Decentralised Energy Masterplan for City of Westminster

Westminster City Council

February 2014

PARSONS BRINCKERHOFF

Decentralised Energy Masterplan for City of Westminster

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Prepared for
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Glossary

AAP	Area Action Plan
AMR	Annual Monitoring Report
CCGT	Combined cycle gas turbine
CCL	Climate Change Levy
CEM	Contract Energy Management
CHP	Combined Heat and Power
CIBSE	Chartered Institute of Building Services Engineers
CIL	Community Infrastructure Levy
CRBO	Community Right to Build Order
DCLG	Department for Communities and Local Government
DEN	Decentralised Energy Network
DG	Distributed generation
DE	District Heating
DNO	Distribution network operator
DPCR	Distribution Price Control Review
DPD	Development Plan Documents
DUoS	Distribution use of system
EfW	Energy from Waste
EPN	Eastern Power Networks
ESCo	Energy Services Company
FTE	Full Time Equivalent
GCV	Gross calorific value
GFA	Gross Floor Area
GLA	Greater London Authority
HNDU	Heat Network Delivery Unit
HTHW	High temperature hot water
HV	High Voltage
IWMF	Integrated Waste Management Facility
ktpa	Kilo tonnes per annum
LDA	London Development Agency

LDDs	Local Development Documents
LDO	Local Development Order
LPN	London Power Networks
MSW	Municipal Solid Waste
MUSCo	Multi-utility Services Company
MW(e)(th)	Mega-watt (electrical) (thermal)
NDO	Neighbourhood Development Order
NDP	Neighbourhood Development Plan
NPV	Net Present Value
OAPF	Opportunity Area Planning Framework
PB	Parsons Brinckerhoff
PPA	Power Purchase Agreement
PPS	Planning Policy Statement
RDF	Refuse Derived Fuel
RHI	Renewable Heat Incentive
ROC	Renewable Obligation Certificate
RRP	Resource Recovery Plant
SIGE	Spark ignition gas engine
SPD	Supplementary Planning Document
SPG	Supplementary Planning Guidance
SPV	Special purpose vehicle
SRF	Solid Recovered Fuel
TfL	Transport for London
TWUL	Thames Water Utilities Limited
UKPN	United Kingdom Power Networks
WCC	Westminster City Council
WDHS	Whitehall District Heating System
WID	Waste incineration directive

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1 EXECUTIVE SUMMARY

"As a country, we spend £32 billion a year on heating. It accounts for around a third of our greenhouse gas emissions. Without changing the way we produce and consume heat, we will not meet our long-term climate change target. To get there, we are going to have to change the way we generate, distribute and use heat in buildings and industry. And we are going to need those changes to take place in an orderly, cost-effective way that ensures a vibrant, low carbon economy and a supply of affordable energy for all consumers."

The Rt Hon Ed Davey, Secretary of State for Energy and Climate Change, March 2013

This report sets out the case for a Westminster-wide District Energy Network. It summarises the Westminster Decentralised Energy Masterplan's proposal for a city-scale decentralised energy (DE) network that would deliver affordable low carbon heat from Combined Heat and Power (CHP) plants, supplying homes and businesses across the city to meet space heating and hot water demands. A District Energy Network (DEN) would also deliver low-carbon and locally produced electricity which would support the increasing power demands of a global city.

A world-class city demands world-class infrastructure

The majority of sewers, roads, transport links and existing gas and electricity networks within Westminster were designed and delivered during the 20th Century. Since then they have been added to and sometimes replaced to try and keep up with pressures from an increase in demand through population growth, and the market place. This piecemeal approach continues to put pressure on this infrastructure. This pressure on the resilience of our existing physical assets is forcing all levels of government, planners and engineers both to think differently, and to require these sectors to show leadership and make the big decisions needed to deliver the infrastructure required of a growing global city.

Energy supply is an integral part of the development process, and effective infrastructure is vital to its ability to be delivered effectively and not delay development or make it unviable. It is clear that energy supply must develop in a variety of ways to respond to current challenges, and that heat is an integral part of this response.

The provision of heat and electricity currently presents a significant economic and environmental cost to development, but on a wider scale also represents an opportunity to become a major new infrastructure prospect. Westminster is a prime location to be a major part of the nation's and the capital's decentralised energy development. Westminster's network has the potential to deliver a number of benefits and opportunities for growth:

- Inward investment, new jobs and wider regeneration
- Local sources of heat and electricity to enable the development industry to deliver new developments
- A secure and efficient heat and electricity supply to support the growth of the retail and office economy
- Affordable low carbon heat for businesses, industries, the public sector and local residents
- Addressing fuel poverty within the city
- Reducing carbon dioxide emissions by more than 100,000 tonnes per annum by 2025 (as against a gas-boiler only base case)
- Facilitating DECC's ambition to move towards a zero carbon heat supply
- Ensuring that Westminster leads in delivering an essential part of London's long term infrastructure jigsaw.

London's future

Ambitions to deliver energy security and to reduce carbon dioxide emissions are already within London-wide and national plans. They are based on evidence from work such as the Stern Review, which reported the environmental and economic consequences of not responding to our changing climate, and nationally through DECC's Heat Strategy published in March 2012.

Regionally the Mayor has made a commitment in the London Plan to achieve an overall reduction in London's carbon dioxide emissions of 60% (below 1990 levels) by 2025, and the London Plan has set the ambitious target for 25% of heat and power used in London to be generated through the use of localised decentralised energy systems by 2025.

The Mayor's objectives for London's energy supply, articulated in his Climate Change Mitigation and Energy Strategy (2011), are that it should be affordable, secure and low carbon. It should make use of local sources of energy in the intelligent, integrated and efficient management of heat and power generation and distribution, and it should be delivered through a framework that provides inward investment and employment opportunities.

The market and policy context mean that a commercial company may struggle to finance the infrastructure required to kick start the network. This is why the public sector is leading in planning for and delivering the initial phases of the Westminster Network.

Over time the network has the potential to deliver heat across the majority of London.Initially the focus is on delivering energy centres and linking pipework in a number of clusters, including new developments that are likely to be built in the coming years and where there are higher building densities. The benefits will be available to all developments and existing occupiers who connect to the network, spread across the public and private sectors.

Decentralised Energy in Westminster

A decentralised energy network offers efficient, locally produced heat and electricity to both new developments and to the existing building stock. It is also possible for a network to supply cooling.

A heat network consists of an energy centre, which usually contains an engine running on natural gas, and a system of pipes that move energy in the form of hot water to where it is needed, much like an electricity network. The electricity generated is often sold to the National Grid, although sometimes public buildings (including housing) can be supplied with this cheap electricity.

Both the short distance between a typical decentralised energy centre and its customers, and the ability to utilise the heat created when generating electricity (rather than wasting heat as centralised power stations have to) mean that approximately 80% of the potential energy from the natural gas is used, rather than approximately 40% from a power station. This enables significant financial and carbon savings over traditional methods of heat and power generation (individual boilers and centralised power stations).

There are already two successful systems in operation in Westminster, one at Pimlico (the Pimlico District Heating Undertaking) serving the Churchill Gardens Estate neighbourhood, and the Whitehall District Heating Scheme which serves the government estate. Both deliver low carbon heat to the buildings that are served by the networks, and both also supply electricity to support the local electricity infrastructure. These two existing networks are the foundation of Westminster's future decentralised energy ambition.

Over time the Westminster District Energy Network will grow by linking together networks and connecting additional heat sources elsewhere across the city, including local energy centres delivered in new developments, and heat stations recovering currently wasted energy from sources including the London Underground transport network, and food waste in Soho. The Westminster scheme will extend to serve additional heat demand from new customers, connection to existing buildings, and support development in neighbouring communities.

The Westminster Decentralised Energy Masterplan

The Westminster Decentralised Energy Masterplan supports the Mayor of London's Vision towards 2050 for smaller heat networks to join together with similar satellite schemes to form integrated networks on a city scale. These city-scale networks will enable affordable low to zero carbon heat from a range of sources to be utilised by domestic, industry, private and public sector customers across London.

The study confirms the potential for the 'Westminster District Energy Network' to continue to expand and deliver heat efficiently to much of Westminster, including early centres in Paddington, Church Street, Tottenham Court Road, and Victoria. It highlights the progress made to date, the opportunities available and the work being undertaken to address the risks for this long-term, strategic infrastructure project.

The Network will deliver economic, environmental and social benefits significantly greater than would otherwise be achieved by individual developments. It will also facilitate inward investment and new jobs, and provide secure, affordable, low-carbon heat to businesses, the public sector and local residents. The network will help tackle fuel poverty, reducing heating costs for residents living in some of London's most deprived neighbourhoods and support national and regional policy on reducing London's carbon footprint. It will also future-proof Westminster to enable it to capitalise on future technological improvements in heat generation. For example Crown Estate has recently installed a hydrogen fuel cell rather than a gas engine on Regent Street.

The Westminster District Energy Network is a strategic infrastructure project. As with any scheme of this nature, it is not without its challenges. Project risks have however been balanced against potential benefits, where the scheme as a whole represents the opportunity to create the first viable heat network of its kind in London.

This research report confirms the Westminster District Energy Network's both technical and commercial viability:

Technically viable: the Westminster District Energy Network will use a mature, well established pipe technology that has been employed for many decades to deliver hot water for heating and hot water provision, using a network of highly insulated steel pipework. The energy (electricity, heat) to feed this network of pipes can be generated from a number of sources, some of which are already being delivered as part of the planning process.

Commercially viable: local authority leadership and development of new funding models will be required to kick start the infrastructure network, de-risking the scheme for future private sector investment. This report shows that after initial investment, the Westminster Heat Network will become self-financing as the customer base grows.

This model proposed through the work shows that the outcomes are of high strategic importance and initially will require capital and costs, which shows why such a wide range of delivery partners are so committed to delivering the Westminster Heat Network:

Partner organisations
- City of Westminster
- The Royal Borough of Kensington and Chelsea
- The London Borough of Camden
- The London Borough of Islington
- The City of London Corporation
- Westminster Property Association
- City West Homes
- Greater London Authority

The Westminster business case
As well as being shown to be technical and commercially feasible, there is the need to ensure that there is a strong business case for the Westminster Decentralised Energy Network.

It is anticipated that the core scheme can be financed from a range of sources including the London Energy Efficiency Fund (LEEF), Energy Company Obligation (ECO), Community Infrastructure Levy (CIL), opportunistic funding through new development and direct local authority investment. Where suitably profitable schemes can be identified, a significant proportion of the costs can be met by the private sector investing in the network rather than traditional heating infrastructure.

The outline financial analysis suggests that, following pump priming, and after a period of network expansion, there will be a long-term commercial return on investment in the heat network. The Westminster Heat Network could then be taken to market as a viable commercial entity.

Major potential customers have already been part of initial discussions and expressed an interest in the Westminster Heat Network. The formal basis for their participation is now being developed. Significant heat savings will arise when compared to a business-as-usual model, and whilst some of the savings will be used to pay for the scheme, there will be financial savings passed on to customers signing up.

It is envisaged that once the strategic network is in place, other customers will also quickly buy into the network. This potential is already demonstrated by existing heat networks in cities such as Birmingham, Nottingham, Sheffield and Southampton.

Next Steps
To enable this vision to be successfully delivered the Council will support a partnership with key stakeholders to develop this plan and undertake the following milestones:

- Establishing and maintaining a ‘live’ database of DE compatible properties, and where possible boiler replacement cycles

- Creating a vehicle for funding DE infrastructure and recouping investment via a ‘distribution charge’ for heat delivered

- Setting up a series of energy centres on major development sites with the capacity for the installation of ‘oversized’ energy plant

- Expanding the operation of PDHU to other areas

2 NON-TECHNICAL SUMMARY

2.1 Opportunity

2.1.1 The City of Westminster lies at the heart of London. The borough hosts numerous buildings of world-wide historical and architectural significance. This is combined with high density levels of development in some areas and with ageing building stock in others. The aim of this masterplan is to develop a strategy for the future delivery of decentralised energy across the diverse districts of the borough, considering how the range of areas can best be served with heat, power and cooling. **The concept is to develop a 'roadmap' to sustainable low-carbon energy hubs which provide local, efficient energy supply points**, and which, critically, avoid piecemeal, stand-alone systems that offer little potential for future coherence or integration into city-wide solutions.

2.2 Context

2.2.1 In the UK, a legally binding target was set in the Climate Change Act 2008 to cut UK carbon emissions by 80% from 2050 from 1990 levels, with at least a 34% reduction to be achieved by 2020. The UK is also subject to the target included in the 2009 Renewable Energy Directive to achieve 15% of its energy consumption from renewable sources by 2020.

2.2.2 London has implemented its own targets that go beyond those at national level. In October 2011, the Mayor of London published his revised Climate Change Mitigation and Energy Strategy, entitled 'Delivering London's Energy Future'[1]. This document sets out the **Mayor's target to achieve 25% of London's energy supply from decentralised energy sources by 2025**.

2.2.3 It is key that London makes a significant contribution towards national carbon dioxide emissions reduction targets. In addition, Ofgem has warned[2] that there could be energy supply shortages in the middle of this decade given the status of the UK's generation fleet. Not enough new capacity is planned or will be built to replace fossil fuel and nuclear plant that is approaching life-expiry. Demand-side energy efficiency measures do not appear to be delivering sufficient savings to reduce demand significantly, and electricity margins (between supply capacity and peak demand) could fall to 2% in the coming years[3]. The need for significant investment in the wider energy supply system to reinstate these margins is anticipated to lead to retail electricity price rises in the short to medium term. With these price rises imminent, the ability to deliver cost-competitive heat to vulnerable residents within Westminster becomes all the more important.

2.2.4 Localised energy systems, particularly those that can operate from a range of clean fuel sources, could help locally alleviate electricity supply reinforcement issues. This aspect of decentralised energy could particularly appeal to the high-value property sector where delivery of service is paramount.

2.3 Benefits

2.3.1 The development of a rationalised decentralised energy supply strategy offers the potential to provide a route to **significant carbon dioxide emissions reductions, to provide residents and businesses with cost-competitive, low-carbon heat, whilst also enabling areas to benefit from future technological advances**. Centralising heat generation plant to key locations within the borough will allow significant opportunities to benefit from economies of scale. These economies

[1] Mayor of London, October 2011, Delivering London's Energy Future, http://www.london.gov.uk/who-runs-london/mayor/publication/climate-change-mitigation-energy-strategy, Policy 4, page 91.
[2] http://www.ofgem.gov.uk/media/pressrel/Documents1/27June2013.pdf, accessed 28th June 2013
[3] ibid

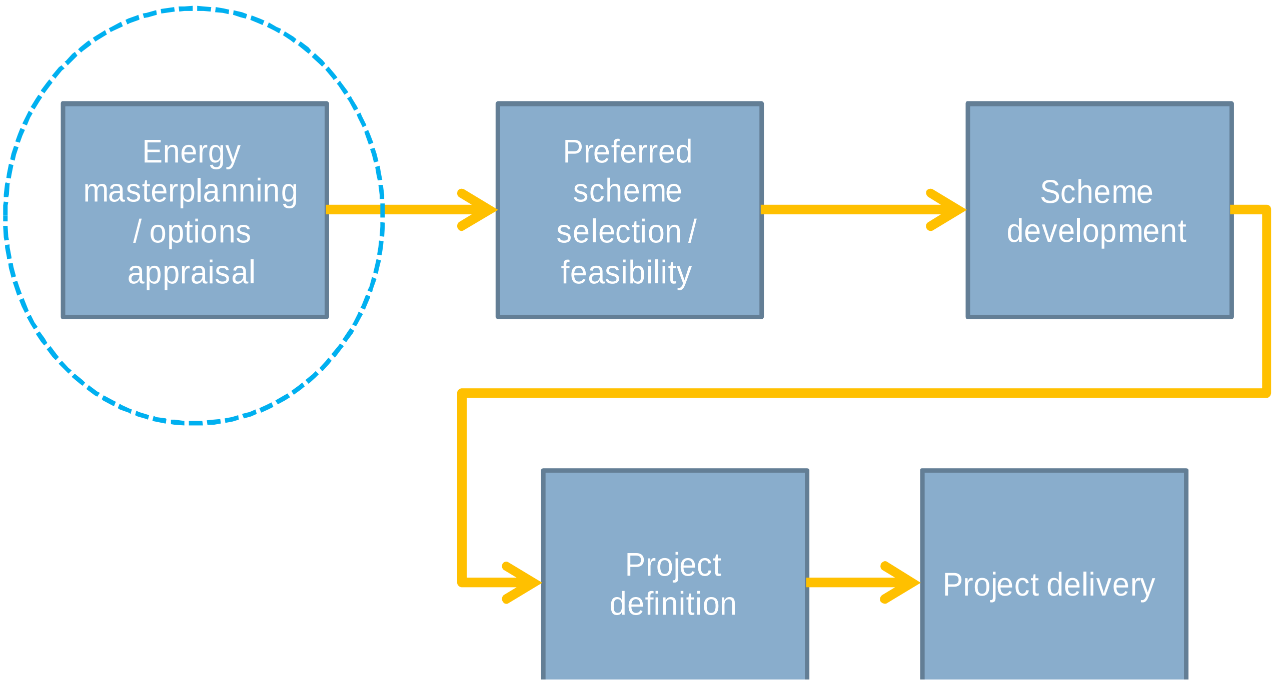
could be seen in utility procurement, deployable plant types, and efficiencies. With a single point of heat supply, replacement of a single item of central plant can be carried out with considerably more ease than the replacement of multiple smaller individual boilers. This aspect of centralised systems represents a form of future-proofing of energy supply.

