTION 4	3	11	11	11	11	7
OPTION 5	11	10	10	1	4	1
OPTION 6	2	5	5	7	5	8
OPTION 7	1	3	3	12	6	11
OPTION 8	12	2	2	2	2	10
OPTION 9	9	1	1	6	1	12
OPTION 10	10	12	12	3	12	9
OPTION 11	8	4	4	5	7	4
OPTION 12	6	6	6	9	9	5

This table has then further been analysed, by assigning a weighting to these rankings of performance. The weighting is based only on NPV (25 yrs - assumed to incorporate the capex and operating margin results), and carbon emissions (reflecting also the % heat met by low-carbon sources) on a 50% / 50% weighting basis. The overall results from this analysis show the following overall rankings[11]:

[11] For example – Option 7 has the following ranks – 3rd in CO2e emissions and 11th in NPV terms. Given the 50%/50% weighting between these categories, Option 7 therefore is given an overall weighted rank of 7 (50% * 3 + 50% * 11).

Figure 22 - Ranking preference of options

RANK	OPTION	TOTAL SCORE	HS1	HS2
1	OPTION 11	4	ASHP 1000 kW	CHP 230kWel
2	OPTION 1	4.5	CHP 230kWel	ASHP 1000 kW
3	OPTION 2	5.5	CHP 400 kWel	ASHP 1000 kW
4	OPTION 5	5.5	CHP 230kWel	ASHP 500 kW
5	OPTION 12	5.5	ASHP 1000 kW	CHP 400 kWel
6	OPTION 8	6	0	ASHP 1000 kW
7	OPTION 6	6.5	CHP 230kWel	ASHP 1500 kW
8	OPTION 9	6.5	0	ASHP 1500 kW
9	OPTION 7	7	CHP 230kWel	ASHP 2000 kW
10	OPTION 3	7.5	CHP 600 kWel	ASHP 1000 kW
11	OPTION 4	9	CHP 800 kWel	ASHP 1000 kW
12	OPTION 10	10.5	CHP 1.2 MWel	0

This table of overall preference shows that top two preferred options are Options 11 and 1, both of which are based on a 230kWe CHP and 1000kWth heat pump. This selection therefore remains the recommended solution for this scheme as currently configured. It is noted that:

- This work is analysing potential configurations for energy plant on the basis of estimated residential and non-domestic quanta. There is potential for error in either direction (i.e. under- or over-estimation of demands), and on the basis that this work is supporting a strategic approach that should remain flexible to respond to changes in quanta / demand, it is suggested that would be better to err on the side of caution in terms of plant selections.
- The step-changes of plant size represented by the top-ranked options are relatively coarse (e.g. the change from 1MWth to 500kWth heat pump), and with further refinement of loads and plant selections, it may emerge that a mid-point selection (e.g. approx. 750kWth) would in fact be the preferred solution. In order to ensure that sufficient space is allocated at this stage, adoption of the larger heat pump unit is suggested.

It is therefore suggested that on the basis of the modelling results presented here that the following approximate energy plant configuration is pursued initially for the expanded scheme:

Table 15 – Suggested plant selections for Central Cluster

	CAPACITY
Heat pump	1,000 kWth output
CHP (gas fired engine)	250 kWe output
Gas-fired boilers	4 no. 2.3MWth output
Thermal storage	75 cubic metres

CARBON EMISSIONS

The modelling results outlined above illustrate the calculated carbon savings that could be delivered by the various options plant selections analysed. The overall carbon intensity of heat has also been calculated, on the basis of the SAP10 carbon emissions factors[12] as replicated here:

Figure 23 - SAP10 carbon factors

Fuel	Standing charge, £ (a)	Unit price p/kWh	Emissions kg CO_{2e} per kWh (b)	Primary energy factor	Fuel code
Gas:					
mains gas	87	3.94	0.210	1.122	1
bulk LPG	69	6.47	0.241	1.163	2
bottled LPG		10.46	0.241	1.163	3
LPG subject to Special Condition 18 (c)	95	4.72	0.241	1.163	9
biogas (including anaerobic digestion)	70	8.15	0.024	1.286	7
Oil:					
heating oil		3.76	0.298	1.188	4
biodiesel from any biomass source (d)		7.10	0.038	1.437	71
biodiesel from vegetable oil only (e)		7.10	0.018	1.042	73
appliances able to use mineral oil or biodiesel		5.06	0.298	1.188	74
B30K (f)		5.67	0.220	1.263	75
bioethanol from any biomass source		47	0.105	1.472	76
Solid fuel: (g)					
house coal		4.15	0.395	1.101	11
anthracite		4.24	0.395	1.101	15
manufactured smokeless fuel		5.20	0.366	1.289	12
wood logs		4.65	0.028	1.046	20
wood pellets (in bags for secondary heating)		6.09	0.053	1.325	22
wood pellets (bulk supply for main heating)		5.51	0.053	1.325	23
wood chips		3.48	0.023	1.046	21
dual fuel appliance (mineral and wood)		4.52	0.092	1.056	10
Electricity: (a)					
standard tariff	72	16.55	0.233	1.738	30
7-hour tariff (high rate) (h)	8	19.47	0.233	1.738	32
7-hour tariff (low rate) (h)		7.60	0.233	1.738	31
10-hour tariff (high rate) (h)	7	17.98	0.233	1.738	34
10-hour tariff (low rate) (h)		10.27	0.233	1.738	33
18-hour tariff (high rate) (h)	11	15.04	0.233	1.738	38
18-hour tariff (low rate) (h)		10.2	0.233	1.738	40
24-hour heating tariff	31	9.83	0.233	1.738	35
electricity sold to grid		0 (i)	0.233	1.738	36
electricity displaced from grid			0.233	1.738	37
electricity exported to grid		3.8	0.233	1.738	37
electricity, any tariff (j)		-	0.233	1.738	39

[12] https://files.bregroup.com/SAP/SAP-10.0_24-07-2018.pdf, accessed 16th April 2019.

This analysis has adopted the following carbon factors throughout the project life-cycle:

Table 16 – Carbon emissions factors used in analysis

	Carbon emissions factor	Unit
Gas	0.210	kgCO2e/kWh
Electricity	0.233	kgCO2e/kWh

The total emissions for the various options analysed are shown above in Figure 19. WSP has also calculated the carbon intensity of heat delivered for the various options analysed, and compared this against various notional 'counterfactual' scenarios. The counterfactual scenarios illustrated here assume the generation of heat through gas boilers, and the main differences between the counterfactual scenarios is the notional location of the boilers, which reflect varying assumptions on heat distribution losses.

Table 17 – Counterfactual Emissions Scenarios

	Counterfactual Scenario 1	Counterfactual Scenario 2	Counterfactual Scenario 3
Assumed boiler location	Individual domestic boilers in flats, and in commercial premises	Base-of-block communal boilers	Single energy centre for whole site
Assumed distribution losses	0%	10%	20%
Commentary on distribution loss assumption	Heat generated at point of use – no distribution losses	Losses in distribution between plant room and end-users (e.g. risers and laterals)	Losses both in buried distribution mains, and also in distribution between base-of-block plant room and end-users (e.g. risers and laterals)

The following calculation illustrates notional carbon intensities for these counterfactual scenarios:

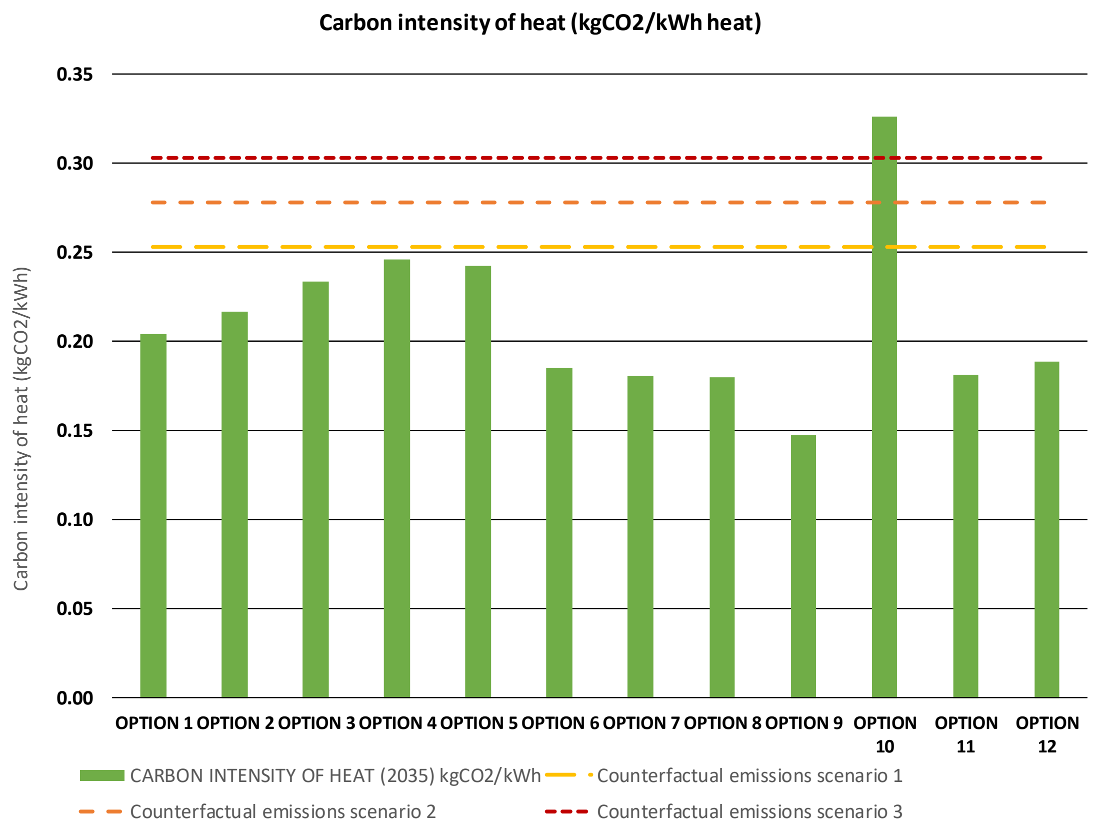
Table 18 – Counterfactual emissions scenarios carbon intensity of heat

	Counterfactual Scenario 1	Counterfactual Scenario 2	Counterfactual Scenario 3
Losses assumption	0	10%	20%
Boiler efficiency assumption	85%	85%	85%
Elec auxiliary consumption for boilers assumption	2%	2%	2%
To supply 1kWh of heat			
Heat required (not including losses) (kWh)	1	1	1

	Counterfactual Scenario 1	Counterfactual Scenario 2	Counterfactual Scenario 3
Heat required (taking losses into account) (kWh)	1	1.1	1.2
Gas required (kWh)	1.18	1.29	1.41
Elec required (kWh)	0.02	0.03	0.03
Gas emissions factor (kgCO2/kWh)	0.21	0.21	0.21
Elec emissions factor (kgCO2/kWh)	0.233	0.233	0.233
Gas emissions (kgCO2)	0.247	0.272	0.296
Elec emissions (kgCO2)	0.005	0.006	0.007
Total emissions to generate 1kWh heat	0.253	0.278	0.303

The following graph shows the calculated carbon intensity of heat of the options analysed, compared against these counterfactual emissions scenarios.