2.3.2 DE infrastructure represents a long-term utility asset, which would be expected to have a lifespan beyond the 2050 time horizon considered in this study. This is a key feature of the technology that cannot easily be recognised in techno-economic assessments, but which contributes to the overall sustainability of the concept. One role of the public sector is to recognise this aspect of the technology and help to de-risk its installation for longer-term societal benefit.

2.4 Development

2.4.1 This masterplan is the first stage in the development of a low carbon energy solution for the borough and this report contains a number of potential approaches. These are presented as 'proof of concept' rather than concrete proposals that must be adhered to. A number of variants of the solutions proposed here would perform comparably. **Further stages of feasibility and design development are required to lead to defined schemes to take forward to procurement and implementation**. A notional diagram of the general process is shown here:

Figure 2-1 Overall project development process

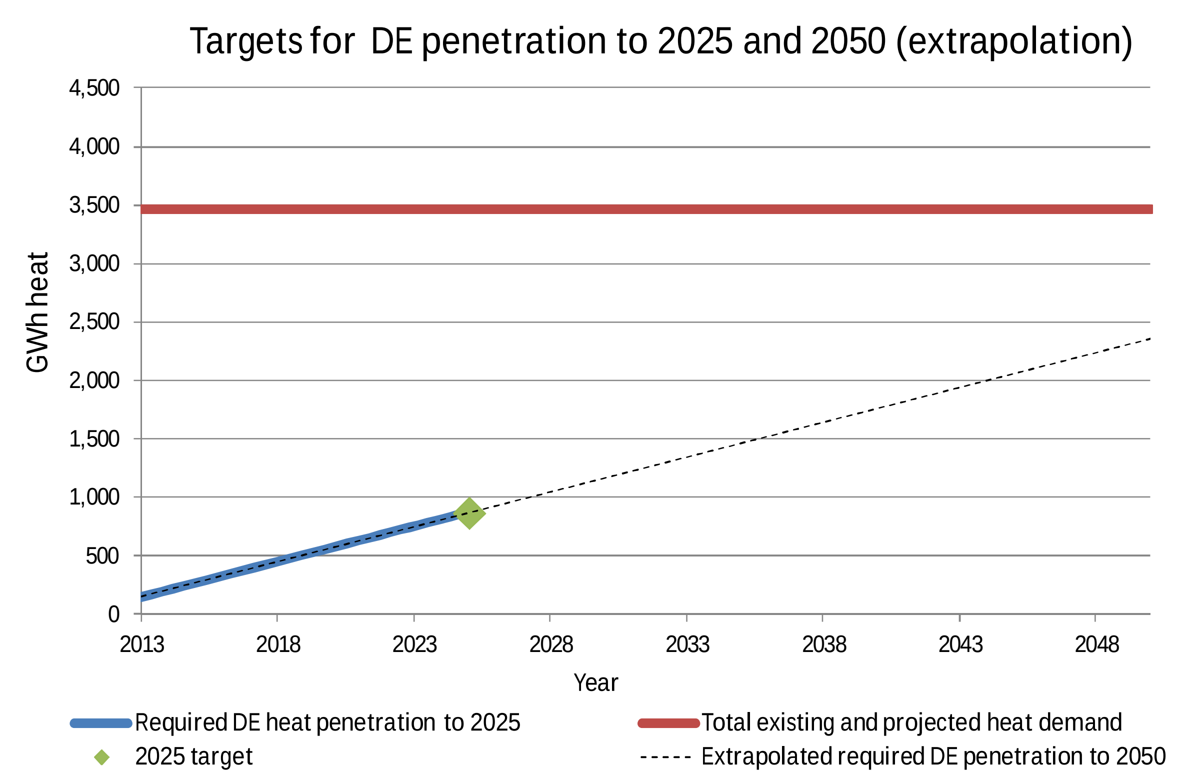


2.5 Achieving targets

2.5.1 The London Mayoral target is for 25% of London's supply to be from decentralised energy sources by 2025[4]. This report assumes that this target applies equally to heat and to power[5], and further that individual domestic gas boilers do not count as a source of decentralised energy. Expressed graphically from an approximate current extent of district heating deployment, this can be shown as follows:

[4] Mayor of London, October 2011, Delivering London's Energy Future, http://www.london.gov.uk/who-runs-london/mayor/publication/climate-change-mitigation-energy-strategy, Policy 4, page 91.
[5] Current levels of heat and power demand are similar in the City of Westminster

Figure 2-2 Illustration of 2025 district heating target for Westminster and extrapolation to 2050

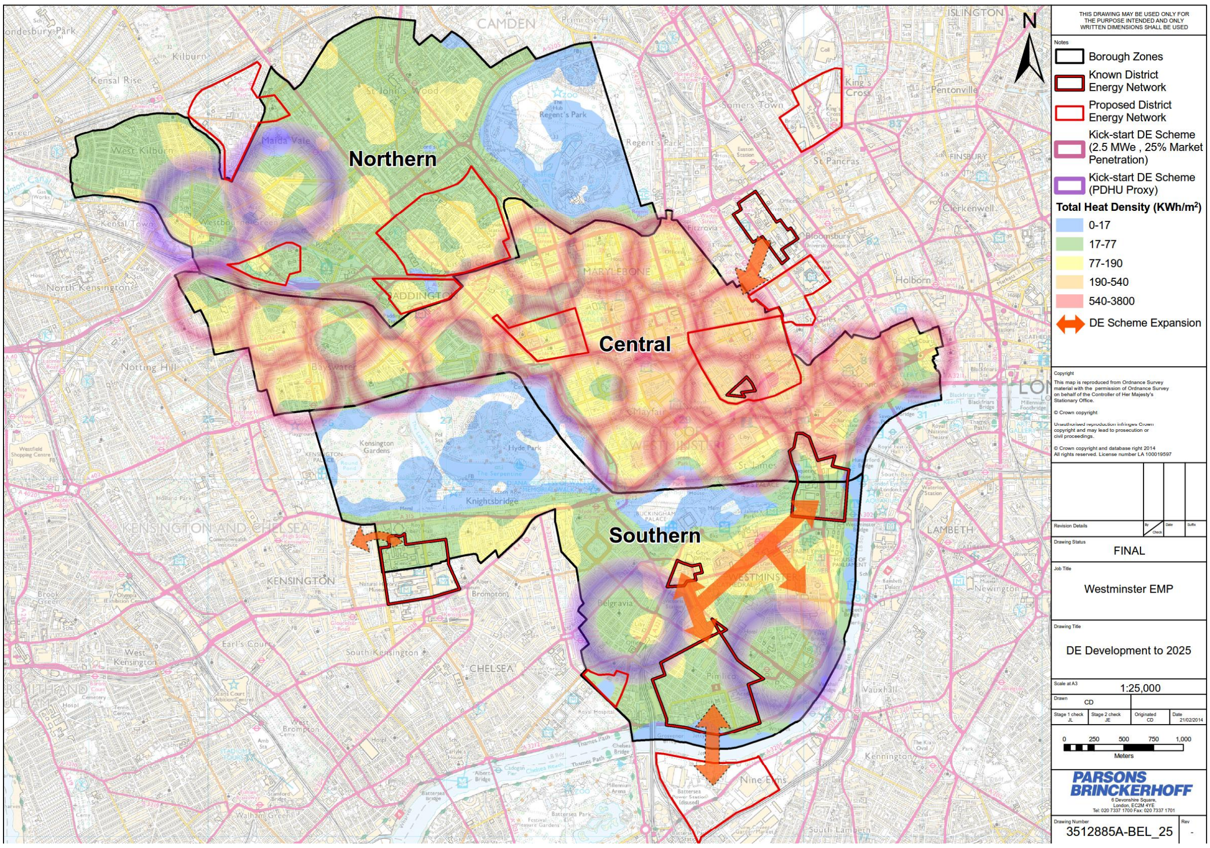


2.5.2 **To meet the 2025 target level requires a 6-fold increase in heat demand met from DE**. This suggests a significant shift from the current *modus operandi* is necessary.

2.5.3 The proposed approach divides the borough into three zones – northern, central and southern. Within the central zone, the proposed roadmap to achieving targets is that by 2025 approximately 25% of properties would be connected to a DE scheme. Similarly, by 2050 75% of properties must connect to achieve the extrapolated target.

2.5.4 Based on demand densities, typical property sizes, and the spacing of the Westminster streetscape, Parsons Brinckerhoff has estimated the extent and cost of kick-start networks required to gather a sufficient customer base to allow WCC to meet its 2025 target, and has further modelled the expansion, or intensification, of this heat supply to 2050. An illustration of the modelled level of networks required is shown below. Each of the circles on the plan below represents the area covered by a proposed DE network scheme by 2025.

Figure 2-3 Network growth by 2025



2.5.5 This level of deployment has the following attributes (with the 2050 figures also shown).

Table 2-1 Contribution of systems towards DE targets

	Heat supply 2025 (GWh p.a.)	Contribution towards 2025 target (866GWh p.a.)	Heat supply 2050 (GWh p.a.)	Contribution towards 2050 target (2,350 GWh p.a.)
Existing DE systems	150	17%	150	6%
Existing system expansion	30	3%	130	6%
Central zone DE systems	500	58%	1,503	64%
Northern and Southern zone DE systems	200	23%	600	26%
Total	880	102%	2,383	101%

2.5.6 Westminster City Council (WCC) is in an excellent position to pursue the rapid expansion of DE within its boundaries as, uniquely, it has long-term operational experience of managing DE projects; the Pimlico District Heating Undertaking has been supplying low cost heat to residents since 1950. This asset, both physically and in terms of the human capital surrounding it is a foundation which WCC should capitalise on in forming a strategy for DE expansion.

2.6 How should expansion be pursued?

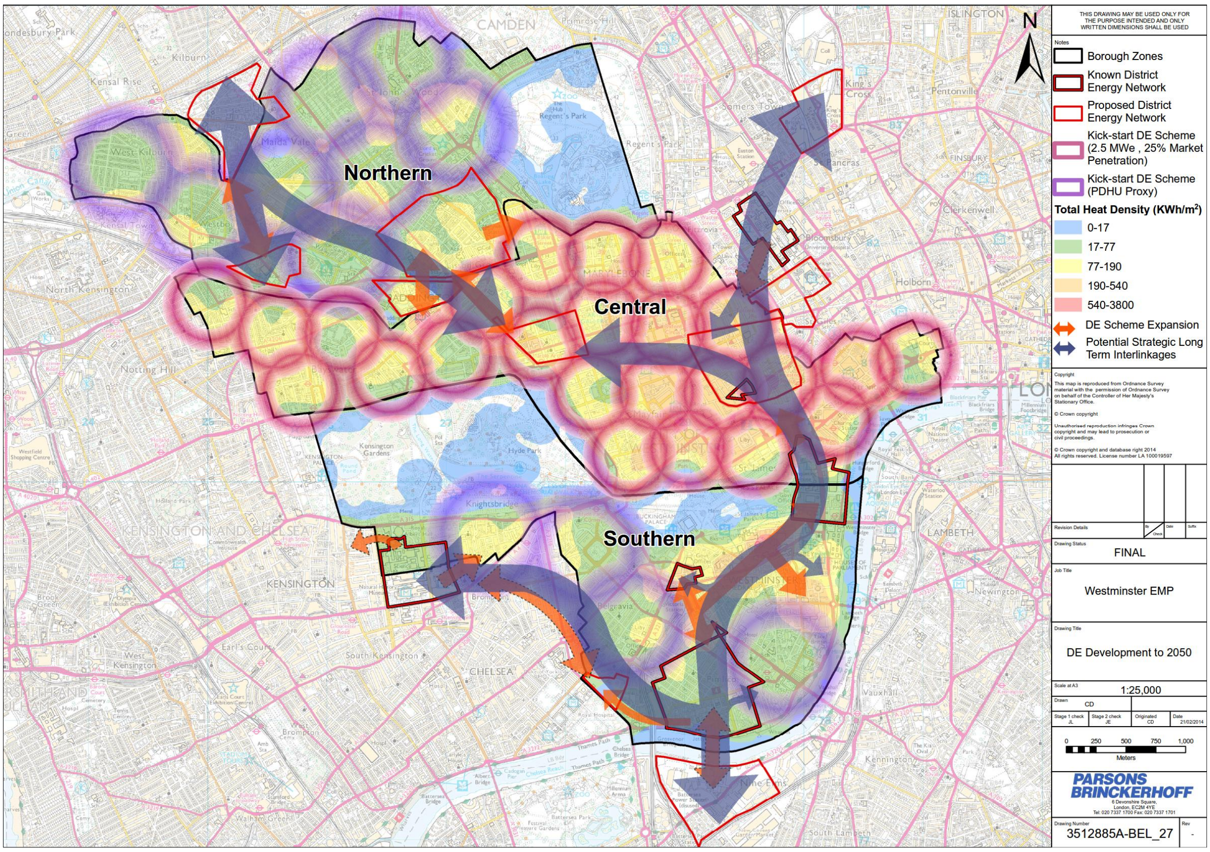
2.6.1 For each new 'kick-start' network the assumption is made that the required energy supply plant would be located within the basement of one of the planning application sites coming forward. **Hence, planning mechanisms must be deployed to ensure that this space is available for DE plant.**

2.6.2 Progressively after the establishment of the initial, kick-start networks it would also be anticipated that rationalisation of schemes takes place. This would encompass the linking of networks, and the centralisation of energy supply plant to progressively larger energy centres. This would enable schemes to access economies of scale, and also potentially to exploit alternative fuels. One concept for this future nexus of generation is Vauxhall Nine Elms Battersea. This is purely conceptual at this stage but a new energy centre is planned for this location and there is an extant connection from the Battersea Power Station site to PDHU via a district heating link under the Thames.

2.6.3 When district heating networks are established, they should be sized for a future-proofed capacity to allow for greater volumes of customers connecting. However, it should be noted that with correct design standards, the capacity of networks can be progressively increased as return temperatures drop (increasing the temperature differential between flow and return pipework, and hence increasing the energy transfer capacity). **This requires coherent implementation of appropriate design standards in new development** (with particular regard to return temperatures, as outlined in the London District Heating Manual).

2.6.4 An illustration of the linking of networks to 2050 is shown below:

Figure 2-4 Network growth in 2050



2.6.5 Similarly to the continental expansion of DE systems, it would also be anticipated that as networks grow both in Westminster and other boroughs, that it becomes possible to make use of power stations outside of the city as a heat source for energy provision.

2.7 Delivery

2.7.1 The paragraphs above illustrate the magnitude of the growth required to meet Mayoral (2025) and extrapolated 2050 targets in line with national carbon savings ambitions. How can this be delivered? Recent research into the barriers to DE deployment[6] have highlighted the difficulty of funding early stage 'soft' costs, and raising capital for physical infrastructure as two key barriers. The high up-front cost of DE schemes has historically meant that only the most heat dense, compact schemes attract private sector investment. As these opportunities are limited in number the deployment needed across Westminster is of a scale where **public sector support will be essential**. This is a key output to note from this study.

2.7.2 What form(s) should public sector support take? It is suggested that WCC could take up a more active role in DE deployment in four key areas:

- Identifying schemes as development comes forward through the planning system, and securing basement space in large new developments for the installation of energy centre plant capable of serving sites beyond the site boundary

6 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/191542/Barriers_to_deployment_of_district_heating_networks_2204.pdf, March 2013, accessed 14th June 2013, Research study by BRE, University of Edinburgh and the Centre for Sustainable Energy for DECC.