Figure 24 - Carbon intensity of heat comparison



This graph illustrates that the two preferred options (Options 11 and 1) both deliver a carbon intensity of heat that is lower than all of the counterfactual scenarios outlined here. This indicates that these options provide a carbon intensity of heat that will help developers to meet their carbon reduction obligations, and hence should be of interest to the SCORE, Bywaters and 9 Osier way sites. This is subject to confirmation of the factors and targets in place at the time of connection. The options that are shown to deliver greater carbon reductions (i.e. lower carbon intensities), are typically those that are based around greater proportions of Heat Pump operation.

CASHFLOW MODELLING OUTPUTS – PREFERRED OPTION

This section outlines the capital and whole life cost (WLC) estimates that have been generated through the population of the TEM developed for the Coronation Square Neighbourhood network Central Cluster scheme.

CAPITAL COST ESTIMATES

The following represents the capital cost assumptions made for the Central Cluster scheme:

Table 19 – Cost estimate by category of cost item

COST CATEGORY	COST (INCLUDING CONTINGENCY)
Energy Centre (Fit Out - LZC Plant)	£ 704,000
Energy Centre (Fit Out - Balance of Plant)	£ 2,986,500
Heat Distribution (Buried)	£ 590,600
Heat Distribution (Substations)	£ 396,000
Development Costs (PM + Professional Fees; FBC to Operation)	£ 1,079,000
Total	**£ 5,756,100**

This table represents the full cost of the Central Cluster scheme, and does not take into account the contribution that TW would be anticipated to make toward the cost of plant.

The TW funding contribution towards the overall scheme cost has been estimated on the basis of a reduced level of energy centre plant designed to serve the SCORE site only. This cost estimate has been compiled by considering the anticipated peak demands of the Central Cluster scheme and the SCORE site only, and applying an appropriate cost ratio to the costs estimated for the Central Cluster scheme. It has been assumed that for the SCORE-only scheme, in order to maintain compliance with Building Regulations and Planning, that a heat pump solution would be required under the SAP10 emissions factors assessment, and hence allowance has been made within this SCORE-only cost assessment for a heat pump installation.

In overall terms, the cost estimate for the SCORE-only scheme (and therefore the anticipated TW contribution to the scheme) is as follows:

Table 20 – Counterfactual scheme cost estimate summary

COST ELEMENT	COST
EC Mechanical Systems	£1,692,000
EC Electrical Systems	£1,072,000
Professional fees	£250,000
Total	£3,014,000

A more detailed breakdown of the cost estimate for the Central Cluster scheme make-up is contained within the appendices to this report.

KEY WHOLE LIFE COST MODELLING ASSUMPTIONS

The following summarises some of the key overall assumptions for the modelling carried out (NB please also see section above “Techno-economic development, introduction / functionality”).

- Heat sales prices have been based upon the Heat Trust figures (please see ‘Counterfactual comparison’ tab in TEM), and a 5% reduction has been applied to the unit cost element of these figures.
- Heat connection charges per residential unit have been assumed at £1,500 per residential unit[13], and based on £90/kW for non-domestic elements of developments
- There is very little electricity export modelled from the energy centre (~17MWh p.a.) and hence private wire electricity is excluded from the model
- The model has excluded RHI support for the heat pump on the basis of the uncertainty of the availability of the subsidy for the scheme given the timing of the development.
- Domestic billing and technical costs are based on £85 and £30 p.a. per dwelling respectively, and non-residential thermal substation billing and maintenance costs are based on £250 and £250 p.a. respectively.
- Adopted (secondary) networks (including both buried and above-ground elements) have been assumed to incur a maintenance cost for the operator of £15 per dwelling p.a.
- Gas and electricity prices have been derived from BEIS projections and Quarterly Energy Prices
    - Gas - based on QEP Table 3.4.1 (March 2019) (average of medium user, 2018 quarterly prices)
    - Electricity – based on BEIS price projections, Central / reference scenario, 2018 prices, Services sector
- Figures have been calculated on both an unindexed and indexed basis, where indexation has been applied to the utility cost streams only (e.g. gas and electricity prices), in line with BEIS projections.

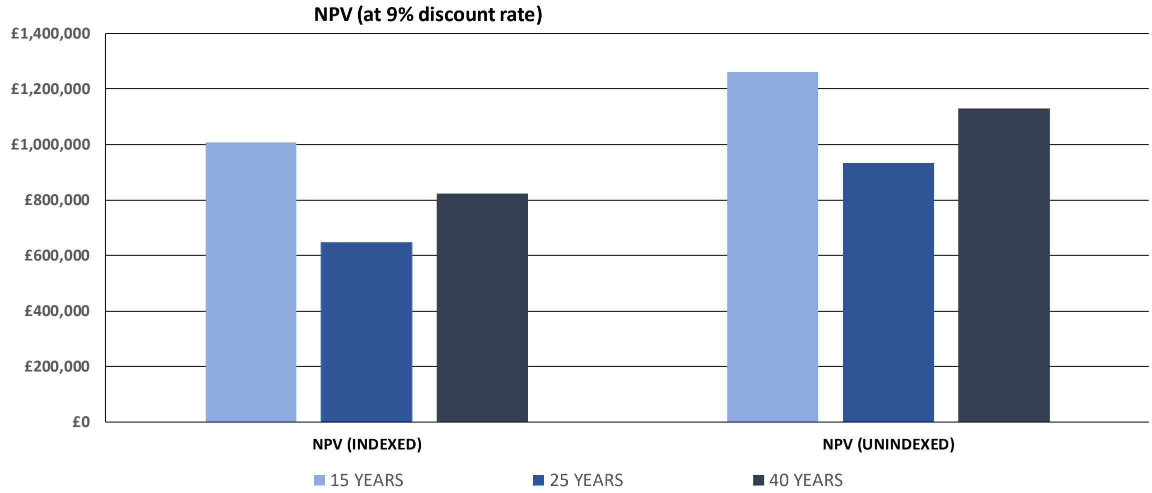
[13] Assuming that the connecting site developers install HIUs, risers, lateral and provide a DH substation plant room – the connection charge therefore represents a notional cost of avoided primary plant for the developer.

WHOLE LIFE COST OUTPUTS

The following outputs should be interpreted in conjunction with the TEM developed for the scheme, and the associated inputs for the project.

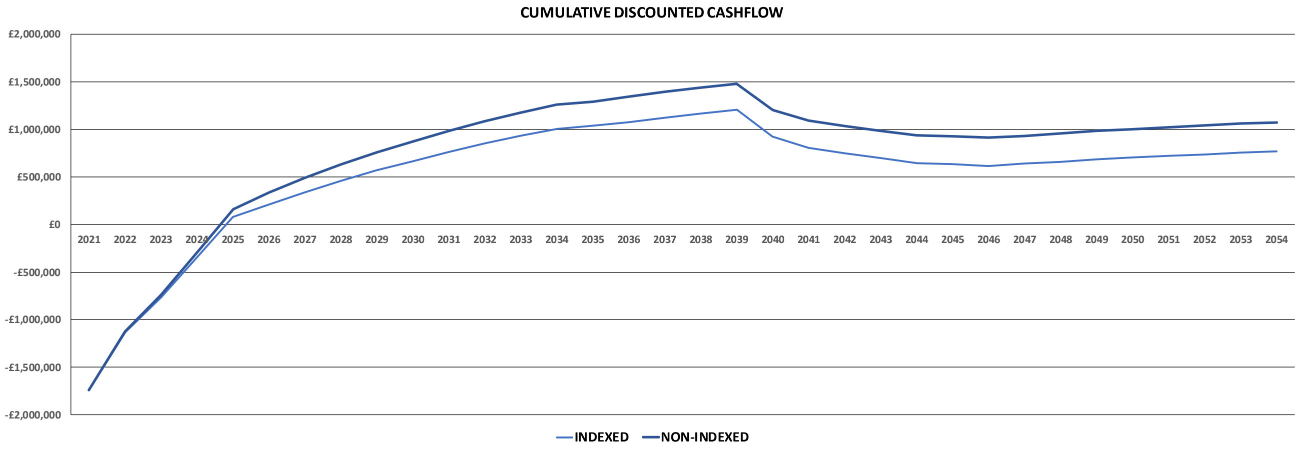
The key outputs from the scheme analysis are that when calculated on a whole life costs basis over 15, 25 and 40 years (unindexed, at a 9% discount rate), the scheme delivers positive values. These figures are shown below:

Figure 25 - Whole life cost analysis outputs



When illustrated on a discounted cumulative cashflow basis, the following overall chart is derived:

Figure 26 - Discounted cumulative cashflow (9% discount rate)



This figure shows that the scheme, in its initial operational phase, delivers very positive annual operating revenues (as shown by the upward gradient of the cashflow line). After the initial 20 years of operation the scheme is assumed to require a number of significant replacements, which then impact the overall scheme cashflow. However, after the initial tranche of replacements, it can be seen that even without RHI revenues, the scheme is modelled to operate with a positive operating margin.