- Maintaining a database of 'compatible' properties and their demands, and data on boiler replacement cycles where available

- Funding the installation of DE networks as a 'network system operator'. This means investing in the infrastructure, and recouping this investment over a long period through charging for the transfer of heat

- Expanding the reach of the PDHU model

2.7.3 After the initial higher risk investment has been made (with public sector support), and when operational income can be demonstrated as a customer base grows, the public sector could then sell the de-risked asset and recoup its initial investment. Alternatively, the asset could continue to serve the City's residents (by being run by the Council or and ESCO delivering sub-market price energy).

2.7.4 Further work on this type of approach is needed to check that it does not contravene any competition regulations.

2.7.5 It will also be essential to access properties that are not coming forward through the planning system. The key actions suggested for WCC above (de-risking DE systems, and reducing investment costs) could attract connection of existing buildings to networks at their time of boiler replacement.

2.8 Conclusions

2.8.1 Westminster has a high density of heat demand that would suggest that there is excellent potential to install DE networks. However, the data on heat demands also suggest that the total demand is made up of a large number of small properties (35%[7]). The high levels of penetration of DE required to meet London's targets mean that connection of some of these smaller properties is necessary as part of the overall route to a low-carbon DE future. This means that the installation of long lengths of DE pipework are required across the borough to achieve high levels of DE penetration, with associated high costs.

2.8.2 The analysis carried out as part of this study is based around average property sizes and average density, in order to be able to draw conclusions on the overall costs and scale of change required to meet targets in 2025 and 2050.

2.8.3 Only a small portion of the demand that needs to be accessed to meet targets will be subject to planning applications in the period to 2050, and hence there is a need to find an alternative, non-planning means to accelerate DE take-up. It is critical that DE becomes a widespread, cost-competitive, acceptable alternative to traditional energy supplies that individuals and business are attracted to.

2.9 Recommendations / next steps

2.9.1 General

2.9.2 Parsons Brinckerhoff strongly recommends that planning approval for development within Westminster is subject to developers providing secondary system designs that are compatible with delivering low return temperatures to a district heating network.

2.9.3 Where possible, allowance should be made in design to accommodate the use of 'waste heat'[8] (i.e. heat that is a by-product of another process, and which is typically

[7] Residential heat demand figure from National Heat Map as percentage of total borough heat demand.
[8] http://www.london.gov.uk/priorities/environment/tackling-climate-change/energy-supply, accessed

at lower temperatures than can be used directly in other buildings). This should include centralisation of chilled water heat rejection plant within developments, co-locating heat delivery stations close to sources of waste heat, and ensuring that systems operate on variable flow, variable temperature principles as outlined in the London District Heating Manual.

2.9.4 The use of distributed absorption chilling driven by heat derived from a district heating network is not recommended as this delivers at best only marginal environmental and economic operational savings, and implies significant additional capital cost, space requirement and plant control complexity.

2.9.5 Chilled water

2.9.6 Tottenham Court Road / East of Oxford Street and Paddington Basin - it is suggested that policy should encourage new developments to consider the supply / purchase of chilled water to/ from immediately adjacent sites.

2.9.7 Victoria - it is recommended that development in this area is future proofed for district cooling connection, and that as strategic new development comes forward, an assessment of the potential to supply / purchase chilled water from a cooling network is required.

2.9.8 Heat sources for DE networks

2.9.9 It is suggested that the use of gas-CHP, and heat pumps recovering waste heat are currently the most suitable technologies for the early phase network development. Gas-fired CHP is arguably the best-fit for Westminster's context, given its small footprint, the availability of gas throughout the borough, its ability to generate carbon savings at relatively low financial cost, and its proven track record. However, the issue of emissions to air from CHP (NOx in particular) should also be noted as a factor that needs to be considered for installations.

2.9.10 The front-runner technologies for the later phases of the network expansion include the use of waste heat resources (with heat pumps) and biofuel CHP technology.

2.9.11 Specific area actions

2.9.12 Parsons Brinckerhoff strongly recommends that any energy centre developed on the Battersea Power Station site (VNEB) should link to PDHU via the existing network under the Thames. Battersea's heritage as a power station, its location and link to PDHU suggest strongly that there should be a strategic push to make use of this location as a site for significant generation capacity that allows economies of scale to be maximised and a wide area of Nine Elms on the South Bank and Westminster to be supplied with heat and potentially electricity from this site.

2.9.13 Chelsea Barracks - It would be a great shame to 'miss' this expansion opportunity for the PDHU system, given that developments of the scale of the Chelsea Barracks do not occur very frequently, and even more rarely in such a beneficial location for system expansion.

2.9.14 It is recommended that the potential of a Whitehall District Heating System (WDHS) to PDHU link should not be seen as a factor influencing the Nova Victoria to PDHU connection. It is recommended that the link between Nova Victoria and PDHU is implemented.

2.9.15 It is recommended that the development of anaerobic digestion in Soho (based on food waste) as a concept technology is supported, given its potential benefits. However, it remains technically and commercially unproven at this stage for the scale of installation and urban environment, and ultimately will only ever be able to make a relatively small contribution towards overall borough energy targets (given the volume of food waste available within the area, and its spatial requirements). The recommendation is therefore to maintain a watching brief, and to assist concept development where easily possible.

2.9.16 South Kilburn - the approach recommended for WCC in this area is to engage with Brent Council to try to facilitate the examination of the potential for the South Kilburn masterplan DE system to link to loads immediately across the borough boundary (St Augustine's Church of England secondary and primary schools, and Tollgate House). The energy centre for the Kilburn development area is understood to be very close to these loads.

2.9.17 Natural History Museum / South Kensington area - The Natural History Museum currently employs an ESCO under a 15-year agreement understood to have started around 2006, and hence a potential 'break-point' for the introduction of an alternative supply for the NHM will occur around 2021. In advance of this point in time, it is recommended that Westminster engage with the NHM and its partners to explore the potential for this system to expand into neighbouring zones. This concept would require support from across the borough boundary to Kensington and Chelsea, and hence engagement with this neighbouring borough would be essential to maximise the potential of this expansion.

2.9.18 Portman Estate – this area represents an excellent prospect for DE success. The anticipated phasing of building development in this area leads to the recommendation of establishing a DE delivery vehicle as early as possible for the entire area. This will then allow a coherent strategy to be developed.

2.9.19 Church Street / Paddington – It is recommended that the Church Street and Paddington Basin areas are linked in terms of heat provision. In addition, the St Mary's hospital is a significant heat user, and this institution should be incorporated in all strategic planning of energy assets for the area.

2.9.20 Westbourne Green – It is recommended that in the strategic long-term a connection between Westbourne Green and the Kilburn South system should be pursued. The alternative connection towards Church Street is geographically more distant, and goes through areas of lower heat density.

2.9.21 Extending DE to properties that are not applying for planning permission

2.9.22 To impose a planning obligation on properties to connect to a DE system when they are simply due to replace their boiler plant would require legislative change. The legality of this with regard to competition laws will need investigation as part of further work. It is also difficult to envisage how an obligation could be effectively implemented. For these reasons, the means suggested at this stage to convince property owners to connect to emerging DE systems at time of boiler replacement is effectively a 'sales' approach, where the product (heat) must be cost-competitive, the market needs to be made aware of the product offering, and confidence must be engendered through good service.

2.9.23 Delivery mechanism

2.9.24 In order to help overcome the problem of raising funds for both feasibility work and physical installations, it is recommended that Westminster use the Community Infrastructure Levy (CIL) to help deliver DE schemes within the borough. The borough should also make use of the development support offered by DECC via its Heat Network Delivery Unit (HNDU), and the GLA via the Decentralised Energy Programme Delivery Unit (DEPDU). Some assistance may also be available from European funds.

2.9.25 The Energy Company Obligation (ECO) may also in certain circumstances be able to offer help with investments, and low-cost loans may be available from the London Energy Efficiency Fund (LEEF), the Green Investment Bank or via the Public Works Loan Board. Further, Allowable Solutions may also offer a route to generate funds for DE installation.

2.9.26 The level of CIL/other support required to support the schemes outlined in this report has been based upon achieving the extrapolated 2050 target for DE penetration. The level of CIL required is based around the cumulative net present values (NPVs) of all the proposed networks, calculated at 6% over the period to 2050.

Table 2-2 CIL level setting

CIL Setting	NPV result (6% discount rate to 2050)
Net present value of DE network installation to 2050	-£459m

2.9.27 It must be noted that these estimates are based on central estimates and have been developed from multiple assumptions, and further that these figures are very sensitive to assumptions – particularly around utility prices, cost of individual connections to premises, and network installation costs.

2.9.28 It is recommended that WCC expands its role in the arena of DE development within its borough to take a more active lead in investing in infrastructure. London First has set out 10 infrastructure priorities for London[9], This document calls for action from the government and Mayor to overcome remaining planning and funding obstacles to the delivery of these priorities. One is for new and upgraded power generation, transmission and distribution infrastructure, with targeted support for low carbon, locally generated energy networks to satisfy the capital's heat demands and also reduce demand on the grid. The Mayor and boroughs can help support take-up of district energy in key areas. With this support in mind, WCC actions should include:

- Maintaining a 'live' database of DE compatible properties, and where possible boiler replacement cycles
- Funding DE infrastructure and recouping investment via a 'distribution charge' for heat delivered through networks that WCC has funded
- Leasing energy centre space on major development sites for the installation of 'oversized' energy plant (or obtaining this through 'planning obligation')
- Expanding the operation of PDHU to other schemes
- Ensuring that developments in the 'licence lite' regime for electricity supply from distributed generators are taken on board for projects within Westminster, when appropriate.

[9] http://londonfirst.co.uk/wp-content/uploads/2013/08/London-Infrastructure-top-ten-priorities-web.pdf , accessed 20th November 2013

3 INTRODUCTION

3.1 Aims and scope

3.1.1 Parsons Brinckerhoff (PB) has been appointment by Westminster City Council to establish an Energy Master Plan (EMP) based on decentralised energy (DE) for the borough and, where appropriate, adjacent areas.

3.1.2 PB understands that the output of this work should be a clear road-map to a state of increased decentralised energy provision with Westminster by 2050, in line with national and regional policy targets for emissions reductions and the expansion of DE. This road-map should be made up of, where appropriate, well-defined projects to take forward, with a delivery plan for implementation and an outline technical / financial model that demonstrates viability both in terms of a 'kick-start' phase and also in the longer term. In other areas, the outputs of this study should lead to clear policy recommendations that have a demonstrable logic in instigating positive change toward DE mobilisation. This study addresses whether a notional proposed solution in different areas is both technically and commercially deliverable, in order to be credible for both Local Authority planners and the private developer community. The report considers the local policies that should be in place in order to facilitate the delivery of this solution.

3.1.3 This report illustrates the process and analysis that has led to a technical solution that meets the requirements of national, regional and local policy and regulation. The outputs of the study form an evidence base from which planning policy can be developed.

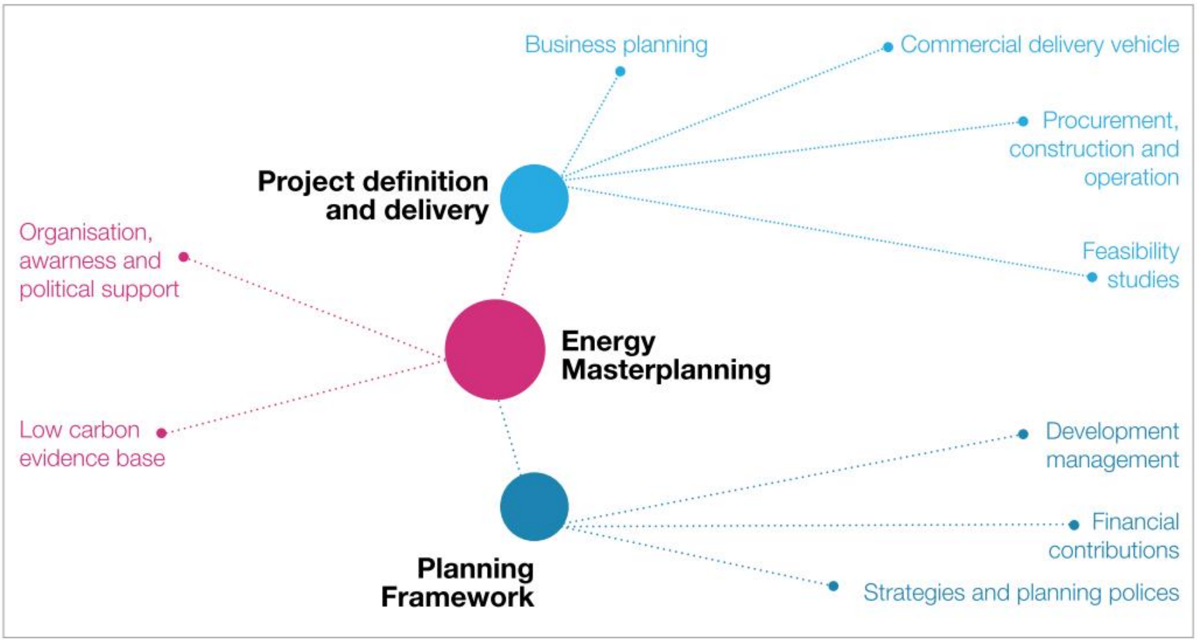
3.1.4 The project brief for this commission notes the following key deliverables:

- *Study report, including elements on:*
  - *Heat generation choices across time*
  - *Heat distribution*
  - *Chilled water network viability*
  - *Policy recommendations*
- *Financial model for the delivery of the DE network identified as 'deliverable' which will be used to inform the CIL*
- *DE network masterplan including network sketches, schematics, dimensioning and diagrams as noted above*
- *List of individual projects with respect to the DE network masterplan*
- *Identification of the preferred delivery sequence for the DE network masterplan and its projects*
- *Recommendations about the change in primary energy source/s over time*
- *Description of relevant electricity arrangements for export and sale across the local electricity distribution network from generator to electricity purchaser.*
- *Identification of key risks and opportunities moving forward, and the important factors to be considered by the Council in the short term*

- *Commentary on the next steps*

3.1.5 The energy masterplanning process is one element in the wider backdrop of the trajectory towards a low-carbon economy. Wider backdrop elements would include both UK factors such as the resilience of national energy infrastructure, generation plant margins, energy prices, and local factors would include fuel poverty, local skills, and the potential to attract investment through low-carbon energy supply, The energy masterplanning process takes place within the planning and delivery context illustrated below[10]:

Figure 3-1 Energy Masterplanning Context



3.1.6 PB would stress the key interlinkage between the planning policy framework and the ability to delivery projects effectively. It is important that the policy framework supports DE's expansion, and is implemented in the assessment of planning applications as they are submitted. From this point of view, capacity building and awareness are important elements of DE masterplanning within local authorities.

[10] Decentralised Energy Masterplanning – A manual for local authorities, Department for Energy and Climate Change, ARUP, Haringey, 2011, Figure 2

4 POLICY BACKGROUND

4.1.1 This section provides a brief overview of the policy framework which currently applies to the development of district energy (DE).

4.2 Climate Change Act

4.2.1 This domestic Act passed in 2008 commits the UK to achieve an 80% reduction in carbon emissions by 2050 relative to a 1990 baseline. This is achieved through a series of carbon budgets each five years in length which define how much the UK can emit.

4.2.2 The Act also set up the Committee on Climate Change which advises government, providing independent advice on how the carbon budgets can be met. These recommendations provide the basis for other policies which implement the UK's emissions reduction strategy.

4.3 UK Government energy policies and incentives

4.3.1 The Government has a range of energy policies in place to implement the low carbon agenda. The table below highlights some of the policies in place that are particularly relevant to DE and low carbon energy provision.

Table 4-1: Polices and Incentives in Place to Support Heat Networks

Policy	Detail
Energy Companies Obligation (ECO)	ECO aims to improve the energy efficiency of hard to treat properties and provides support for vulnerable and low-income households. Connections to heat network schemes are eligible for ECO financial support in certain circumstances.
Renewable Heat Incentive	The RHI provides funding for renewable heat at the commercial and industrial scale with funding through a tariff paid for each kilowatt hour. Heat networks are eligible.
Renewables Obligation	Heat from a renewable CHP plant can claim, in some cases, a 0.5 Renewable Obligation Certificate uplift for Good Quality CHP, although this band closes on 31st March 2015. This may be replaced by a specific RHI tariff for Good Quality CHP.
CHP Quality Assurance	This scheme seeks to ensure that the support available for CHP is targeted to schemes delivering genuine energy saving benefits compared to separate generation of heat and power.
Zero Carbon Homes policy	This policy envisages that low carbon heat networks could be employed to help developers meet the zero carbon standard in England as it is neither feasible nor cost-effective to do so in all cases solely through on-site measures.
Building Regulations	Regulations set standards for new buildings in terms of carbon emissions, and this indirectly encourages low carbon heat network development. Developers are able to meet their regulations requirements in the most cost effective way they choose including adopting good fabric energy efficiency standards and/or connecting developments to heat networks.
Licence Lite	Ofgem has proposed licensing arrangements to enable smaller scale electricity generators to gain better access to the electricity supply market and obtain a higher price for their power. Obtaining a good price for the electricity produced in CHP plants (which provide heat to networks) can be critical to the viability of DE systems.
EU ETS	Combustion plants over 20 MW (thermal input) are included in the EU ETS which means larger boiler or CHP installations supplying a heat network over this size require EU ETS permits.

Table 4-2: Polices in Place to Support Heat and Cooling in Buildings

Policy	Detail
Climate Change Levy (CCL)	CCL levied on fossil fuels is designed to encourage sites to switch to lower carbon forms of heating. Sites achieving Good Quality CHP are eligible for relief. This scheme is being phased out from April 2013.
Carbon Reduction Commitment (CRC) Energy Efficiency Scheme	Organisations consuming more than 6,000MWh of electricity per qualifying year are required to participate in the CRC scheme which aims to encourage energy efficiency by taxing carbon emissions at a rate of £12 per tonne in the year 2012/13.
Energy Saving Advice Service	Telephone-based service offered by the Energy Saving Trust (EST) on behalf of DECC offering impartial energy saving advice to homes and businesses. The Service will be supporting the Green Deal and ECO as those schemes develop.
Green Deal	This programme is designed to help improve the energy efficiency of homes and businesses by making improvements with some or all of the cost paid for from the savings on their energy bills. Energy-saving improvements for heating include insulation, draught-proofing, double glazing and condensing boilers and micro-CHP.
Energy Related Products and Energy Labelling Directives (ERPD)	The ERPD will set minimum performance requirements for heating and hot water products. The EU Regulations are due to come into force in late 2013, with the minimum performance standards taking effect in 2015 and 2017. The ELD will introduce a labelling system for energy using products based on their efficiency which from 2013 includes labelling of heating and hot water systems. Products are rated from G to A+++. Compliance with the labelling requirements by February 2015 is mandatory.
Enhanced Capital Allowances (ECA)	The Energy Technology List contains a range of energy efficiency heating technologies that qualify for an ECA, which can be installed in a commercial property including boiler equipment, CHP, heat pumps, HVAC equipment and controls.
Feed in Tariffs (FITs)	Although primarily a mechanism to support renewable electricity from microgeneration, FITs are also used to support domestic micro-CHP (under 2 kWe) installations that are certified under the Microgeneration Certification Scheme.
Renewable Heat Incentive (RHI)	The (non-domestic) RHI provides tariff-based financial support for renewable heating in commercial, public, not-for-profit and community buildings over a 20 year period. Domestic RHI proposals are due in summer 2013.
Energy Performance of Buildings Directive	This directive aims to drive the reduction of energy use by requiring all buildings developed after 2020 to be nearly zero energy, or after 2018 for public buildings. Other key measures include Display Energy Certificates for larger public sector buildings to show actual energy use; and Energy Performance Certificates that display energy efficiency ratings. They are also used to underpin the Green Deal, ECO, RHI and FiTs.
Building Regulations	The Building Regulations (which will uplift standards with each revision) implement the Energy Performance of Buildings Directive and ensure that buildings are constructed to a high standard. Through energy efficiency standards the aim is to decarbonise new buildings.
Microgeneration Certification Scheme	MCS certifies renewable energy generating technologies up to $45kW_{th}$ and up to $50kW_{e}$. It is primarily aimed at consumer protection and acts to drive industry standards. Certification is required by a number of government policies, including the RHI, FiTs and Green Deal.
The Standard Assessment Procedure (SAP)	SAP and the Simplified Building Energy Model are methodologies for assessing the energy demand of homes and non-domestic buildings respectively and are used to assess compliance of a new property the requirements of building regulations.
Smart Meters	Every home and smaller business in Great Britain is to have smart electricity and gas meters. Roll-out is expected to start in 2014 and be standard across the country by the end of 2019.

4.3.1 In December 2011 the UK Government produced the report The Carbon Plan: Delivering our Low Carbon Future as required by the Climate Change Act which outlined the government's approach to energy and climate change, outlined its strategy to achieve carbon budgets in each sector and outlined in detail how it intends to deliver the fourth carbon budget for the period 2023 to 2027.

4.3.2 The report suggests that the 2050 carbon emissions reduction target is likely to require reducing emissions from buildings to near zero by 2050, and up to a 70% reduction in emissions from industry – the majority of which are heat related.

The Future of Heating – Meeting the Challenge[11]

4.3.3 In March 2013 DECC produced a policy paper called 'The Future of Heating - Meeting the Challenge'. The paper sets out specific actions to help deliver low carbon heating over the next several decades and provides an assessment of the current situation, the barriers and challenges. The paper addresses industry, heat networks, buildings and the grid infrastructure.

4.3.4 For heat networks the following actions were identified:

- DECC will support local authorities in developing heat networks by establishing a Heat Networks Delivery Unit (HNDU) within the Department that will work closely with project teams in individual authorities.
- DECC will provide funding over two years to contribute to local authorities' costs in carrying out early stage heat network development. This will enable local authorities to bring forward projects to the stage where they are suitable for investment by the Green Investment Bank and commercial lenders
- DECC will seek to endorse an industry-led consumer protection scheme for heat network users later this year, and encourage the heat networks industry to work with consumer groups in developing this practice
- DECC will implement Article 9 of the Energy Efficiency Directive, which covers heat metering
- DECC will work with the Low Carbon Innovation Coordination Group (including the Carbon Trust, BIS, the Energy Technology Institute, the Technology Strategy Board and the Scottish Government) to identify the key technological solutions that require innovation support
- DECC will consider further how heat networks can be better supported as part of the next Renewable Heat Incentive policy review in 2014.

4.3.5 For buildings the following actions were identified:

- DECC will introduce a voucher scheme for installer training to build up the installer base in preparation for the domestic Renewable Heat Incentive
- DECC will pilot a green apprenticeship scheme over the coming year, with the aim of offering 100 places in the renewable heat sector
- DECC will support development of a new consumer guide produced by industry and consumer organisations, improving the way low carbon heating is communicated to consumers and providing advice to installers and intermediaries such as local authorities
- DECC will explore what role tighter standards on building emissions and heating systems could play in achieving the goal of decarbonising heat in all buildings between 2020 and 2050.

[11] https://www.gov.uk/government/publications/the-future-of-heating-meeting-the-challenge

4.3.6 At a national level government is encouraging consideration of low carbon heat networks through the National Planning Policy Framework. The framework expects local planning authorities to identify opportunities for development of decentralised energy supply systems and for co-locating heat customers and suppliers.

Para 94 of the NPPF states "In determining planning applications, local planning authorities should expect New development to comply with adopted Local Plan policies on local requirements for decentralised energy supply unless it can be demonstrated by the applicant, having regard to the type of development involved and its design, that this is not feasible or viable."

4.4 Regional and Local Energy Policies

Outline details on the policy framework for London are summarised below.

The London Plan[12]

4.4.1 The London Plan is the strategic plan for London which sets out an integrated economic, environmental, transport and social framework for the development of the capital to 2031. London boroughs' local plans need to be in general conformity with this plan and its policies guide decisions on planning applications by councils and the Mayor.

London Plan Supplementary Planning Documents (SPDs)[13]

4.4.2 SPDs provide further detail on policies in The London Plan where detailed guidance is required to support implementation. The London Plan SPD that is most relevant to planning for decentralised energy is the Sustainable Design and Construction SPD (a revised draft was consulted on in summer 2013), which includes emission standards for CHP and biomass installations. In addition to advising of standards this document also direct the reader to additional resources where required.

Climate Change Mitigation and Energy Strategy (CCMES)

4.4.3 The Mayor has a duty to prepare and publish a Climate Change Mitigation and Energy Strategy which after consultation was published in 2011. The document sets a target to reduce carbon emissions by 60% of 1990 levels by 2025 by retrofitting homes and public sector buildings with energy efficiency measures, and aiming to supply 25% of London's energy from decentralised energy sources.

London Heat Map and District Heating Manual[14]

4.4.4 The Mayor's Decentralised Energy Programme has produced the London Heat Map and a District Heating Manual for London to support the initiatives provided by City Hall to promote the Mayor's decentralised energy target.

4.4.5 The London Heat Map, which is regularly updated, provides spatial intelligence on factors relevant to the identification and development of decentralised energy opportunities. Local authorities can use the map as the starting point to developing Energy Master Plans to inform decentralised energy policies in their local development frameworks.

4.4.6 The District Heating Manual for London provides practical guidance for developers, network designers and planners with the aim of creating a consistent framework for

[12] http://www.london.gov.uk/priorities/planning/london-plan
[13] http://www.london.gov.uk/priorities/planning/supplementary-planning-guidance
[14] http://www.londonheatmap.org.uk

delivering efficient, interconnecting, district heating networks. One aspect the document addresses in the planning guidance section is the factors to consider when there is a timing mismatch between the construction of a building and availability of district heating, this can in include future proofing and grace periods.

Westminster City Council Planning Policy on District Energy[15]

4.4.7 Policy CS38 of the adopted Core Strategy states:

> "*Infrastructure that is or has previously been in use as part of a heating network will be protected.*
>
> *Major development should be designed to link to and extend existing heat and energy networks in the vicinity, except where the council considers that it is not practical or viable to do so.*
>
> *Where it is not possible to link to an existing heat and energy network, major development will be required to provide site-wide decentralised energy generation that minimises greenhouse gas emissions and has the potential to be extended to serve other development sites in the vicinity, except where the council considers that it is not practical or viable to do so, including where all available technologies would have an unacceptable impact on local air quality.*
>
> *Smaller developments will be encouraged to be enabled to connect into heat and energy networks."*

4.4.8 This strategic policy may be reviewed in light of this report as well as alterations of government policy. Its implementation will also be supported through more detailed policy and application in the emerging Westminster City Plan and Supplementary Planning Guidance on energy and carbon reduction. .

[15] http://www.westminster.gov.uk/services/environment/planning/ldf/corestrategy/

5 PROJECT RATIONALE

5.1.1 The policy summary above contains the following headline targets:

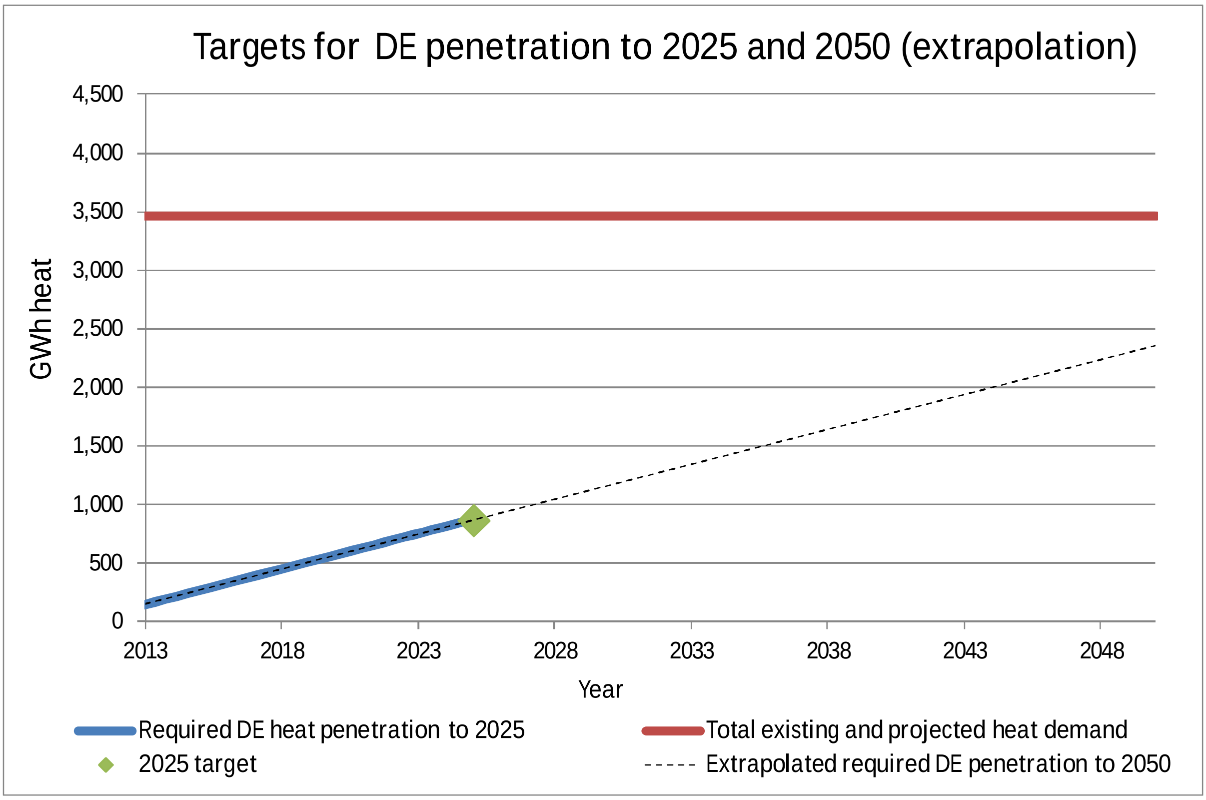
- The UK's legally binding target of an 80% carbon emission reduction by 2050 on a 1990 baseline
- The London Mayor's target of achieving a 60% reduction on a 1990 baseline by 2025, and for 25% of energy to be supplied by decentralised energy

5.1.2 If the target for heat supply is assumed to be the same as for other forms of energy (i.e. power / cooling), then the approximate target for heat distribution by decentralised energy by 2025 could roughly be assessed as 25% of the current demand[16] – i.e. 25% of 3,464GWh – equivalent to 866GWh.

5.1.3 Given that the current level of DE deployment[17] in WCC is very approximately 150GWh (heat), WCC has an obligation to assist in the delivery of these policy targets at the borough level in order to achieve an almost six-fold increase over the next decade to achieve this rough target of 866GWh.

5.1.4 This report also considers a speculative further target for DE broadly in line with a continuation of the same rate of expansion. This is notional, but represents a framework assumption within which the implications of the expansion of DE required to 2050 can be postulated.

Figure 5-1 Illustration of 2025 District Heating target for Westminster and extrapolation to 2050



[16] A further assumption here is that existing demands also reflect total future demands – this assumes that there is an even balance between the intensification of sites that come forward for development, and the improved energy performance of those sites.

[17] Rough figure based on addition of heat demands of PDHU, WDHS, and 'museum area' networks, rounded up to nearest 50GWh. Rounding up assumed to account for other smaller network systems within the borough.

5.1.5 This chart illustrates that on the basis of a straight extrapolation of the current DE penetration and the 2025 target equates to around 2,350GWh of heat supplied by DE by 2050.

Figure 5-2 Summary DE targets (2025 and extrapolation to 2050)

Date	DE penetration (thermal demand)
2013	150 GWh
2025	866 GWh
2050	2,350 GWh

5.1.6 The high density of the urban environment in Westminster in comparison with the majority of other London boroughs can be considered a rationale for delivery of an even higher percentage DE, in order that London as a whole can meet its Mayoral target more efficiently. Meeting the 2025 London target should therefore be seen as essential for Westminster, and the ambition should be to exceed it.

5.1.7 This report attempts to establish and justify where possible *where*, *how*, and *in what form* DE should be implemented in order for these policy priorities to be met. This report attempts to set out how WCC could develop a suite of policies, and other delivery mechanisms in order to progress to this point from the status quo.

5.1.8 The pure energy delivery objectives outlined above cannot be considered in technical isolation from other borough priorities. WCC also has a duty of care in improving the lot of the most deprived within its borough boundary, and hence consideration of how the implementation of DE systems could help alleviate fuel poverty has also formed part of the selection of the schemes recommended within this Energy Masterplan.