ZERO-CARBON TRANSITION PLAN

The delivery of zero-carbon energy is an aspiration that is highlighted in the New London Plan that is currently undergoing Examination in Public.

A zero-carbon transition plan must take a long-term view of what mechanisms could contribute towards the overall UK target of reduction of emissions by 80% by 2050 – i.e. an approximately 30yr timescale. WSP would comment that there is no 'silver bullet' solution that WSP is aware of that will allow the delivery of zero carbon energy to the site. A zero-carbon solution would have to rely on a number of factors combining to reduce overall carbon emissions from the site.

On the assumption that the physical restrictions of the site prevent large-scale import of biofuels and the large-scale installation of solar and wind-based renewable technologies, then the transition to zero-carbon delivery of energy will have to be made at least partially via the 'traditional' utility delivery structure – the gas and electricity networks.

Energy efficiency measures, behavioural change, and potentially other demand side measures will all have a role to play in the progressive reduction of emissions related to the provision of warmth and power to the scheme, however, the major contributor towards decarbonisation in the medium to long term is likely to be the decarbonisation of both the power and gas grids.

A suggested transition path towards zero carbon for the CSN network could therefore consist of the following elements, but the degree to which these measures would allow zero-carbon to be achieved will very heavily depend upon the grid-based elements:

- Energy efficiency measures / demand reductions
  - Behavioural change – education / price signals to incentivise demand reduction / improved feedback mechanisms to encourage self-regulation of energy consumption
  - Low-flow hot water fittings (with the majority of flats in private ownership, the degree to which this is implemented will be linked to education and behavioural change above)
  - Higher efficiency appliances (as above – appliances will typically be selected by private owners, and efficiency will therefore depend on market regulation and consumer choice)
  - Fully LED lighting
  - The 'internet of things' leading to more efficient control of system to reduce overall consumption

  [NB - It is considered unlikely that improvements to building fabric would be viable and implementable over the notional 30yr timescale considered here.]

- Supply measures
  - Decarbonisation of gas grid

    Based on increased proportions of biogas and hydrogen in distribution (outside of the control of LBWF or site developers)
  - Decarbonisation of electricity grid

    Based on increased overall proportion of renewable generation (wind / solar / biomass) and reduction in fossil fuel contributions to generation mix. Potentially increased nuclear power generation and increased recovery of energy from waste streams via anaerobic digestion, energy from waste, sewage heat recovery etc (outside of the control of LBWF or site developers).

- Increased deployment of solar technology on the CSN site.
  Based on improved efficiency and economic performance of solar solutions leading to additional generation from solar technologies.

The potential increase in solar deployment on the site is the one area where it may be possible to future-proof the proposed designs for the CSN scheme. The allowance of suitable connection points (or space for them) within the electrical designs could facilitate future expansion of solar PV potential for the site, for example. It is conceivable that within the time horizon considered here, that solar PV manufacturing costs fall, and efficiencies increase to the extent that the viability of installations is greatly improved, and installation on facades and roof spaces becomes attractive. However, this is speculative, and it is suggested that at this stage it would only be appropriate to integrate very low-cost future proofing measures for this potential technological development.

PROJECT RISKS

WSP has prepared a risk register for the project, highlighting technical risks only (this does not attempt to capture political, regulatory, commercial or other risks, but rather attempts to focus on those areas that are predominantly linked to the technical elements of the scheme).

The full risk register is contained within the Appendices to this document, and provided separately in MSExcel format, so that LBWF can update and expand upon this register as the project progresses.

The top risks as identified post anticipated mitigation actions are listed here:

Table 21 – Top-rated risks

No.	Risk	Mitigation Action	Score (from max of 25) (post mitigation)
1	The pace of development means that the Energy Centre cannot be commissioned early enough to qualify for the RHI, leading to uncertainty surrounding technology solution.	Ensure sufficient space in Energy Centre to accommodate some flexibility in technology selection.	12
2	Architectural development locates energy centre in unsuitable location for flue routes / refrigerant purge / or too small an area to serve enlarged network	Work with project team to ensure that energy centre space is located in a suitable location	10
3	SCORE site resists requirement to allow appropriate space for enlarged energy centre	Continue to hold regular and open discussions on this requirement with the SCORE site Developer.	10
4	Affordability of supplied heating and hot water for new residents – including potential impacts on fuel poverty.	Develop 'terms' of engagement / delivery for ESCos working on the project, if possible	9
5	No ESCo involvement to take the scheme forward (as LBWF do not want to become an ESCo) and therefore delivery mechanism for wider scheme is unclear	A sufficiently heat-dense, suitably located scheme should attract ESCos. Key mitigating actions are therefore to ensure suitability of EC space and customer base.	8
6	Demand sites (Bywaters and 9 Osier Way) propose not to connect to DEN	Ensure that heat can be delivered at an attractive price and carbon content. Ensure planning obligations are imposed and enforced.	8

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This report has been compiled at a stage when the developer (Taylor Wimpey) of the SCORE site is still in the process of changing their outline architectural designs for the development. WSP has assisted in delivering a review of early stage designs for a SAP10 emissions factor solution that were produced by Metropolitan (working on behalf of Taylor Wimpey). However, it is now understood that Taylor Wimpey will be submitting a design based on SAP2012 emission factors, and hence it is anticipated that a different solution will be proposed, and hence a further stage of review is expected to be required.

The initial review of the proposed SAP10 energy centre raised a number of key issues including:

- The location of the energy centre appeared unsuitable for flues
- The general space allowance for plant appeared inadequate for suitable access, ventilation, noise attenuation and welfare of operatives
- The space allocation appeared to be insufficient when compared with the Developer Agreement requirement for an area of 750 sq m
- There did not appear to be clarity on the demarcation between the ESCo plant and the plant serving retained assets for the site (e.g. electrical infrastructure)
- There needs to be further work carried out to establish the noise criteria under which roof plant and acoustic attenuation will need to be designed

WSP has developed a notional energy centre layout that it considers suitable for the provision of energy to the Central Cluster customer base. This shows an area larger than the 750sq m required by the Developer Agreement, but different plant selections may impact this area, as will the architectural shape of the EC shell that is available to the ESCo.

WSP has developed a techno-economic model for the site that reflects costs from an ESCo perspective. This model assumes that the energy centre shell will be provided to the ESCo by Tayor Wimpey and that TW would also fund the ESCO's installation to the level of cost that TW would have borne under a SCORE-site only solution, and that the plant for the supply of energy to the enlarged scheme will be delivered by the ESCo. The following table shows some of the key metrics associated with this:

Table 22 – Key plant attributes

	CAPACITY
Heat pump	1,000 kWth output
CHP (gas fired engine)	250 kWe output
Gas-fired boilers	4 no. 2.3MWth output
Thermal storage	75 cubic metres

The following table shows some of the key WLC model inputs / outputs:

Table 23 – Key whole life cost model inputs / outputs

	FIGURE	UNIT
Estimated capital cost	£5,756	£,000
NPV (40yrs, 9% discount rate)	£1,131	£,000
Carbon intensity of heat (full build-out)	0.181	$kgCO_{2e}$ / kWh heat

This table illustrates that the notional solution that WSP has developed appears to deliver a positive whole life cost, and low-carbon heat over the project life based on the assumptions contained within the TEM. These assumptions may differ from those of an appointed ESCo for the project, and hence this can only be indicative at this stage. However, WSP believes that they demonstrate that the development of a scheme to serve the Central Cluster by an ESCo would be viable on the basis set out in this report, as corroborated by the paper prepared by Metropolitan which was shared by TWEL.

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Recommendations and next steps

LBWF does not wish to become an ESCo, and is seeking to allow the private sector to deliver the energy provision to the area. This naturally leads to a reduction in control in comparison with a delivery mechanism where LBWF actively were involved in the scheme delivery. The key challenge for LBWF is therefore to establish a suitable framework within which an acceptable scheme is delivered.

WSP would suggest that the planning system is be the key mechanism through which LBWF can ensure an acceptable solution is delivered by the development partners of the Central Cluster scheme. The following actions are recommended:

- Continue to liaise closely with Taylor Wimpey (and their selected ESCo partner) to develop an energy centre and heat distribution network that is acceptable to LBWF to serve buildings in the Central Cluster. This is anticipated to involve technical design meetings as well as strategic discussions.
    - It would be beneficial, for LBWF to have visibility or even influence over the TW procurement of an ESCo, so that LBWF can have confidence that the basis of this procurement is in line with the principles that LBWF expects for the wider development area.
- Continue to require from Taylor Wimpey an area of at least 750sq m for the provision of the district heating energy centre, with suitable flue routes and for access for plant delivery / maintenance.
- Ensure that whichever ESCo partner is appointed by Taylor Wimpey they have provided a clear strategy for the delivery of cost-competitive, low-carbon heat to all consumers in the Central Cluster. This must take into account the imminent ending of the RHI subsidy for heat pumps. This strategy must consider how to deliver a suitable carbon intensity of heat, such

that the overall solution for the SCORE site (and wider network) meets planning and Building Regulation requirements, and also incentivises other sites to connect to the network.

- Ensure via Planning Conditions that LBWF has the power to review and approve / amend submitted designs at detailed planning stages, such that LBWF can ensure appropriate compatibility with the technical solutions envisaged.
- Taylor Wimpey are seeking support from LBWF for a SAP2012 solution. However, it is understood that GLA would only support a CHP-based solution if it can be demonstrated that the scheme is 'strategically significant'. It is understood that the following would be required for this:
    - Demonstrate the importance of the scheme in the local and regional context
    - Demonstrate how the initial scheme can be delivered and that the commercial structure is also in place to ensure the development and expansion from the Central Cluster into the strategic-scale project
    - Demonstrate that there is a clear plan to decarbonise the heat supply in the future which is being committed to by key stakeholders.