6 ENERGY DEMANDS

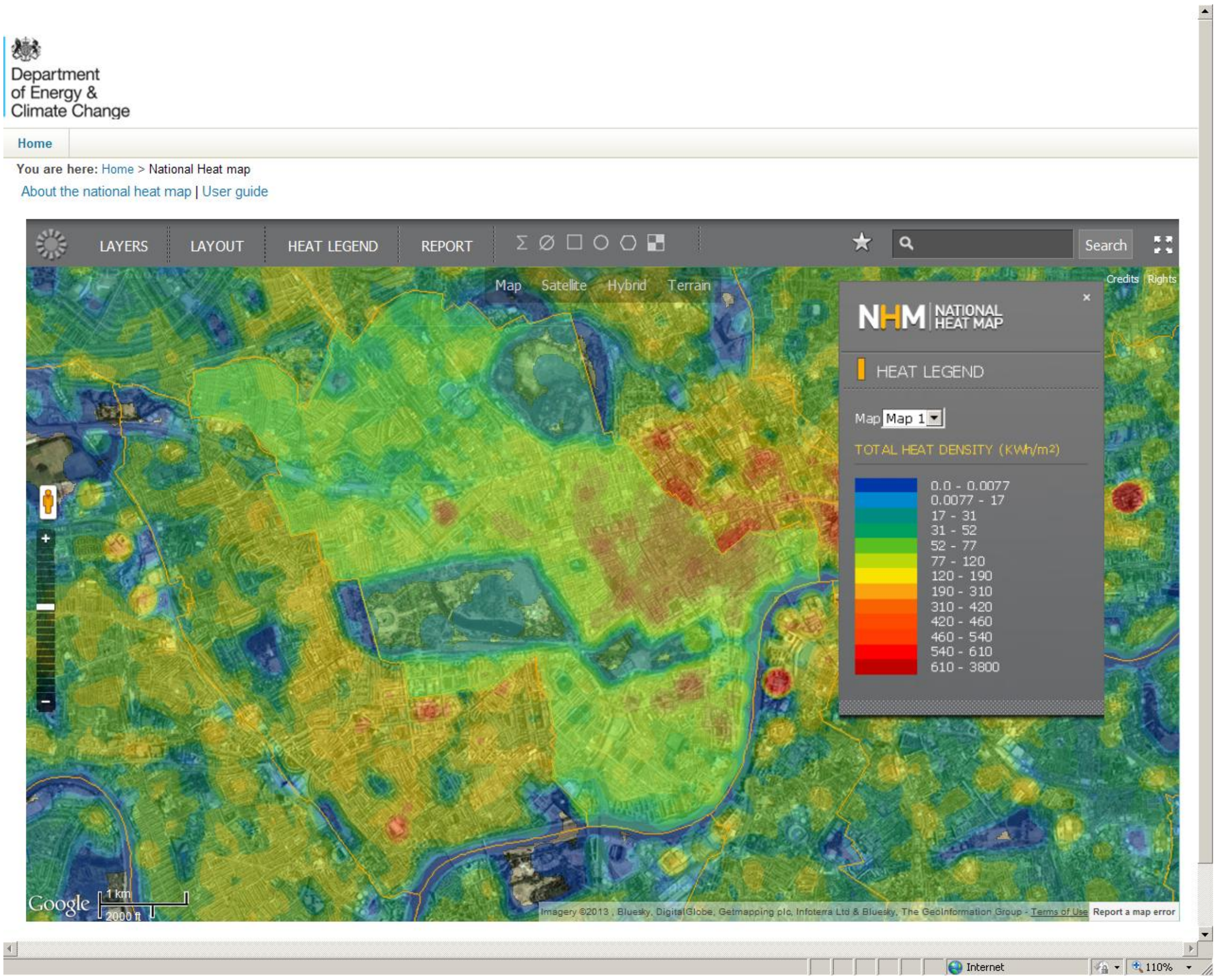
6.1 Energy demand mapping principles

6.1.1 PB has collated data for heating, electricity and cooling demands using the following priority hierarchy of data sources:

- Actual consumption records (existing buildings) (based on the London Heat Map data collection)
- Planning energy statements / other energy modelling results available
- Benchmarked loads

6.1.2 The heat demand distribution across the borough has also been compared with the National Heat Map (NHM) database (DECC) on-line tool[18]. The following heat demand density map has been derived from this tool:

Figure 6-1 National Heat Map Illustration of WCC



6.1.3 This tool uses the following methodology[19]:

[18] http://tools.decc.gov.uk/nationalheatmap/, accessed 1st May 2013
[19] http://tools.decc.gov.uk/en/content/cms/heatmap/about_map/about_map.aspx, accessed 1st May 2013.

"The National Heat Map is built from a bottom-up address level model of heat demand in England. The model estimates the total heat demand of every address in England, but based on published sub-national energy consumption statistics and without making use of metered energy readings.

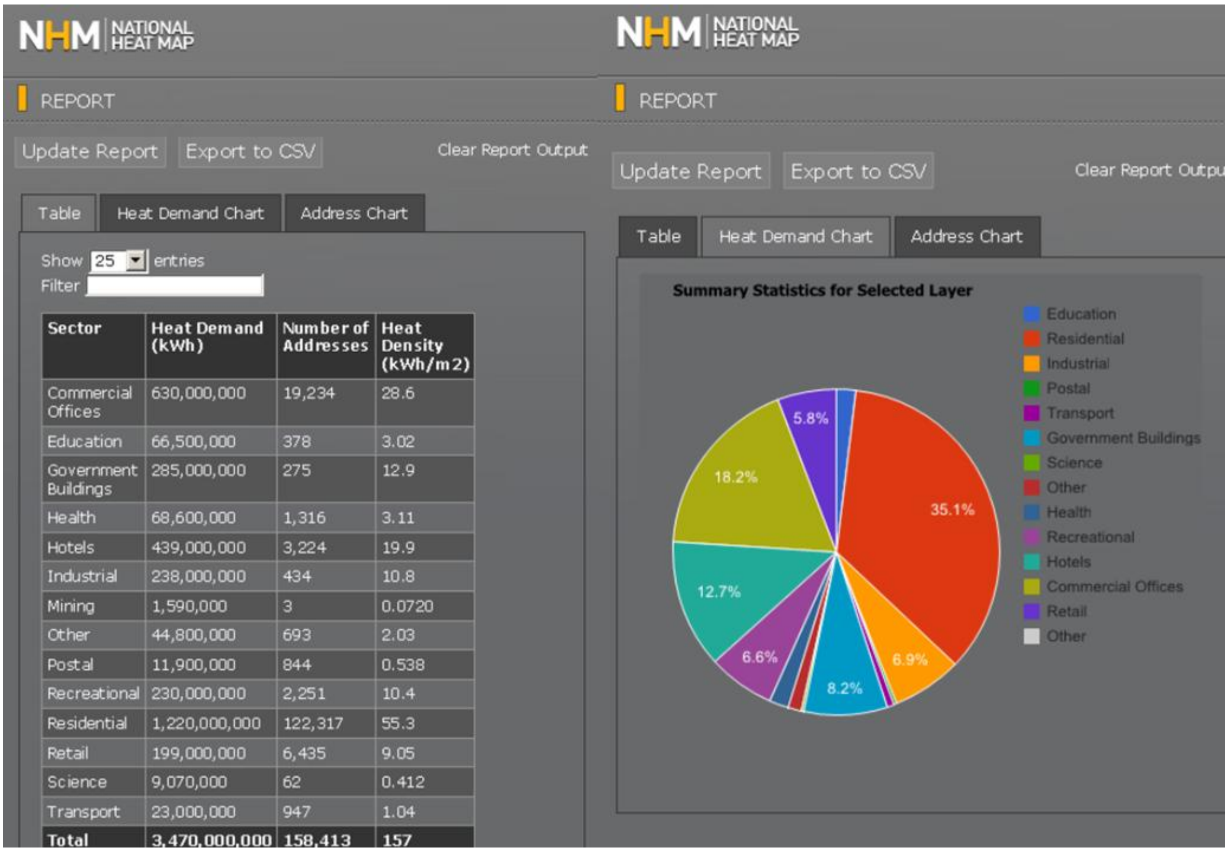
Heat demand density web maps were produced from this model, covering Residential, Commercial, Industrial, Public Buildings (DECs) and Total heat demand.

In addition point locations for Combined Heat and Power plants and Power Stations were mapped along with Local Authority and regional boundaries.

For both residential and non-residential models, heat demand was first estimated at address level using a range of data sources. These estimates were then used in a weighted disaggregation of known small-area average heating fuel consumption. The inputs to the heat demand model are summarised in the following tables."

6.1.4 On a borough-wide basis, this methodology has given rise to the following overall outputs:

Figure 6-2 National Heat Map WCC total heat demand figures



Sector	Heat Demand (kWh)	Number of Addresses	Heat Density (kWh/m2)
Commercial Offices	630,000,000	19,234	28.6
Education	66,500,000	378	3.02
Government Buildings	285,000,000	275	12.9
Health	68,600,000	1,316	3.11
Hotels	439,000,000	3,224	19.9
Industrial	238,000,000	434	10.8
Mining	1,590,000	3	0.0720
Other	44,800,000	693	2.03
Postal	11,900,000	844	0.538
Recreational	230,000,000	2,251	10.4
Residential	1,220,000,000	122,317	55.3
Retail	199,000,000	6,435	9.05
Science	9,070,000	62	0.412
Transport	23,000,000	947	1.04
Total	3,470,000,000	158,413	157

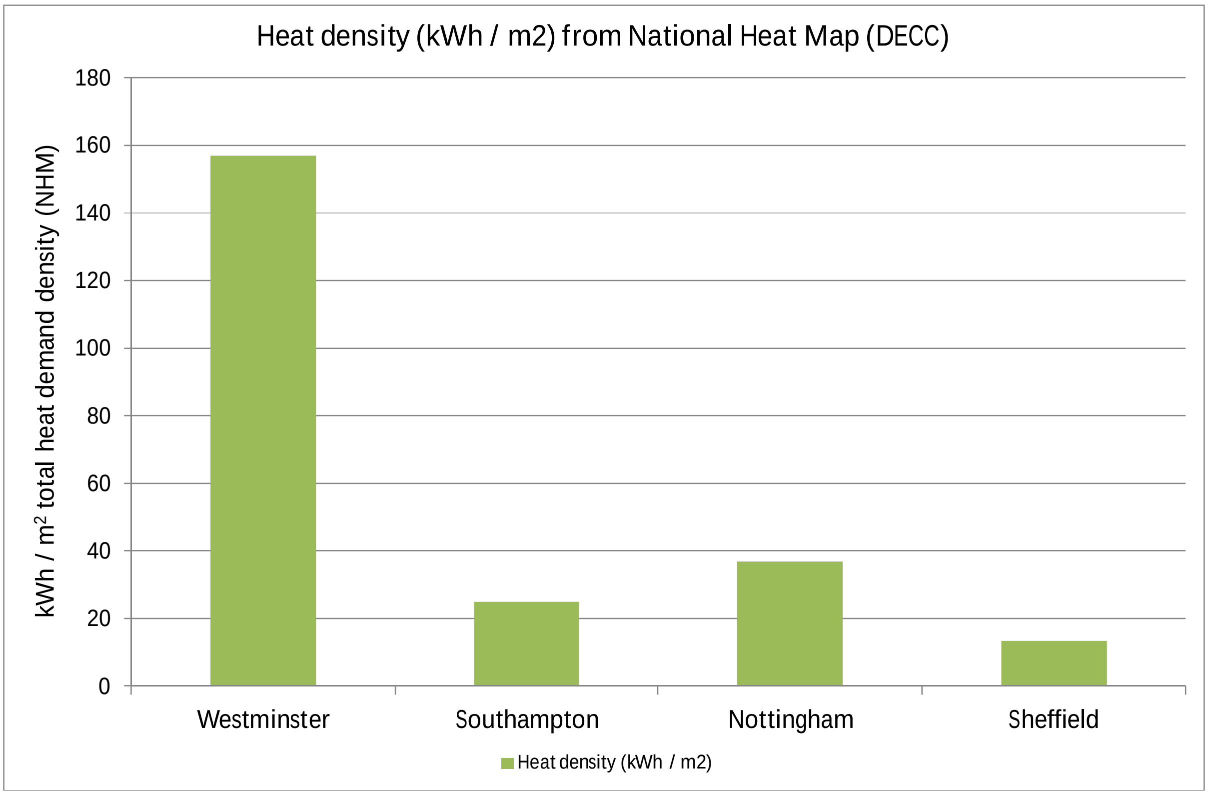
6.1.5 This level (3,470GWh) of heat demand over the borough, and a density of 157kWh/m^2 is indicative of the significant potential for decentralised energy delivery. It has been compared with other UK cities with DE networks operating include Sheffield, Nottingham, and Southampton. The following table illustrates the heat demand density of these cities as derived via the NHM. The comparable maps for Southampton, Nottingham and Sheffield are contained within Appendix A.

Table 6-1 Comparison of heat densities of UK DE cities

Area	Total heat demand (GWh)	Number of addresses	Heat density (kWh / m^2)
Westminster	3,470	158,413	157
Southampton	1,420	108,912	25
Nottingham	2,770	146,351	37
Sheffield	6,360	380,689	15

6.1.6 The different heat demand densities of these localities are shown below:

Figure 6-3 Heat demand density comparison



6.1.7 This graph puts into perspective the apparent potential of Westminster to host DE networks in the light of historical development of DE in other cities in the UK, illustrating that the environment should be conducive to DE installation. This begs the question – "if Westminster's heat densities are so high, meaning that DE should be commercially viable – why hasn't it happened already?" – some tentative answers to this question are included within the section on 'Current barriers to DE deployment' (Section 7).

6.2 Specific area mapping

6.2.1 This study considers the means to encourage the roll-out of DE across all areas of the borough. However, a selection process has been used (by Westminster CC) to focus this study on those areas where there is the most apparent short-term potential for networks to emerge. This process of selection is described below:

- Areas with existing district heating networks (Pimlico District Heating Undertaking, Nova Victoria, Whitehall District Heating System, UCL[20], Bloomsbury Heat and Power[21], Museums area (Natural History Museum[22], Science Museum / Imperial College)

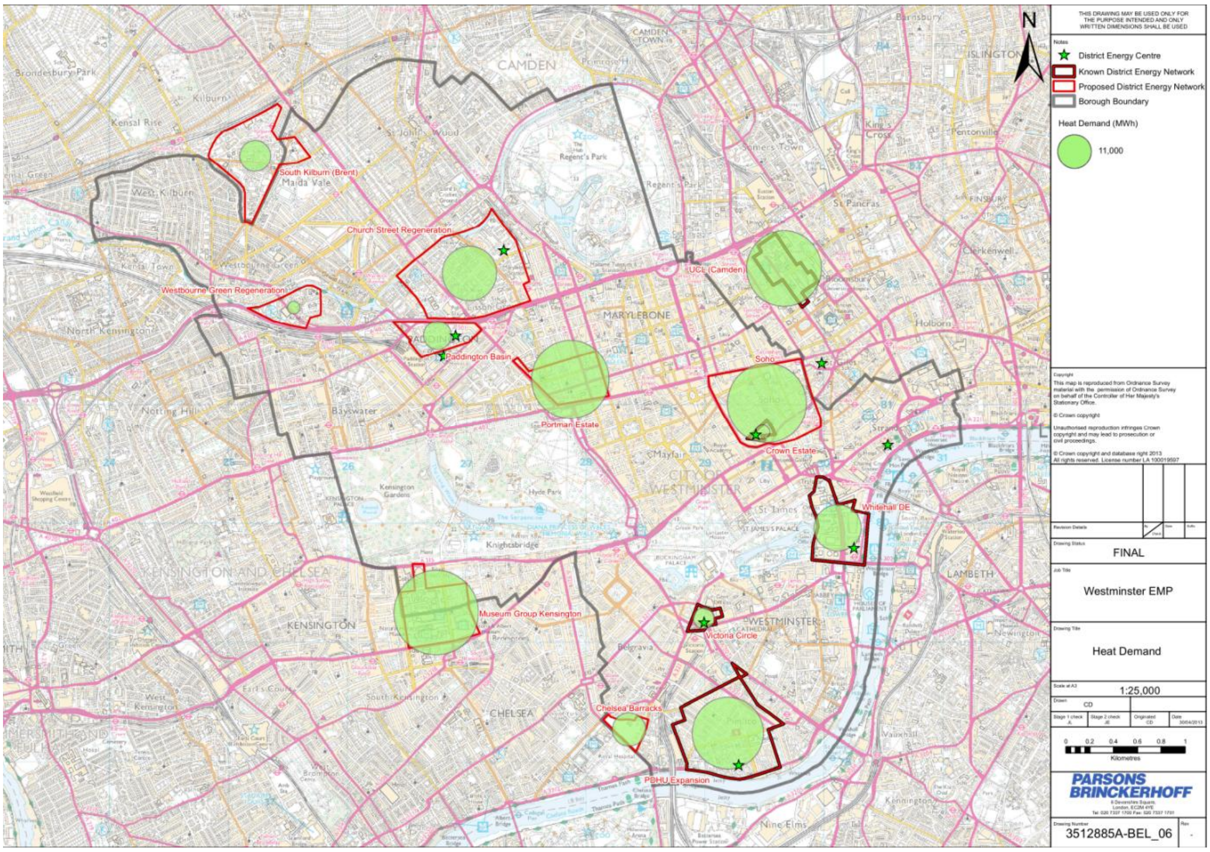
- Areas where significant levels of growth / redevelopment are anticipated over the coming years (Westbourne Green, Paddington Basin, Church Street, South Kilburn, Portman Estate at Marble Arch, Tottenham Court Road area, Chelsea Barracks)

- Areas of particularly high density of existing energy demands (Soho)

- Areas where the council is a major property owner and can exert greater control

6.2.2 These areas are displayed on the map below:

Figure 6-4 Areas of initial focus



6.2.3 These areas represent the focus of immediate opportunities. However, as noted above, this is not to the exclusion of development of DE in the remainder of the borough, which is also considered in this study.