The next steps for the project for LBWF are therefore:

- Await redesign of the energy centre space from the Taylor Wimpey team, including:
    - Flue strategy – demonstrating how the location of the EC is suitable for the proposed and future plant, given the heights of adjacent blocks
    - Noise assessment – demonstrating how the proximity of potential receptors both at roof level and near ground level have been factored into the EC designs
    - Access and maintenance strategies – demonstrating that there is sufficient space for the safe and efficient upkeep of plant
    - Overall EC design reflecting the above
- Provide technical and architectural feedback on these designs when available
- Continue to liaise with TW and their appointed ESCo on the commercial form of the agreement for the delivery of energy to the SCORE site and the Central Cluster scheme , including the strategic context and potential decarbonisation in the future
- Continue to reinforce planning mechanisms to encourage inter-connection of the neighbouring sites
    - London Heat Map
    - Planning Policy
- Continue to engage with the relevant developers of the key sites at Bywaters and 9 Osier Way to:
    - Ensure that these sites are aware of the expectation of connection in line with planning policy

Appendix A

RISK REGISTER

RISK REGISTER

LBWF - Coronation Square Technical Risk Assessment (DEN)

Risks for LBWF and Scheme operator considered

			Pre mitigation score				Post mitigation score		
			Potential impact (A)	Likelihood of occurrence	Gross risk severity (unmitigated)		Potential impact (A)	Likelihood of occurrence	Net risk severity (post mitigation)
	Risk category	Risk description	1 = minor impact, 5 = show stopper	1 = very unlikely, 5 = extremely likely	Grid 1 matrix	Potential mitigation	1 = minor impact, 5 = show stopper	1 = very unlikely, 5 = extremely likely	Grid 1 matrix
1	Technical / infrastructure	Demand sites (Bywaters and 9 Osier Way) propose not to connect to DEN	4	3	Severe	Ensure that heat can be delivered at an attractive price and carbon content. Ensure planning obligations are enforced.	4	2	Significant
2	Technical / infrastructure	SCORE site resists requirement to allow appropriate space for enlarged energy centre	5	3	Severe	Continue to hold regular and open discussions on this requirement with the SCORE site Developer.	5	2	Significant
3	Technical / infrastructure	Access to plant room area is limited to one façade	3	3	Significant	Work with project team to ensure that energy centre designs are sufficiently flexible to allow access from both possible facades	2	3	Significant
4	Technical / infrastructure	Architectural development locates energy centre in unsuitable location for flue routes / refrigerant purge / or too small an area to serve enlarged network	5	3	Severe	Work with project team to ensure that energy centre space is located in a suitable location	5	2	Significant
5	Technical / infrastructure	Competing heat supply options from other district heating networks make connection to the SCORE site unattractive	5	1	Significant	Ensure that heat can be delivered at an attractive price and carbon content. Ensure planning obligations are enforced.	5	1	Significant
6	Technical / infrastructure	Road congestion as a result of installation works.	3	3	Significant	Ensure early liaison with highways authorities to mitigate potential effects and allow for alternative routes to be planned	2	2	Minor
7	Technical / infrastructure	Damage caused to other utilities during DH network installation.	4	3	Severe	Ensure that the location of services is known, using desk surveys, and ground penetrating radar where necessary to obtain more information. Use hand dig in areas of uncertainty, or in sensitive areas (e.g. near to HP/IP gas mains)	3	1	Minor
8	Technical / infrastructure	Will the levels of carbon reduction be sufficient for developers to be interested in the scheme as a means of meeting their carbon reduction targets? (i.e. developers will not connect if carbon savings are not high enough)	4	1	Significant	Connection to a DH network is one approach of many which developers can use to reduce development carbon emissions. New developments are required by the London plan to connect to a DH network if one is present, or if not to implement a site-wide network. The presence of a DH network in the borough should be seen as a positive by developers, who thus do not need to build an energy centre on their site. Competitive cost of heat will also encourage developers to connect	4	1	Significant
9	Technical / infrastructure	Heat losses on the network are overly high.	3	2	Significant	Specify Type 2 or 3 insulation, and carry out inspections during installation to ensure that suitable insulation around valves etc. is correctly put in place. Discuss riser positioning and shortening laterals with architectural team if possible.	2	1	Minor
10	Technical / infrastructure	Inability to find a suitable location for top-up energy centre plant.	4	3	Severe	Work with SCORE site developers to ensure that adequate space is allocated in development. Potential to adopt a model of distributed boilers (rather than central boiler plant), which would significantly reduce the space required for the central plant room.	3	2	Significant
11	Commercial	Consumers unwilling to connect to the network.	4	3	Severe	Provide a competitive heat price to customers, and heat with a low carbon intensity.	4	1	Significant
12	Technical / infrastructure	Impact of Medium Combustion Plant Directive on distributed boiler plant.	1	1	Insignificant	The element of this for plant under 5MW comes into force in 2027, and thus will only affect later stages of the project. New plant can be procured with impact of directive in mind.	1	1	Insignificant
13	Technical / infrastructure	Failure of Heat pumps / other primary plant	3	2	Significant	Heat provided by back-up boilers installed within primary energy centre or satellite boiler rooms, therefore the impact will only be on energy centre operator. Responsibility of ESCO.	3	2	Significant
14	Technical / infrastructure	Heat demands turn out to be higher in reality than the values used within modelling	2	2	Minor	If heat demand does turn out to be larger than expected load management could be used to spread peaks, and additional heat sales may benefit the commercial performance of the plant.	1	2	Minor
15	Technical / infrastructure	Heat demands turn out to be lower in reality than the values used within modelling	3	3	Significant	As above. If demands are lower than expected, this increases the potential for the network to be extended to serve additional loads. Mitigation would be to actively identify and engage with new potential customers to bring heat load up to level that delivers commercially viable scheme.	2	3	Significant
16	Technical / infrastructure	Cost of gas rises at a greater rate than predicted within modelling	3	2	Significant	All heat sales values are based upon gas prices and indexed in relation to them. The price of gas therefore will have little impact on the feasibility of the schemes. A large portion of electrical generation in the UK is also linked to gas, and hence the spark spread should also remain relatively stable. This is beyond the power of	2	2	Minor
17	Technical / infrastructure	Cost of grid electricity rises more swiftly than predicted	2	2	Minor	Increasing cost of electricity will have a positive effect on the performance of CHP within the EC as it makes generating electricity more attractive. Increasing electricity costs will negatively impact heat pump operation, hence mitigation is the transfer as much heat generation to CHP as possible.	1	2	Minor
18	Technical / infrastructure	Actual boiler efficiencies are lower than those used in modelling, resulting in higher cost of heat generation	2	2	Minor	Measure efficiencies to ensure figures are empirically tested, and apply as project progresses to models used in later stages of project development.	2	2	Minor
19	Technical / infrastructure	Tendered costs are higher than those accounted for in feasibility / masterplan work	3	3	Significant	Ensure that contingency is included in project development / budgets as work moves forward, and that competitive tendering process is used.	3	2	Significant
20	Technical / infrastructure	Failure to obtain planning permission	4	2	Significant	Ensure that schemes meet with planning guidance and minimise impact on the surrounding area and residents	4	1	Significant