6.2.4 As a general principle, it is has been assumed that the overall borough demands do not significantly change with new development. This approach is considered acceptable given that there are two key typical opposing trends for development –

[20] Outside of the WCC borough boundary, but considered in this report as having significance to DE strategy within WCC
[21] As above.
[22] As above

on the one hand an intensification of site use (i.e. greater useable floor-space for a given site footprint), and on the other hand a significant improvement in energy efficiency (based on the requirements of Building Regulation and planning).

6.2.5 Demands for existing systems / areas have been derived from a number of sources, and combined with data from the London Heat Map. The sources of information that PB has used in order to estimate the demands of the 'focus' areas are listed below:

Table 6-2 Sources of information for specific areas

Area designation	Data source	System type
PDHU	PB project work carried out over a number years on the PDHU system, and recently as part of the analysis of the Victoria Circle to PDHU interconnection	Wet system heat emitters, centralised supply at PDHU pumphouse, 'traditional' design temperatures, LTHW distribution.
Victoria (including Nova and surroundings)	PB project work carried out on behalf of Nova project developer and benchmarks for other sites.	LTHW distribution, designed with low-temperature return.
Museums area (South Kensington)	PB project work carried out at Science Museum, Imperial College and Natural History Museum.	Mixed distribution systems including steam, medium temperature hot water and some LTHW heat recovery
South Kilburn	Invitation to tender documents for Energy Study	Area-wide network anticipated to be designed in line with Mayoral guidance on DE systems
Whitehall District Heating System	PB project work carried out on behalf GPS	Currently MTHW distribution, LTHW use at buildings.
Soho	Estimated through benchmarks	Mixed, multiple sites. Assumed to be significant number of leaseholders with electric heating systems
Chelsea Barracks	Planning application documentation	LTHW system
Paddington Basin	Mix of published information on developments and benchmarking	Assumed to be LTHW for the most part, although this is unconfirmed.
Church Street	Arup report	LTHW distribution
Westbourne Green	Mix of published information, existing block consumption information from WCC, and benchmarks	Existing blocks are electrically heated. Assumed that new development would be LTHW.
Portman Estate (nr Marble Arch)	GLA preliminary analysis presentation (Feb 2013)	Area-wide network anticipated to be designed in line with Mayoral guidance on DE systems

Table 6-3 Key DE area system demands

Area designation	Heat demand (MWh)
PDHU	48,440
Victoria (including Nova and surroundings)	3,996
Museums area (incl NHM and Victoria &Albert system)	67,600
South Kilburn	9,104
Soho	59,059
Whitehall District Heating System	20,825
Chelsea Barracks	10,623
Paddington Basin	7,395
Church Street	27,822
Westbourne Green	1,508
Portman Estate	57,000
TOTAL	**313,372**
…of which existing (PDHU, WDHS, museums)	136,865

6.3 Scale of borough demand vs new build

6.3.1 On the basis of an assumed level of 326 major applications per year across the borough (based on last 5 years figures), each with an average demand of 62MWh p.a. (based on current average per site demand for non-domestic sites) – this is equivalent to 'new demand' of 20.2GWh per year. This compares with the borough demand as a whole of 3,470GWh. This is equivalent to around a replacement rate of 0.6%, and illustrates that theoretically, more than 100 years would be required before there is planning system opportunity for intervention for the majority of systems.

6.3.2 This comparison of the level of demand from new builds and planning applications with the demands from existing building stock illustrates the importance of making use of planning applications (particular larger scale sites) to leverage access to existing stock, where greater positive impacts can be generated. One mechanism by which this could be accomplished is 'allowble solutions' (see section 18.8.2)

6.3.3 This is also important from the perspective of 'additionality' of carbon savings. New applications will be governed by the requirements of Building Regulations and planning law, and under all circumstances (i.e. irrespective of the recommendations of this energy masterplan) will be required to achieve high levels of energy efficiency and low-carbon energy supply. These requirements could be supported through the delivery of district and community heating. However, when consideration is given to existing stock neighbouring planning application sites, additional savings can be achieved through accessing this existing stock, which would otherwise have no impetus to improve their own carbon efficiency.

6.4 Stakeholder discussions

6.4.1 In addition to assessing energy demands, PB has also engaged with various stakeholders in order to understand the drivers of key organisations with influence over general anticipated trends of energy use across the study period.

6.4.2 The Westminster Property Association[23] (WPA)

6.4.3 Representatives of the WPA were invited[24] to contribute their views on the objectives and approach that this study should take, and to provide insight into the 'developer' attitude to DE development.

6.4.4 The following represents a summarised interpretation of some of the key issues raised at this session:

- Programme, cost and confidence in delivery of the DE network are all key elements for a developer considering the connection to a DE network.
- 'Liquidity' is a key element of the developer market – i.e. the ability to sell a site without encumbrance of the responsibilities to supply other sites with energy into the future. It is of importance to developers to have a 'detachable asset' to trade. This points strongly towards the preference to be able to treat district energy as another statutory utility where connection is a simple matter, and where transfer of responsibilities and suppliers between organisations on sale is a simple, established procedure.
- There are still confidence issues in the DE market – i.e. that potential connectees to a DE system are not certain of having the same degree of personal control of the delivery of energy / cost as they might do under an own plant scenario.
- Land value for energy centres is a clear problem in Westminster, where alternative uses will deliver greater economic benefit to developers. This points to the need for an alternative mechanism of finding energy centre locations than has historically been the case (i.e. historically there has been a reliance on planning gain in individual developments to fund the increased space requirements for wider area network energy centres).
- The point was raised that an end-game target might be a system such as that in Malmo, Sweden, where there are a number of heat sources and heat recovery mechanisms integrated into a cycle of high overall resource efficiency. Equally, we should take lessons from both success stories and less successful projects within the UK. The case of Citigen was noted as an example of a project in a similar, high-density environment.

6.4.5 PDHU

6.4.5.1 PB had a brief opportunity to consult with David Wickersham on the future of PDHU within the context of this study. This lead to consideration of some wider elements of policy and heat market regulation:

[23] http://www.westminsterpropertyassociation.com/
[24] Meeting held with WPA representatives on 1st May 2013, WCC offices.

- PDHU is one of the few long-term DE operations in the UK. The importance of consumer satisfaction and protection was raised, linked to questions on the form of future regulation of the heat market.

- The political dimension of PDHU's operation and its ownership was also raised, and whether there might be appetite within WCC to use the basis of PDHU's experience in operation to form a wider energy delivery vehicle.

6.4.6 Government Procurement Service (GPS)

6.4.7 GPS currently own and operate (via Cofely) the gas turbine and top-up and standby boiler plant that serve the Whitehall district heating system (WDHS), and the Whitehall standby power distribution system (WSDS). Recent liaison with GPS indicated that there are concerns surrounding the potential link between the WDHS system and outside customers, and that in order for the supply of third-party customers to be acceptable to GPS, various changes would have to be implemented. This is discussed in greater detail in section 12.2.

6.4.8 Others

6.4.9 Buro Happold (BH) waste heat sources – PB liaised with BH on the work that BH has carried out on the availability of waste heat within the London area. This work is discussed in sections 8.4 and 11.5.

7 CURRENT BARRIERS TO DE DEPLOYMENT

7.1.1 As noted in the heat demand (section 6), at the level of technical potential, it would appear that there is an excellent opportunity throughout the borough's built environment to implement district heating. However, if this is the most efficient and economic solution, why has it not happened already?

7.1.2 This section draws on recent research commissioned by DECC[25], and PB's own experience of DE implementation.

7.1.3 Factors with the greatest impact on DE deployment identified in DECC's report are replicated below in Table 7-1. The colours and number of asterisks after each point reflect the relative impact on heat network projects.

Table 7-1 Barriers to establishing a heat network (Exec Summary, table 1, DECC, 2013)

	Local Authority Led	Property Developer Led
Objective setting and mobilisation	• Identifying internal resources to instigate scheme and overcome lack of knowledge (**) • Customer scepticism of technology (*)	• Persuading building occupants to accept communal heat (mandated by the planning authority) (*)
Technical Feasibility and Financial Viability	• Obtaining money for feasibility/viability work (***) • Identifying and selecting suitably qualified consultants (**) • Uncertainty regarding longevity and reliability of heat demand (*) • Uncertainty regarding reliability of heat sources (*) • Correctly interpreting reports prepared by consultants (*)	• Selecting suitably qualified consultants (**) • Uncertainty regarding longevity and reliability of heat demand e.g. lack of heat demand in new buildings (*) • Uncertainty regarding reliability of heat sources (*)
Implementation and Operation	• Paying the upfront capital cost (***) • Obtaining money for independent legal advice (***) • Lack of generally accepted contract mechanisms (**) • Inconsistent pricing of heat (**) • Up-skilling LA procurement team on DH (*)	• Concluding agreement with energy services provider including obtaining a contribution to the capital cost (**) • Lack of generally accepted contract mechanisms (**) • Inconsistent pricing of heat (**)

7.1.1 This Table 7-1 highlights that it is the upfront capital costs for both study work, legal fees and the installation costs of networks that are the most frequently cited barrier to DE installation. This can be condensed arguably into the statement that it is the risk of investment and the difficulty of sourcing capital for DE systems that is the most significant barrier to DE deployment currently. **A key challenge of this study**

25 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/191542/Barriers_to_deployment_of_district_heating_networks_2204.pdf, March 2013, accessed 14th June 2013, Research study by BRE, University of Edinburgh and the Centre for Sustainable Energy for DECC.

is therefore to identify how, and where, efforts should be applied to help overcome these barriers (particularly of raising capital for initial deployment) to allow deployment to accelerate.

7.1.2 Table 7-1 seems to represent the key barriers to DE once a scheme has been identified, but for the built environment in Westminster a further set of challenges could also be associated with the identification of suitable network for feasibility / viability testing:

- Difficulties in creating and maintaining a database of DE compatible installations
- Lack of powers of intervention when buildings are not part of the planning system (i.e. not submitting a relevant planning application)
- Identifying appropriate thresholds of heat density when a heat network might become viable

7.1.3 Means of moving towards a system that circumvents or overcomes these issues are suggested in section 18 (Delivery).

8 HEAT DISTRIBUTION

8.1.1 The optimisation of phased growth of heat distribution infrastructure is central to this project. PB's proposed approach has been to develop a strategy for network growth that joins key loads within an appropriate timescale, and which minimises the need for interim, piecemeal energy supply plant. However, clearly in areas of low density, or where there is little prospect for short-term DE deployment, it will be unavoidable to operate individual low-carbon, on-site solutions to meet planning or other environmental requirements.

8.1.2 A further factor in devising a strategy is an understanding of the degree to which already consented (or soon to be consented) development can be required to connect to networks that are not fully certain to emerge. In this context, the guidance of the District Heating Manual[26] is adopted. This states:

Figure 8-1 Extract from 'District heating manual for London', GLA, p.66

Where there is a DH network being delivered but there is no programme to connect the development due to its distance from the network and the lack of plans for intervening sites:

- The development should be designed on the basis of its own CHP with standby boilers etc, and 'future-proofed' according to the guidelines given above;
- Allowance could be made to defer investment (installation) in the CHP plant for, say, five years to allow time for the DH to be constructed and connected to the network. Once the network connection is made, the requirement to install CHP falls away.
- If the DH network connection is not made within five years and there is no reasonable prospect of doing so, then the development

26 http://www.londonheatmap.org.uk/Content/uploaded/documents/DE_Manual_for_London_February_2013_v1.0.pdf, accessed 14th June 2013, pdf page 66 (section 8.2.2)

should be required to install CHP. A planning obligation could be employed from the outset to ensure the CHP installation is carried out.

- During the five year period, the development will be supplied with heat from its own heat-only boilers noting that the environmental benefits will not accrue until either the DH network connection is made or CHP installed.
- The developer could be given a planning condition allowing any 'freed-up' plant space resulting from the DH connection to be used for more profitable purposes.

8.1.3 In general, when DE network assets are designed, some key principles should apply:

- Buried pipework assets installed at the inception of a scheme's emergence must be of sufficient capacity to serve the anticipated final expansion loads of the scheme. This should include allowance for clearly defined capacities (and temperatures) of future connections, if appropriate. Heating plant should be installed in a modular manner to ensure maximum efficiency over periods of expansion
- Network assets must be 'maintainable' – i.e. in areas to which the scheme operator will have access
- Network specification should fit the aspiration for this infrastructure and be a long-term (i.e. 40+ years) asset that will benefit future energy supply system changes
- Networks should avoiding major road routes where possible to minimise cost and disruption in installation.

8.2 Heat network sizing

8.2.1 The calculation of the size of network connections has been carried out on the basis of assumptions regarding temperature differentials between flow and return pipework, and pipework characteristics as shown below.

- Flow temperature – 95 deg C
- Return temperature – 65 deg C (accounting for a mix of existing and new connections)

Table 8-1 Network design characteristics

		SPINE		Branches (final connections)	
mm nominal diameter	Actual ID (Seamless Steel) (mm)	Max allowable pressure drop (pa/m)	Max velocity (m/s)	Max allowable pressure drop (pa/m)	Max velocity (m/s)
32	36.1	200	0.75	200	0.75
40	42	200	1	200	1
50	53.1	200	1.15	200	1.15
65	68.8	200	1.5	200	1.5
80	80.8	200	1.75	200	1.75
100	105.1	200	2	200	2
125	129.7	200	2.5	200	2.5
150	155.2	200	3	200	3
200	211.9	200	3	200	3
250	265.8	200	3.5	200	3.5
300	315.9	300	3.5	300	3.5
350	347.6	300	3.5	300	3.5
400	398.4	300	3.5	300	3.5
450	448	300	3.5	300	3.5
500	499	300	3.5	300	3.5
600	601	300	3.5	300	3.5

8.2.2 An allowance of 15% above frictional pressure losses has been included to account for bends and fittings.

8.2.3 The size of connections and hence costs of network development is driven by the temperature differential that can be achieved across consumer connections. A 10 deg C reduction in return temperature would increase the capacity of connection by 20% for no increase in network capital or operating cost. This level of return temperature reduction is easily achievable but it requires an enlightened, different approach by building system designers. This approach will have a minimal impact on building costs at construction but will cost considerably more as a retrofit. Ensuring that this change is implemented as widely as possible will require a combination of incentives, lower connection charges, guidance and requirements through planning conditions or similar. The added potential future benefit of such changes is discussed in section 8.4.

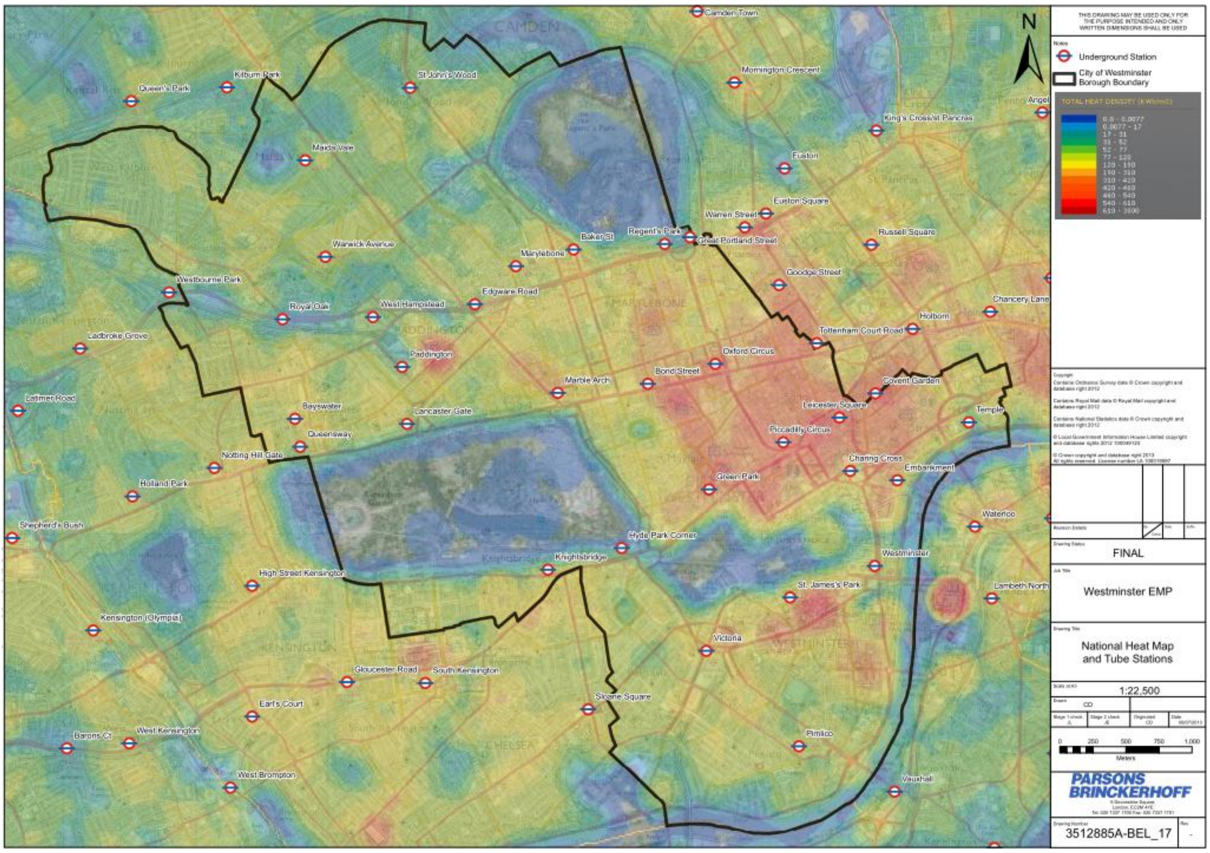
8.3 Network design / materials

8.3.1 For the network installation within the borough for heat (and chilled water) distribution, PB recommends the use of steel pre-insulated pipework. The key alternative technology on the market currently is plastic pre-insulated pipework. This alternative system can have significant benefits in terms of reducing the labour-intensity of installation (by reducing the need for welded joints) and can help reduce overall installation costs. However, particularly at higher temperatures (i.e. 90 deg C and above), the longevity of the plastic systems is considerably reduced. Equally, larger diameters of plastic pipework are not available (particularly relevant for cooling networks), and hence the primary recommended area for its application is in lower temperature, local heat networks.

8.4 Opportunity to use waste heat

8.4.1 Parsons Brinckerhoff has considered the use of waste heat sources in the borough to supply the network with low carbon energy. There are two potential identified significant waste heat sources in the area: the underground, where heat is emitted through ventilation shafts or from new stations; and electricity substations, where heat is emitted from large transformer equipment. A plan illustrating the location of underground stations in relation to existing heat demand is included in Appendix 20.4, and at lower resolution below. It should be noted however, that ventilation shafts do not always coincide with station locations, hence this is only indicative of potential. The heat density illustrated below is derived from the National Heat Map.

Figure 8-2 Tube stations and heat density within WCC



8.4.2 This map illustrates that particularly high densities of heat demand are close to the stations surrounding Soho, Green Park, Bond Street, Marble Arch and St James's Park.

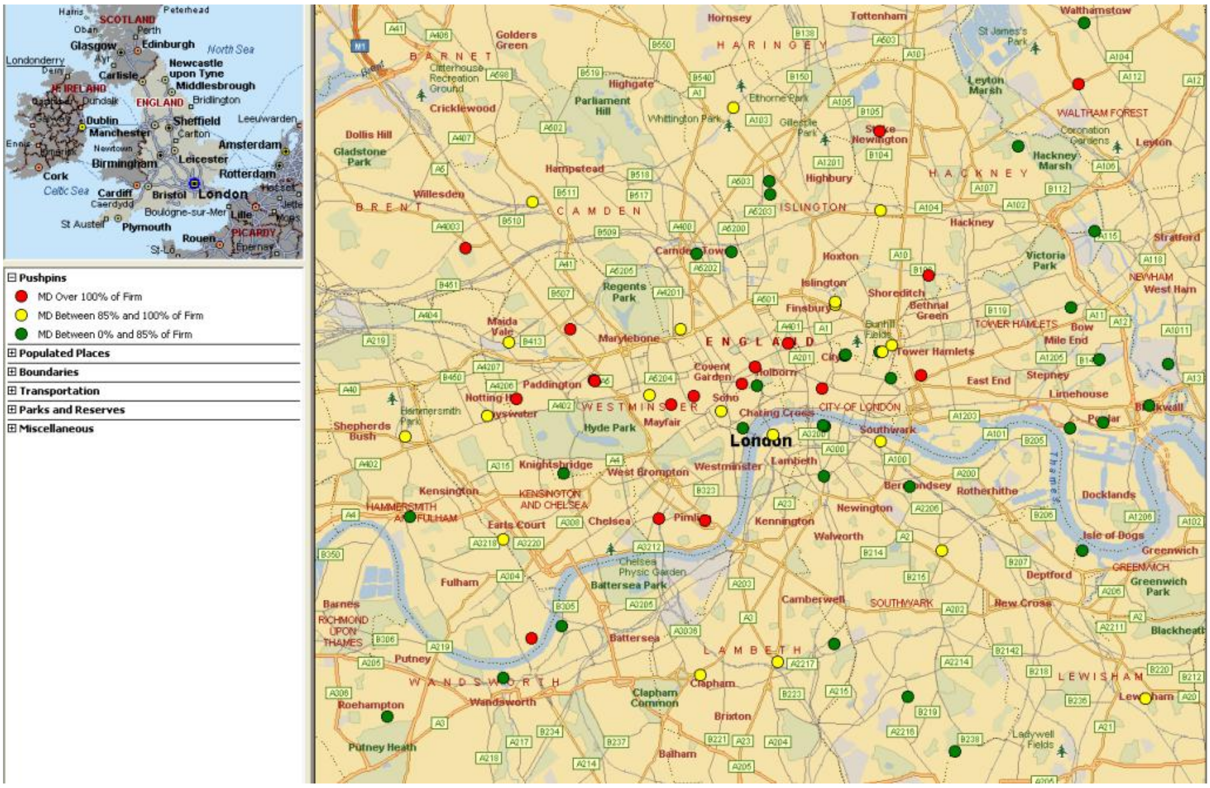
8.4.3 Of these stations, Green Park is particularly highlighted as a site with potential to utilise available 'waste heat'. A ground-sourced cooling system has recently been installed at Green Park Station. This abstracts water from a borehole within the park area to the south-west of the station at a rate of approximately 25l/s, and circulates this water in air-handling units within the station. The warmed water is then re-injected to ground in a second borehole at the eastern edge of the park. Typical operating temperatures would be 14 deg C extraction, and 24 deg C re-injection.

8.4.4 The investigation of the opportunity to cool the re-injection water from 24 deg C to approximately 4 deg C and distribute the available heat to local major heat users should be investigated. As a portion of this available heat is derived from natural ground source energy, this portion would benefit from renewable heat incentive support. The 20 deg C temperature differential that the 're-cooling' of the abstracted water would allow means that this could be an efficient source of energy for a heat network local to Green Park station. The key difficulty in the establishment of a network in this area will be establishing long-term heat purchase contracts with the commercial organisations that might take heat from the network. This is an example of a scheme where there is a role for the public sector to de-risk the initial installation to allow the scheme to establish itself and demonstrate commercial viability, which should then allow for system expansion.

8.4.5 Substations

8.4.6 The recovery of heat from substations is initially thought only to be likely to be viable from primary substations. The following chart illustrates the current locations of these assets:

Figure 8-3 UKPN primary substation asset locations



8.4.7 It can be seen that there is a concentration of these assets within the central area around Soho, Covent Garden, Holborn, Mayfair. However, also of note are substations close to the Pimlico DE network (by Vauxhall Bridge Road), and close to the Church Street redevelopment area (also to be served by DE). PB would suggest that in the shorter term these two substations represent potential opportunities that should be investigated for connection to the existing or emerging DE networks of these areas. It is recommended that the lessons learned and outcomes of the European-funded Bunhill scheme in Islington are closely followed, and that following this project's completion, the potential for replication within Westminster be investigated.

8.4.8 River Thames

8.4.9 The large volume of water within the Thames should also be considered an exploitable natural heat source. Again, the location of PDHU's energy centre close to the river would suggest that if the commercial viability could be proven, the supply of heat from the Thames into the PDHU network is a possibility worth investigating.

8.4.10 Other sources

8.4.11 Other heat sources noted in the GLA's recent study[27] on secondary heat sources include, air source and ground source, power station heat rejection, building cooling system heat rejection, industrial sources, water treatment works, and sewer heat mining. The most relevant to Westminster from this list would be building cooling system heat rejection. Given the large number of offices and computer facilities within the borough, this is a very relevant category of secondary heat source. Server facilities have year-round heat rejection, and the recovery of this rejected heat could provide a DE network with a base-load supply of useful energy. However, as the source of this heat is not 'renewable' the RHI does not currently support heat that makes use of this 'waste energy' and the economics of this combination of source and heat-pump are therefore marginal.

8.4.12 This leads to the recommendation for central government to support the re-use of waste heat that would otherwise have been rejected to the atmosphere. It might also be possible to introduce a 'tax' on heat rejected to atmosphere, albeit this would require the introduction of new monitoring and reporting requirements, and PB is not aware of this type of system in place in any other locations.

8.4.13 Benefits of waste heat utilisation

8.4.14 The benefits of using waste heat to supply a district network include: potential for carbon reduction, as waste heat itself is normally considered to be carbon neutral (or very low carbon); it reduces reliance on volatile and increasingly expensive fossil fuel markets to supply the network with heat; without pre-empting any commercial arrangements with potential waste heat suppliers, it is not commoditised and is therefore likely to be available at low cost. There are, however, some key considerations in supplying a DE network with waste heat.

8.4.15 Waste heat by definition is likely to be low grade and therefore not suitable for district heating in its primary state. In this instance, it is necessary to 'step up' the grade of the heat so it is at a suitable operating temperature for district heating. This is done using a heat pump, which uses electricity as part of the process. The efficiency of this process (i.e. the amount of electricity required) is a product of the grade of the waste heat and the required 'step up'.[28] Typically, under current market prices, a DE network supplied with waste heat via heat pump must operate at low temperatures (see section 10.5.1) in order for the cost of heat generation to be lower than a gas boiler alternative method of heat generation.

8.4.16 For efficient operation of a low temperature network, secondary systems should be designed to maximise heat transfer and thereby minimise return temperatures. This can be achieved using large radiators and/or under-floor heating or similar. Note that this is considered best practice for district heating networks, regardless of the network flow temperature, as it makes for a more efficient delivery of heat and, ultimately, reduced costs. As such, **Parsons Brinckerhoff strongly recommends that planning approval for development within the borough is subject to secondary system designs that are compatible with delivering low return temperatures to a district heating network**. **At detailed planning stage, careful assessment of major applications must take place to ensure that the proposed designs at a detailed technical level are suitable to deliver low return temperatures to a primary network under the full range of anticipated operating conditions.**

[27] Mayor of London, London's zero carbon energy resource – secondary heat, July 2013, Summary Report, p10.

[28] Parsons Brinckerhoff recently completed a study looking at the viability of heat pumps in district heating networks, which concluded that cost and carbon savings are achievable under the right conditions.

8.4.17 The assessment of major applications in terms of energy delivery systems should be carried out by officers with a suitable understanding of the issues involved, and could potentially be 'scored' by Westminster on the basis of a template that is developed for this purpose.

8.4.18 The use of secondary designs delivering lower temperature returns will also enable the future integration of lower flow temperatures. This could in turn lead to the sourcing of heat from a more diverse set of 'waste heat' sources including ventilation shafts, transformers at substations, etc. This is thought to be particularly relevant to summer periods, when low space heating demands mean that network flow temperatures can be reduced significantly, at the same time as there is typically greater availability of 'waste heat' from cooling operations.

8.4.19 It is proposed that one aim of the strategic design of energy supply systems must be to increase overall efficiency in energy delivery. One means of achieving this is through the re-use of 'waste heat' when appropriate efficiencies can be achieved. Therefore, whilst this study cannot with certainty predict the pattern of waste heat supplies and potential system flow temperatures, it is recommended that the following principle should be adopted. **It is recommended that where possible allowance should be made in design to accommodate the use of 'waste heat'. This should include centralisation of chilled water heat rejection plant within developments, co-locating heat delivery stations close to sources of waste heat, and ensuring that systems operate on variable flow, variable temperature principles as outlined in the London District Heating Manual.**

9 ELECTRICITY

9.1 Electricity infrastructure masterplanning

9.1.1 One element of the development of an EMP for the borough is that electricity network infrastructure must be capable of supporting the integration of decentralised generation. This section describes the electrical connection of CHP to the UKPN network. It considers the potential to 2050 to expand the coverage of DE networks and local generation within the borough.

9.1.2 This section:

- Comments on the UKPN Long Term Development Statement Document (LTDS)
- Comments on the constraints of adding Distributed Generation (DG) due to fault level and the possible advantages to UKPN resulting from negation of the requirement for network reinforcement.
- Summarises the generalities of the process of applying for connection of a generator. In addition, it will cover potential changes to the application system that we would perceive to be desirable (in the context of wanting to see an acceleration of decentralised energy deployment), and any actions that Westminster as a borough could take in order to help lobby / deliver changes to the system.

9.1.3 UKPN Long Term Development Statement (LTDS)

9.1.4 As part of the regulatory requirements, UKPN provides a load forecast for the next 10 years and as such the reinforcement plans are relatively accurate within this timeframe, forming part of their submission to OFGEM for each distribution price control review (DPCR).

9.1.5 A 40 year forecast is very difficult especially as new strategies are being developed as part of the Low Carbon Transition Plan. UKPN is moving towards smart grids with new projects under evaluation/test which will also enable an increasing number of DGs to be connected to the network.

9.1.6 The LTDS has been found to be out of date with respect to the DG already connected. Therefore it is not very useful in determining whether additional DG may be connected. This has been raised with UKPN, by PB, at their DG Customer Experience Workshop and UKPN have committed to increasing the frequency and completeness of data updates. In the mean time the assessment of generation connections needs to be done case by case.

9.1.7 A new team within UKPN was recently formed to focus on several projects in London including enabling and integrating distributed generation.

9.1.8 High Fault Level

9.1.9 From a UKPN perspective, and in Westminster in particular, the connection of medium scale generation (~5-20MVA) may be limited by an available 11kV or 33kV point of connection (usually at a primary or grid substation) and high fault level.

9.1.10 Substations in Central London often have a high fault level due to substantial generation connected. This can be mitigated by changing the network running arrangement (for example opening the bus section) resulting in operational constraints and increased network risk. There are other solutions such as replacing low fault rated equipment or installing fault current limiters which are under review.

9.1.11 The connection of additional generation will increase the fault current.

9.1.12 There is also a potential impact on power quality, network losses and load flow due to the addition of DE.

9.1.13 The fault rating of existing equipment (specifically circuit breakers) can limit the amount or available point of connection for generation. This is the result of several factors such as age of equipment, location and density of the network.

9.1.14 PB is involved in a research project to investigate the application of Fault Limiting Reactors to the UKPN network.