21	Commercial	Life cycle costs are greater than expected, for example replacement and maintenance	3	2	Significant	Continue to update financial model as more detailed design stages are progressed, and cost details are confirmed	3	1	Minor
22	Technical / infrastructure	Non-cooperation of stakeholders in connecting to scheme	3	2	Significant	Ensure effective communication/liaison with customers and that benefits of the scheme are clearly defined and communicated.	3	1	Minor
23	Technical / infrastructure	Difficulties in achieving legal agreement between implementation parties delays project implemention	2	3	Significant	Open process of developing agreement early and allow sufficient time in programme	2	2	Minor
24	Economic	Network operator goes bankrupt after before or during operation	3	2	Significant	A sufficiently profitable scheme will be taken on both another party	2	1	Minor
25	Technical / infrastructure	The capex used in concept stages is not sufficient to deliver schemes	4	2	Significant	It must be acknolwedged that costs can move in both directions from initial estimates made during feasibility stages. Detailed design will develop greater cost certainty.	3	2	Significant
26	Technical / infrastructure	The pace of development means that the Energy Centre cannot be commissioned early enough to qualify for the RHI, leading to uncertainty surrounding technology solution.	4	3	Severe	Ensure sufficient space in Energy Centre to accommodate some flexibility in technology selection.	4	3	Severe
27	Procurement	Government incentives / subsidies mean that an alternative technology is preferred	1	2	Minor	It is hoped that Government subsidies will support those technologies that need assistance. The scheme should remain flexible as far as possible in its selection of technologies and space allocation for plant. Generation technologies are to some	2	1	Minor
28	Technical / infrastructure	Indexation/ cost changes over project lifespan	2	2	Minor	Examine sensitivity of scheme to utility price movements at feasbility stage and use this to inform investment decision.	1	2	Minor
29	Technical / infrastructure	Market driven heat sales price may not be sufficient to cover costs	4	2	Significant	Utility price sensitivity should inform risks around this aspect of the project.	3	2	Significant
30	Technical / infrastructure	Overspend on capital during delivery stage	3	2	Significant	Build in contingency to business models, ensure that costs are based on relevant recent experience and reputable sources	2	2	Minor
31	Technical / infrastructure	Poor level of service from DE operator	2	2	Minor	Ensure service level agreements are in place and monitored / enforced	2	1	Minor
32	Technical / infrastructure	Private sector partner priorities may conflict with public sector vision	2	2	Minor	Set out expectations and limits and try to maintain involvement in all stages of project	2	2	Minor
33	Technical / infrastructure	Poor operational management results in reduced CO_2 reduction potential	3	2	Significant	Ensure key performance indicators are in place and monitored / enforced	2	1	Minor
34	Technical / infrastructure	Burden of contract negotiation may have significant costs that outweigh some of the benefits	3	3	Significant	Keep contractual arrangements simple and transparent. Standardise service level agreements with assistance of public sector bodies	2	2	Minor
35	Technical / infrastructure	Contract risks being overcomplicated and difficult to administer	3	2	Significant	Keep contractual arrangements simple and transparent. Standardise service level agreements with assistance of public sector bodies	2	2	Minor
36	Technical / infrastructure	Regulatory change (particularly in terms of heat sales market)	2	2	Minor	Regulation of market will protect consumers - if scheme is technically and commercially sound this will not present undue risk	2	1	Minor
37	Technical / infrastructure	Air quality issues from energy centre combustion equipment (centralised top-up plant options)	3	3	Significant	Engage with the Environment Agency to establish acceptable emissions levels and ensure that scheme designs fall within these limits	2	1	Minor
38	Technical / infrastructure	Development thermal demand is significantly different from than that assumed	2	3	Significant	Adjust designs / scheme concept in response to this trend emerging in early development. Remain flexible in design.	2	2	Minor
39	Political / regulatory / social	Gas and electricity contracts for the energy centre are not negotiated at the same time, leading to a sub-optimal spark spread	3	3	Significant	Negotiate contracts in parallel and seek to match high electricity tariffs to potential CHP operational periods	2	2	Minor
40	Technical / infrastructure	Utility market energy price shifts decrease the 'spark spread', and CHP viability decreases	4	2	Significant	Conduct sensitivity analysis at design stages to evaluate these risks	3	2	Significant
41	Technical / infrastructure	No ESCo involvement to take the scheme forward (as LBWF do not want to become an ESCo) and therefore delivery mechanism for wider scheme is unclear	4	3	Severe	A sufficiently heat-dense, suitably located scheme should attract ESCos. Key mitigating actions are therefore to ensure suitability of EC space and customer base.	4	2	Significant
42	Technical / infrastructure	Changes in GLA Energy Assessment Guidance affecting the acceptability of DE networks	3	2	Significant	New London Plan indicates continued support for decentralised energy	3	2	Significant
43	Technical / infrastructure	Affordability of supplied heating and hot water for new residents – including potential impacts on fuel poverty.	3	3	Significant	Develop 'terms' of engagement / delivery for ESCos working on the project, if possible	3	3	Significant
44	Technical / infrastructure	Risk that scheme might not qualify for BEIS HNIP project funding	2	3	Significant	Develop scheme in way that makes receipt of grant funding more likely or not required	1	2	Minor

Appendix B

COST ESTIMATES

CAPEX ITEMS	CATEGORY	COST EXCLUDING CONTINGENCY	CONTINGENCY	SOURCE NOTES	COST INCLUDING CONTINGENCY
PRIME MOVERS					
Prime mover no. 1 (heat pump)	Energy Centre (Fit Out - LZC Plant)	£500,000	10%	As per plant database entries	£550,000
Prime mover no. 2 (CHP)	Energy Centre (Fit Out - LZC Plant)	£140,000	10%	As per plant database entries	£154,000
EC MECHANICAL SYSTEMS					
Heat pump (ancillary elements (dry air coolers, interconnecting pipework), pumps)	Energy Centre (Fit Out - Balance of Plant)	£200,000	10%	Interpolated from recent project tender quotes to suit size. Cost includes allowance for dry air coolers and pipework and pumps between basement and roof level	£220,000
Heat pump LTHW shunt pump	Energy Centre (Fit Out - Balance of Plant)	£5,000	10%	Estimate	£5,500
SCR kit	Energy Centre (Fit Out - Balance of Plant)	£50,000	10%	Interpolated from recent project tender quotes to suit size	£55,000
Boiler and CHP flues (within plant room)	Energy Centre (Fit Out - Balance of Plant)	£20,000	10%	Interpolated from recent project tender quotes to suit size	£22,000
Boiler flue attenuators	Energy Centre (Fit Out - Balance of Plant)	£0	10%	Estimate	£0
Vertical flue runs (inc CHP flue)	Energy Centre (Fit Out - Balance of Plant)	£168,000	10%	Estimate - service shaft and support positions by others	£184,800
DH Distribution pumps - Main	Energy Centre (Fit Out - Balance of Plant)	£32,000	10%	Interpolated from recent project tender quotes to suit size	£35,200
Boiler LTHW shunt pumps	Energy Centre (Fit Out - Balance of Plant)	£20,000	10%	Estimate	£22,000
Variable temperature blending pumps	Energy Centre (Fit Out - Balance of Plant)	£10,000	10%	Estimate	£11,000
Thermal storage	Energy Centre (Fit Out - Balance of Plant)	£90,000	10%	1k£ per meter cubed (75m3) split across 3 vessels	£99,000
Pressurisation & Expansion Plant	Energy Centre (Fit Out - Balance of Plant)	£45,000	10%	Interpolated from recent project tender quotes to suit size	£49,500
Sidestream filter	Energy Centre (Fit Out - Balance of Plant)	£10,000	10%	Interpolated from recent project tender quotes to suit size	£11,000
Vacuum Degasser	Energy Centre (Fit Out - Balance of Plant)	£5,000	10%	Interpolated from recent project tender quotes to suit size	£5,500
Chemical dosing pump and enclosure	Energy Centre (Fit Out - Balance of Plant)	£5,000	10%	Estimate	£5,500

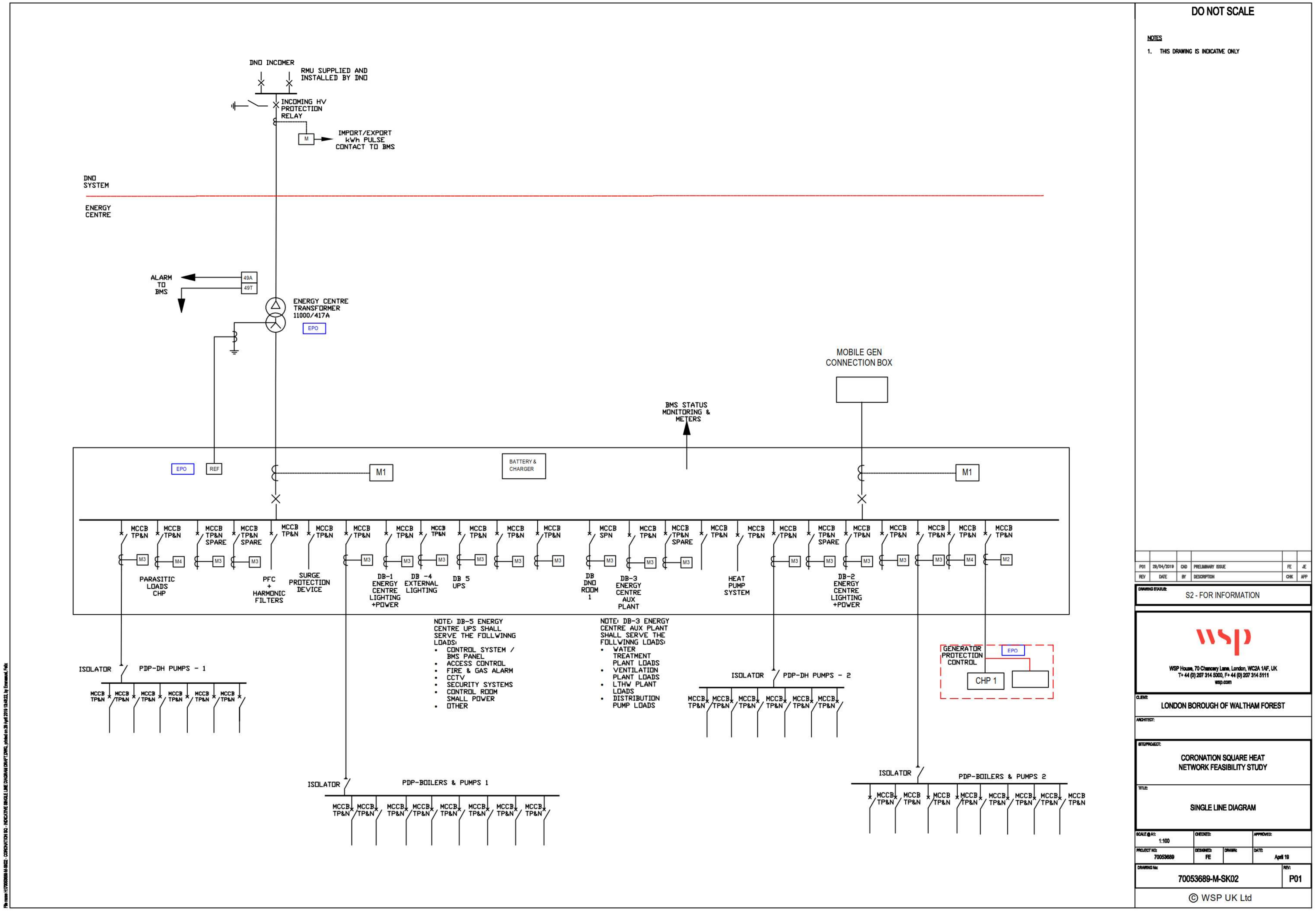
CAPEX ITEMS	CATEGORY	COST EXCLUDING CONTINGENCY	CONTINGENCY	SOURCE NOTES	COST INCLUDING CONTINGENCY
Cold water break tank and booster set	Energy Centre (Fit Out - Balance of Plant)	£7,000	10%	Estimate	£7,700
Water softener	Energy Centre (Fit Out - Balance of Plant)	£10,000	10%	May not be required if backup storage not required / mains pressure sufficient	£11,000
Urea Storage Tank	Energy Centre (Fit Out - Balance of Plant)	£4,000	10%	Interpolated from recent project tender quotes to suit size	£4,400
Heat Pump Plantroom Extract System	Energy Centre (Fit Out - Balance of Plant)	£75,000	10%	Estimate	£82,500
Ammonia Scrubber/Absorber	Energy Centre (Fit Out - Balance of Plant)	£0	10%	Subject to ammonia dispersion assessment	£0
Ammonia Plume Dispersion Study	Energy Centre (Fit Out - Balance of Plant)	£5,000	10%	WSP Fee Estimate - needs to be undertaken during commercialisation	£5,500
Ammonia Leak Detection System	Energy Centre (Fit Out - Balance of Plant)	£0	10%	Included in extract system	£0
Toilet Extract System	Energy Centre (Fit Out - Balance of Plant)	£0	10%	Assumed provided under shell and core arrangement	£0
Welfare Sanitary Systems	Energy Centre (Fit Out - Balance of Plant)	£0	10%	Assumed provided under shell and core arrangement	£0
Welfare ventilation system	Energy Centre (Fit Out - Balance of Plant)	£0	10%	Assumed provided under shell and core arrangement	£0
Attenuators for main plant areas (Natural Ventilation)	Energy Centre (Fit Out - Balance of Plant)	£32,000	10%	Estimate. Subject to final acoustic assessment	£35,200
Condensate / above ground drainage pipework & ancillaries	Energy Centre (Fit Out - Balance of Plant)	£5,000	10%	Interpolated from recent project tender quotes to suit size	£5,500
Safety valve catchment pots	Energy Centre (Fit Out - Balance of Plant)	£8,000	10%	Estimate	£8,800
LTHW Pipework & Ancillaries	Energy Centre (Fit Out - Balance of Plant)	£300,000	10%	Interpolated from recent project tender quotes to suit size	£330,000
Gas Pipework & Ancillaries (including incoming metering only at low pressure)	Energy Centre (Fit Out - Balance of Plant)	£65,000	10%	Assumes regulation enclosure provided by others - Interpolated from recent project tender quotes to suit size - risk for medium pressure enclosure should regulation need to be carried out within plant area	£71,500
Cold Water Services Pipework & Ancillaries	Energy Centre (Fit Out - Balance of Plant)	£15,000	10%	Interpolated from recent project tender quotes to suit size	£16,500
Below Ground Drainage (foul and surface water)	Energy Centre (Fit Out - Balance of Plant)	£0	10%	Assume provided by others as part of overall utility provision	£0
Incoming Gas main	Energy Centre (Construction - Utilties)	£0	0%	Assume provided by others as part of overall utility provision	£0

CAPEX ITEMS	CATEGORY	COST EXCLUDING CONTINGENCY	CONTINGENCY	SOURCE NOTES	COST INCLUDING CONTINGENCY
Incoming Water Main	Energy Centre (Construction - Utilties)	£0	0%	Assume provided by others as part of overall utility provision	£0
Incoming Drainage Main	Energy Centre (Construction - Utilties)	£0	0%	Assume provided by others as part of overall utility provision	£0
Services Structural Support Systems	Energy Centre (Fit Out - Balance of Plant)	£60,000	10%	Interpolated from recent project tender quotes to suit size	£66,000
Testing and Commissioning	Energy Centre (Fit Out - Balance of Plant)	£100,000	10%	Interpolated from recent project tender quotes to suit size	£110,000
Thermal store	Energy Centre (Fit Out - Balance of Plant)	£75,000	10%	Based on approximate cost per cubic metre	£82,500
EC ELECTRICAL SYSTEMS					
UKPN Substation & DNO Connection	Energy Centre (Fit Out - Balance of Plant)	£0	10%	Assume cost borne by the developer	£0
HV Cables/Containment	Energy Centre (Fit Out - Balance of Plant)	£15,000	10%	Assumed Tx room and DNO intake room will be adjacent to each other. Estimate based on similar size projects/quotes	£16,500
Transformer	Energy Centre (Fit Out - Balance of Plant)	£50,000	10%	Estimate based on similar size projects/quotes	£55,000
LV Switchboard	Energy Centre (Fit Out - Balance of Plant)	£75,000	10%	Estimate based on similar size projects/quotes	£82,500
LV Cables/DBs/PDPs/Containment	Energy Centre (Fit Out - Balance of Plant)	£225,000	10%	Estimate based on similar size projects/quotes	£247,500
UPS for plant control equipment only	Energy Centre (Fit Out - Balance of Plant)	£15,000	10%	Interpolated from recent project tender quotes to suit size	£16,500
Fire & Gas Detection System	Energy Centre (Fit Out - Balance of Plant)	£40,000	10%	Interpolated from recent project tender quotes to suit size	£44,000
Lighting & Small Power, minor plant aux.	Energy Centre (Fit Out - Balance of Plant)	£50,000	10%	Interpolated from recent project tender quotes to suit size	£55,000
Earthing	Energy Centre (Fit Out - Balance of Plant)	£15,000	10%	Interpolated from recent project tender quotes to suit size	£16,500
BMS	Energy Centre (Fit Out - Balance of Plant)	£300,000	10%	Estimate based on similar sites/projects	£330,000
Energy Metering/status monitoring	Energy Centre (Fit Out - Balance of Plant)	£35,000	10%	Interpolated from recent project tender quotes to suit size	£38,500
Security /CCTV/Access control	Energy Centre (Fit Out - Balance of Plant)	£25,000	10%	Interpolated from recent project tender quotes to suit size	£27,500

CAPEX ITEMS	CATEGORY	COST EXCLUDING CONTINGENCY	CONTINGENCY	SOURCE NOTES	COST INCLUDING CONTINGENCY
Telecomms /data	Energy Centre (Fit Out - Balance of Plant)	£10,000	10%	Interpolated from recent project tender quotes to suit size	£11,000
Metering hub (Residential)	Energy Centre (Fit Out - Balance of Plant)	£225,000	10%	Residential hub for monitoring, assumes developer provides HIU meters and communication links to fibre	£247,500
Electrical Testing and Commissioning including CHP and HPs	Energy Centre (Fit Out - Balance of Plant)	£30,000	10%	Estimate based on similar sites/projects	£33,000
NETWORK AND SUBSTATIONS					
DH NETWORK 2022	Heat Distribution (Buried)	£489,424	0%	Based on rates as per Inputs sheet and build-out as per network model	£489,400
Substation minor - new buildings	Heat Distribution (Substations)	£60,000	10%	1 off connection (9 Osier Way). Risk associated with number PHXs.	£66,000
Compatibility & Connection works at new minor buildings	Heat Distribution (Substations)	£40,000	10%	Estimate	£44,000
Substation major - new buildings	Heat Distribution (Substations)	£180,000	10%	2 off connections (Bywaters & Score). Risk associated with number PHXs.	£198,000
Compatibility & Connection works at new major buildings	Heat Distribution (Substations)	£80,000	10%	Estimate	£88,000
Substation Energy Metering	Heat Distribution (Buried)	£0	0%	Included within substation costs above	£0
Fibre Network	Heat Distribution (Buried)	£15,570	0%	£50/m for fibre network. Interpolated from recent project.	£15,600
Cable pit & duct system	Heat Distribution (Buried)	£85,635	0%	Based on civils rate per linear meter of trench.	£85,600
System Testing & Commissioning	Heat Distribution (Buried)	£0	10%	Included above	£0
GAS BOILERS					
GAS BOILER	Energy Centre (Fit Out - Balance of Plant)	£92,000	10%	Based on rates as per input tab and required boiler capacities	£101,200
GAS BOILER	Energy Centre (Fit Out - Balance of Plant)	£46,000	10%	Based on rates as per input tab and required boiler capacities	£50,600
GAS BOILER	Energy Centre (Fit Out - Balance of Plant)	£46,000	10%	Based on rates as per input tab and required boiler capacities	£50,600
DEVELOPMENT COSTS					
Clients PM	Development Costs (PM + Professional Fees; FBC to Operation)	£215,000	0%	Assumed at 5% on all cost elements	£215,000

CAPEX ITEMS	CATEGORY	COST EXCLUDING CONTINGENCY	CONTINGENCY	SOURCE NOTES	COST INCLUDING CONTINGENCY
Contingency allowance	Development Costs (PM + Professional Fees; FBC to Operation)	£0	0%	Assumed at 0% on all cost elements	£0
Contract Preliminaries	Development Costs (PM + Professional Fees; FBC to Operation)	£305,000	0%	Assumed at 8% on all cost elements	£305,000
Principle Contractor Overhead and Profit	Development Costs (PM + Professional Fees; FBC to Operation)	£344,000	0%	Assumed at 8% on all cost elements	£344,000
Design Fees	Development Costs (PM + Professional Fees; FBC to Operation)	£215,000	0%	Assumed at 5% on all cost elements	£215,000
TOTAL		**£5,384,629**			**£5,756,100**

Figure B-1 - Electrical arrangement basis for costing



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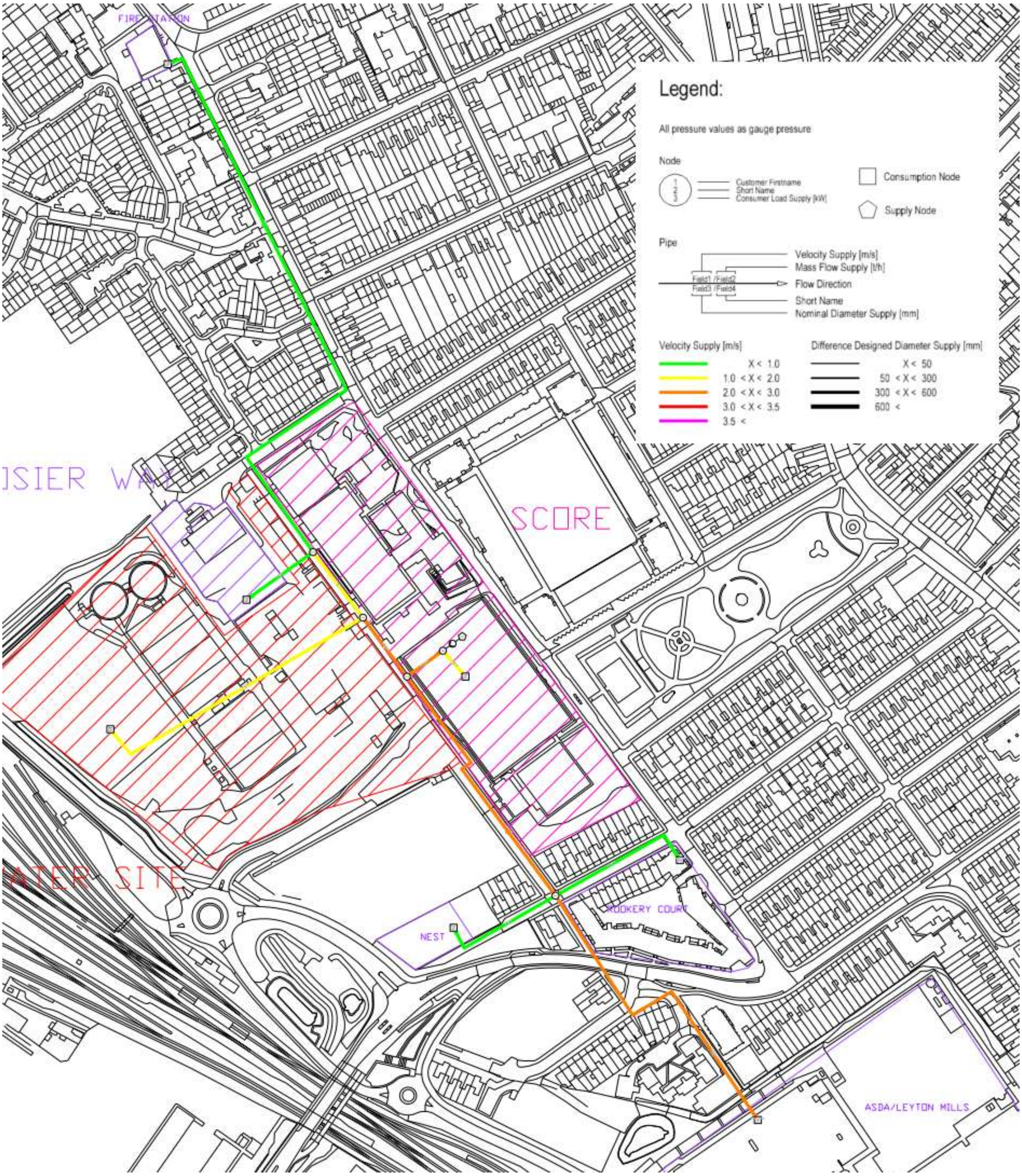
Appendix C

NETWORK ANALYSIS

Expanded Network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All pressure values as gauge pressure
Node
1
2
3
Customer Firstname
Short Name
Consumer Load Supply [kW]
Consumption Node
Supply Node
Pipe
Field1 /Field2
Field3 /Field4
Velocity Supply [m/s]
Mass Flow Supply [t/h]
Flow Direction
Short Name
Nominal Diameter Supply [mm]
Velocity Supply [m/s]
X < 1.0
1.0 < X < 2.0
2.0 < X < 3.0
3.0 < X < 3.5
3.5 <
Difference Designed Diameter Supply [mm]
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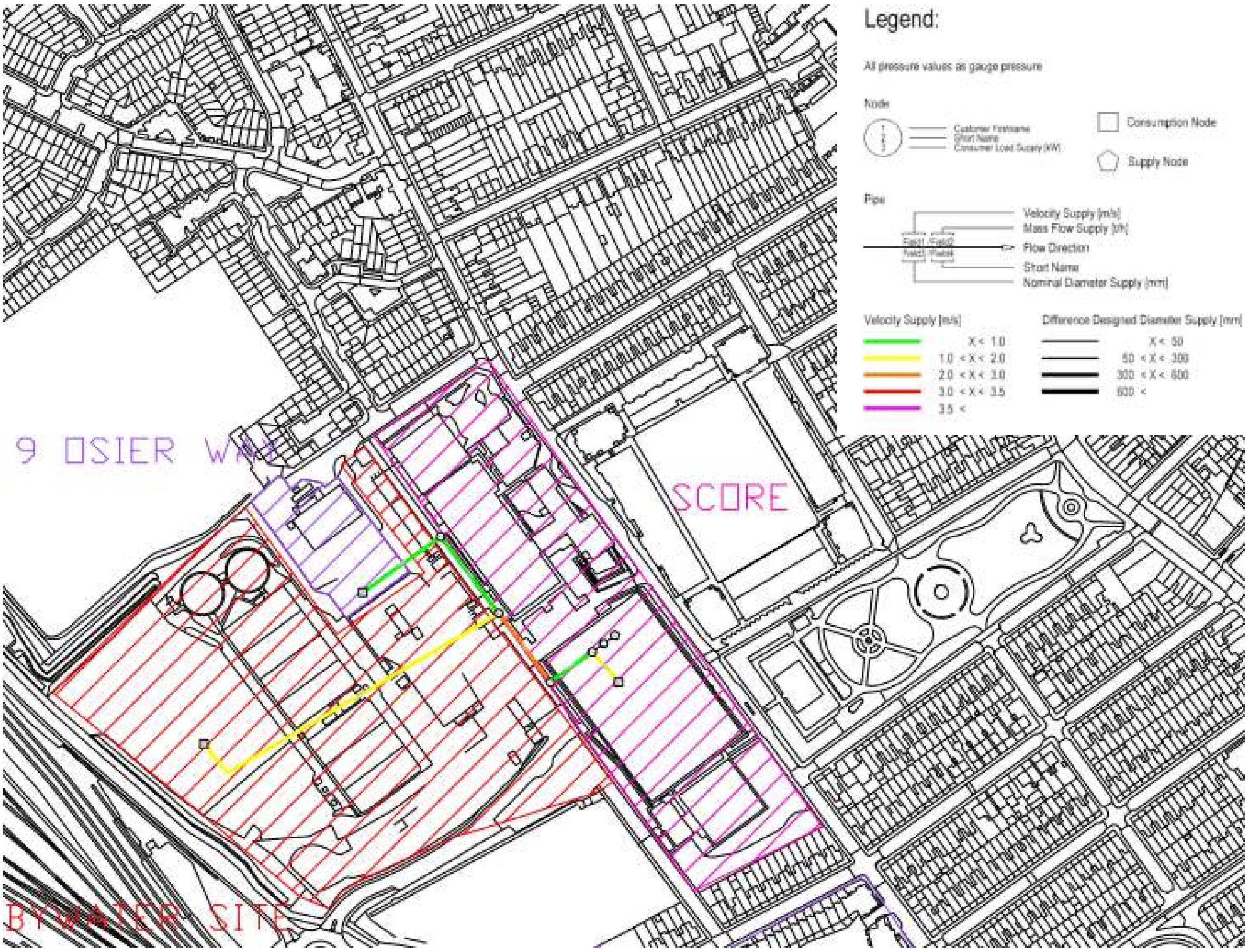
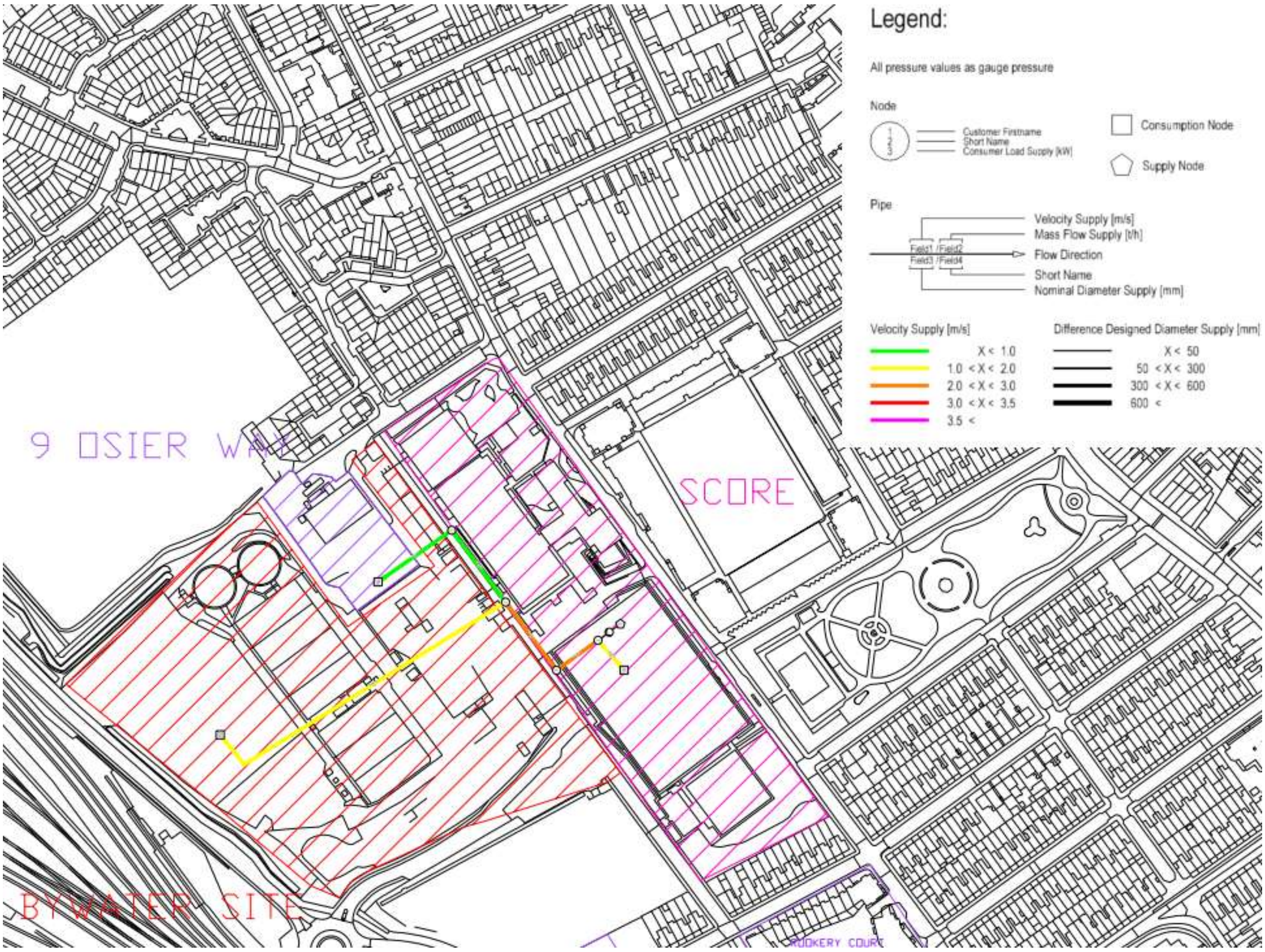
50 < X < 300
300 < X < 600
600 <
SCORE
ROOKERY COURT
NEST
ASDA/LEYTON MILLS

Core, Futureproofed network

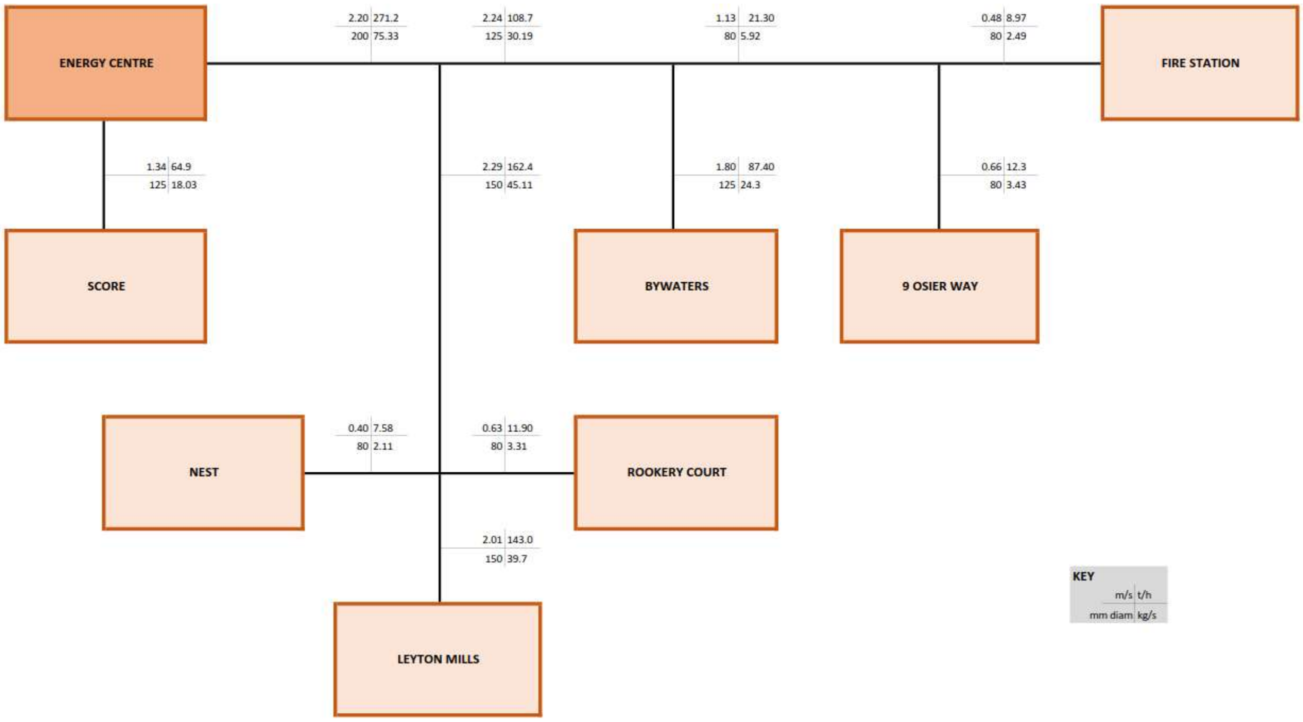


Core, non-future proofed network

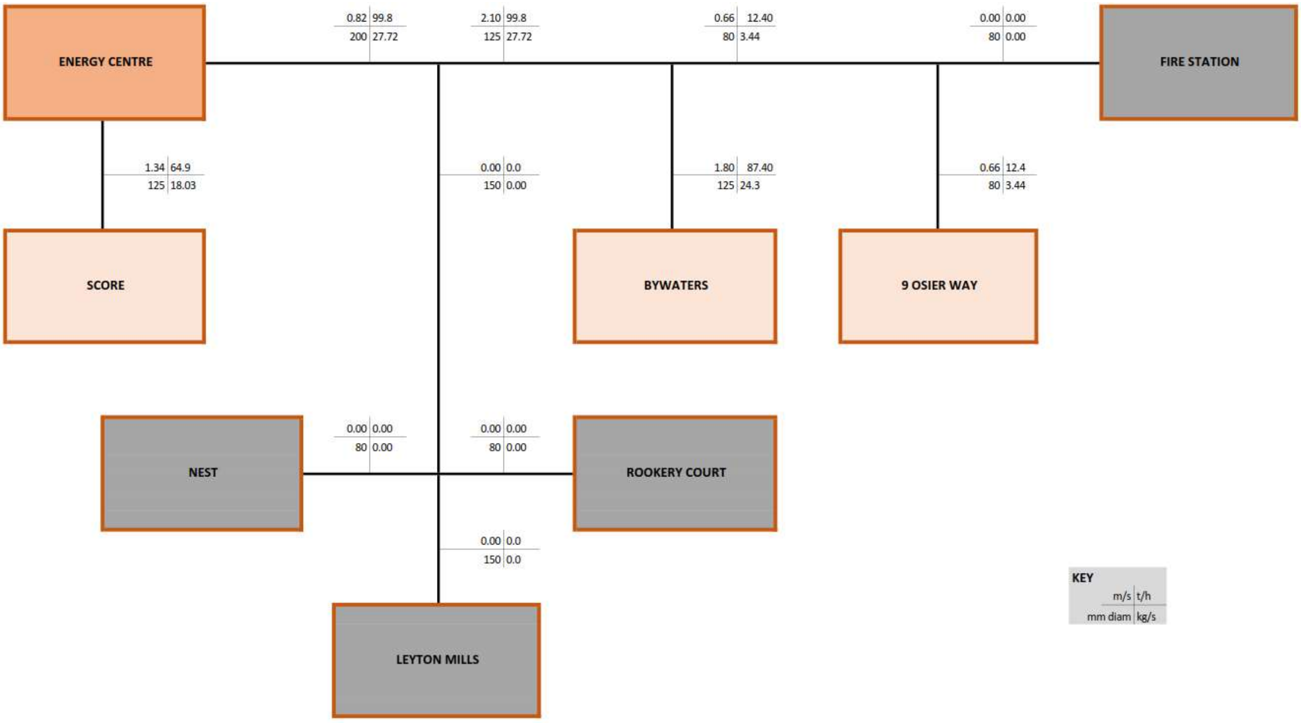


Network schematics

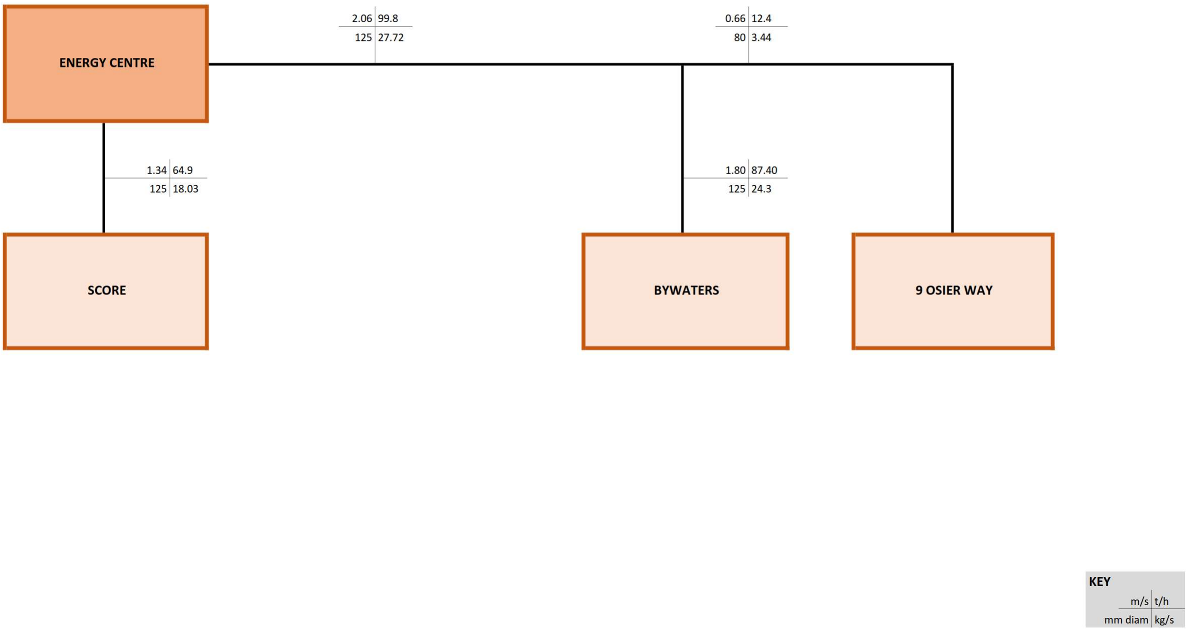
Expanded network



Core, future-proofed network



Core, non-future proofed network



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