9.1.15 Network Reinforcement

9.1.16 Depending on the type and availability of the generation to operate when required by UKPN, the connection of DE may be an option to avoid network reinforcement (i.e. upgrade of transformers, cables, etc). Implementation of DE, especially at lower voltage level, may result in a decrease of demand from the upstream network. For example on 33/11kV primary substations where the demand is close to or above the firm capacity (capacity available immediately following an N-1 situation) UKPN would consider several options such as load transfer to adjacent substations or reinforcement (increase firm capacity).

9.1.17 If generation is connected to the 11kV network (and available when required) it will decrease the demand from the primary substation to values below the firm capacity thus removing the need to reinforce. This is a simplistic view as it will depend on factors such as type of generation, availability and network topology. It will also require a greater visibility and control of the network as the generation will mask the load of that feeder/substation. PB is involved in an on-going project to investigate the application of Active Network Management (ANM) and Demand Response (DR) to DE connected to the UKPN network.

9.1.18 Application Process

9.1.19 The Energy Networks Association (ENA) has developed a Common Application Form on behalf of DNOs and UKPN accepts this.

9.1.20 The application process allows for preliminary discussions with the DNO prior to submission of an Application Form. However, previous experience has shown that UKPN are reluctant to hold any discussions without having first received an application form to allow them to allocate a project reference number and to be in possession of pertinent data relating to the project.

9.1.21 If, as is usually the case, final data for the generator is not available at this early stage then generic information should be provided. On the basis of this, UKPN will discuss the project and will provide a budget estimate which can be turned into a formal quotation at a later stage.

9.1.22 Issues relating to the difficulty of making initial feasibility decisions from the LTDS and of gaining access to UKPN engineers for early discussions have been raised with UKPN, by PB and others, at their DG Customer Experience Workshop. UKPN have undertaken to take measures to improve the accuracy and comprehensiveness of information within their LTDS and to improve access to the appropriate engineers for preliminary discussions at an early stage in projects. As a result of PB's involvement over many years with UKPN on projects within London we already have good working relationships with UKPN engineers and this facilitates access for such early discussions.

9.2 Decentralised energy and power resilience

9.2.1 The UK is currently operating a fleet of power generation stations that has significant numbers that are approaching life-expiry. At the same time, price and policy uncertainties mean that there is no new capacity planned to be built before 2016. This will lead to a tightening of the margins of generation capacity over demand, as described in the following report by Ofgem[29]:

Figure 9-1 Excerpt from Ofgem Electricity Capacity Assessment Report 2013

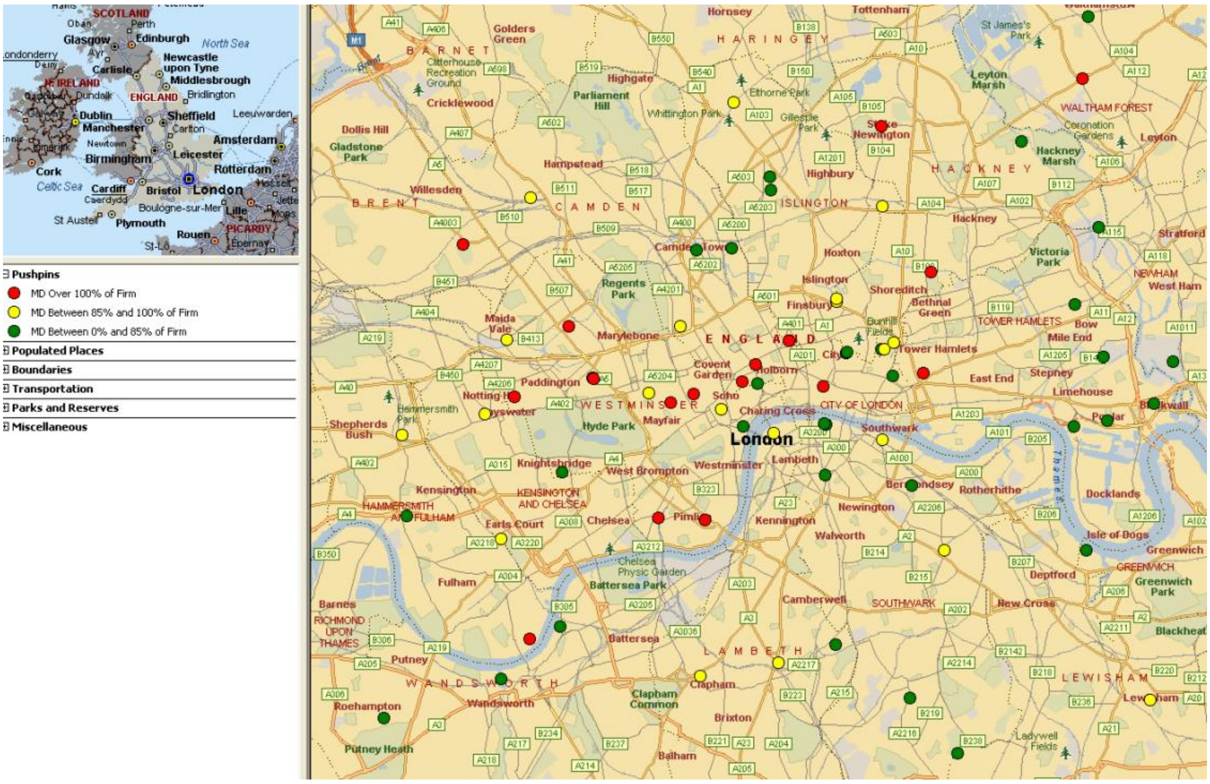
> To illustrate the potential impact on customers, we estimate in the Reference Scenario that the probability of a large shortfall requiring the controlled disconnection of customers increases from around 1 in 47 years in winter 2013/14 to 1 in 12 years in 2015/16. This increases significantly to around 1 in 4 years if the demand reductions fail to materialise. Aside from the potential for controlled disconnections, any tightening in de-rated margins could impact customers through an increase in wholesale prices.

9.2.2 This suggests that particularly over the coming years (i.e. to 2015), and presumably to a lesser degree into the longer-term future there is a significant risk of supply failure due to lack of generation capacity.

9.2.3 At the same time, there are also challenges faced in terms of power distribution. There are key areas of development within the London area that are faced with ensuring that they have an adequate power resilience in terms of distribution. This is related to the discrepancy between the regulation that governs the level of investment that distribution network operators are authorised to make (and pass on to customers), and the timeframes that larger development sites are working to. For example, the approx 15 year development timeframe of the development of Nine Elms on the Southbank cannot (from a formal regulatory point of view) fully be taken into account in terms of the level of investment that the transmission / distribution network operators are authorised to make. This could lead to the inefficient solution of an interim substation sized for early-years growth, which then has to be replaced at a later date with a unit with greater capacity. This illustrates that there is likely to be a continuing strain on network apparatus capacity, and that substations are frequently operating a close to capacity. This situation is also illustrated by the following plan.

[29] Ofgem, Electricity Capacity Assessment Report 2013, June 2013, page 6

Figure 9-2 Maximum demand vs firm capacity illustration



9.2.4 This figure illustrates that within the Westminster area there are a number of substations that currently operate at greater than 100% of *firm* capacity (red dots) at times of peak demand (implying a risk of inability to meet peak demands if one element of the plant fails). This does not imply adequate resilience in the system, and is indicative of the constraints on investment that the regulatory framework imposes.

9.2.5 CHP is not generally seen as a means of increasing the electrical resilience of a site. This is largely due to CHP's inherent need for maintenance on a regular basis, and the fact that gas-fired units are typically only available for operation for around 92%-94% of the year due to mix of scheduled and unscheduled maintenance outages. This means that a single CHP unit cannot be relied upon to be available during a period of power outage.

9.2.6 Furthermore, CHPs operate in parallel to the grid, and the G59 protection mechanisms that are put in place for all CHP units will cause an operational CHP unit to 'trip out' (switch off) in the event of grid failure.

9.2.7 However, at the site level, a CHP generator can be specified to be capable of 'black starts'. This does not prevent a CHP unit from 'tripping out' in the event of grid failure. A 'black start' CHP unit would, however, be capable of restarting shortly after a grid outage has occurred, whilst the power is still down. This type of CHP does not, therefore on its own, provide for a seamless supply of power to site, but can form part of a site-resilience solution

9.2.8 At a grid network level, the contribution to resilience is more pronounced. As generators become more prevalent, it would be anticipated that at times of peak demand, greater levels of local generation would be operational. This means a reduced level of strain on the transmission and distribution networks. This alleviation of stress on the system, and the reduction in need for grid reinforcement resulting from local generation is currently rewarded under the 'TRIAD' system.

This payment mechanism rewards generators on the basis of their level of output at the three peak (half hour) demand periods of the year. .

10 CHILLED WATER NETWORKS

10.1.1 This section considers the potential feasibility for district cooling in Westminster. The three opportunity areas considered in this analysis are:

- Paddington Basin
- Victoria
- Tottenham Court Road / East of Oxford Street

Figure 10-1 Location of three study areas with 500m radius rings

10.2 Methodology

Cooling Load Methodology

10.2.1 Each opportunity area was subject to a desktop survey to identify buildings which appeared to be of a scale where it would be worthwhile for them to be supplied by a chilled water network.

10.2.2 The cooling demand for each building was calculated by multiplying the net building floor area by internal cooling benchmarks developed by Parsons Brinckerhoff.

Table 10-1: Benchmarking Assumptions

Category	Benchmark
Office	61 kWh/m^2
Hotel	58 kWh/m^2
Hospital	54 kWh/m^2
Net internal area as % of gross area	75%

10.2.3 The net floor area for each building was assessed using mapping tools to identify the floor plate area and the number of floors and multiplying this gross area by a reduction factor to account for space which is not actively cooled.

10.2.4 Whilst it is recognised that not all of the buildings identified would want to connect to district cooling network either because it is cost prohibitive or because they simply do not want to, the modelling analysis provides an assessment of the viability of the maximum potential for a district cooling scheme – i.e. assuming that all identified buildings connect.

10.2.5 For the Paddington and Victoria opportunity areas the analysis is based upon an assessment of relatively recent and new build properties where buildings are likely to have at least partial centralisation of chilled water supplies within their buildings and are not likely to utilise individual cassette style chillers.

10.2.6 In the East of Oxford Street / Tottenham Court Road area there is less recently and newly built property. However there is potential for development from its designation as an opportunity area. Therefore an alternative approach has been utilised and is explained further in section 10.5.

Modelling Analysis

10.2.7 The loads identified have been connected by a notional chilled water network and then grouped into clusters to be analysed by Parsons Brinckerhoff's internal modelling software. This software tests each combination of clusters identified and ranks their financial performance. For each individual test the software appropriately sizes the energy centre plant, the district cooling network and customer connection equipment. Each individual test is based on an avoided business as usual cost scenario where each building has individual electric chillers. This means that if an individual test has a positive net present value then that particular combination of cluster loads has the potential to be cooled more cost effectively by a district cooling network than by individual building chillers. A summary of the assumptions which underpin this model are presented in the table below.

Table 10-2: Modelling Assumptions

Category	Composition	Value (if applicable)
Cooling Sales Price Composition	Sales price based on equivalent cost of building self supply which is also known as the Business As Usual. This cost is composed of:	
	25 year average of DECC central price projection scenario for service electricity.	13.3 p/kWh
	Climate change levy (electricity)	0.541 p/kWh
	CRC cost of carbon	£16 per tonne
	Electricity carbon factor	0.541 kg/kWh
	Building chiller coefficient of performance	3
	Avoided maintenance costs	Varies according to plant size
	Avoided chiller and heat rejection unit cost	£300 per kW
	Avoided chiller replacement cost cycle	20 years
	Cooling sales price discount	0%
Cooling Sales Price		10.03 p/ kWh
Capex Costs	Energy centre building cost	Avoided by co-opting space from a major planning applicant.
	Chiller, heat rejection and ancillary plant items	£225 per kW
	Energy centre design fees	10%
	District cooling network – Load factor used for pipe sizing	5%
	District cooling network – Installation cost increase to account for London Utility Service density	50%
	District cooling network design fees	3%
	Contingency	20%
Opex Costs	25 year average of DECC central price projection scenario for industrial electricity.	11.9 p/kWh
	Parasitic electricity demand	1% of cooling generated
	Chiller coefficient of performance – central plant – high efficiency natural refrigerant chillers	6
	Maintenance cost • Plant – chillers, pumps, • Customer – heat exchangers, metering and billing	Varies according to number of customers and scale of demand
	District cooling network annual maintenance costs	1% (of initial capex)
Replacement Costs	Main plant items replacement cycle	20 Years

10.3 Paddington

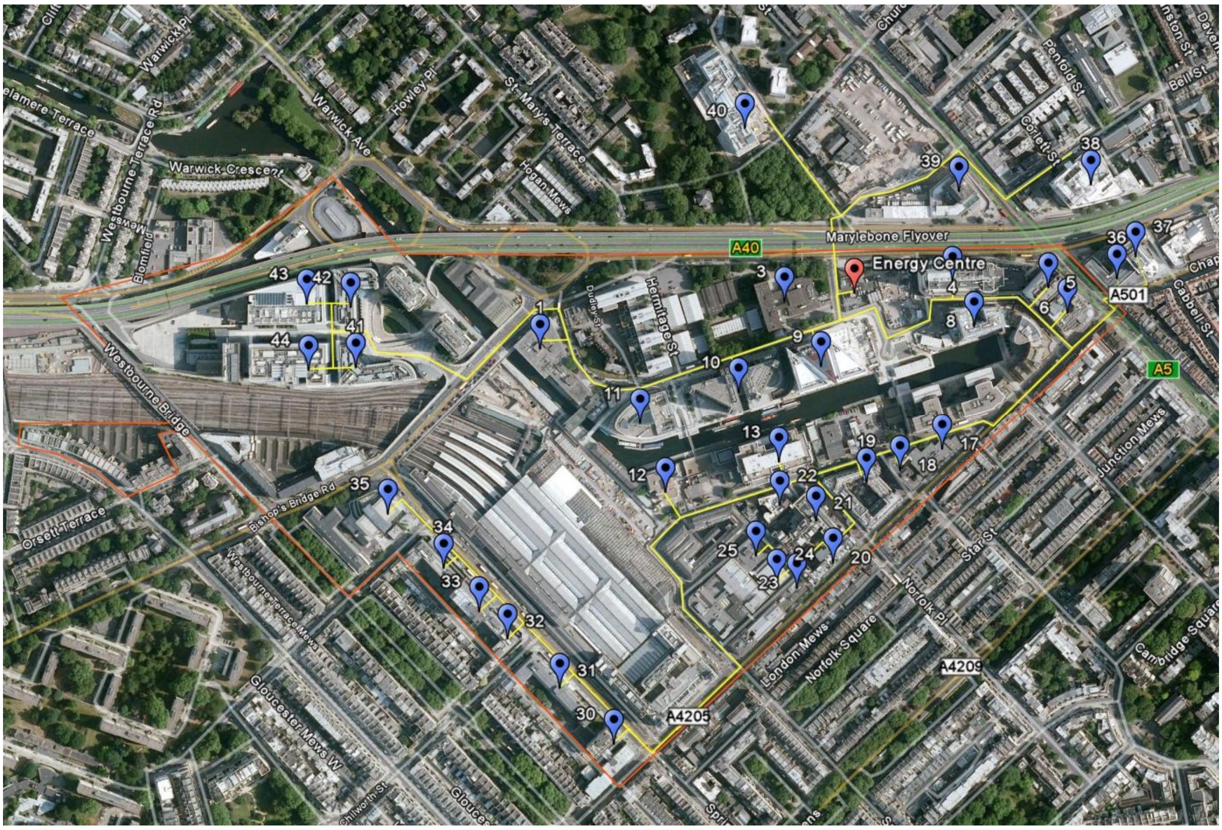
Area Description

10.3.1 This area contains a mix of use types including office, hotel, conference, residential and retail, as well as . the St Mary's Hospital estate. The terraced residential areas surrounding the opportunity area provide a natural boundary for a district cooling network (on the basis of the expense of infrastructure installation to cross these areas). The mothballed Mail Rail tunnel may offer an opportunity to connect eastwards.

Potential Existing Loads

10.3.2 A network linking the buildings identified was developed and is shown in the figure below. The loads where then grouped into 10 clusters and analysed. The notional location of the energy centre is within Paddington Basin next to the Hilton Metropole hotel. This is purely a notional location and does not imply any plans or designation of this area for this use.

Figure 10-2 Paddington area and existing building stock potentially suitable for district cooling



Modelling Analysis

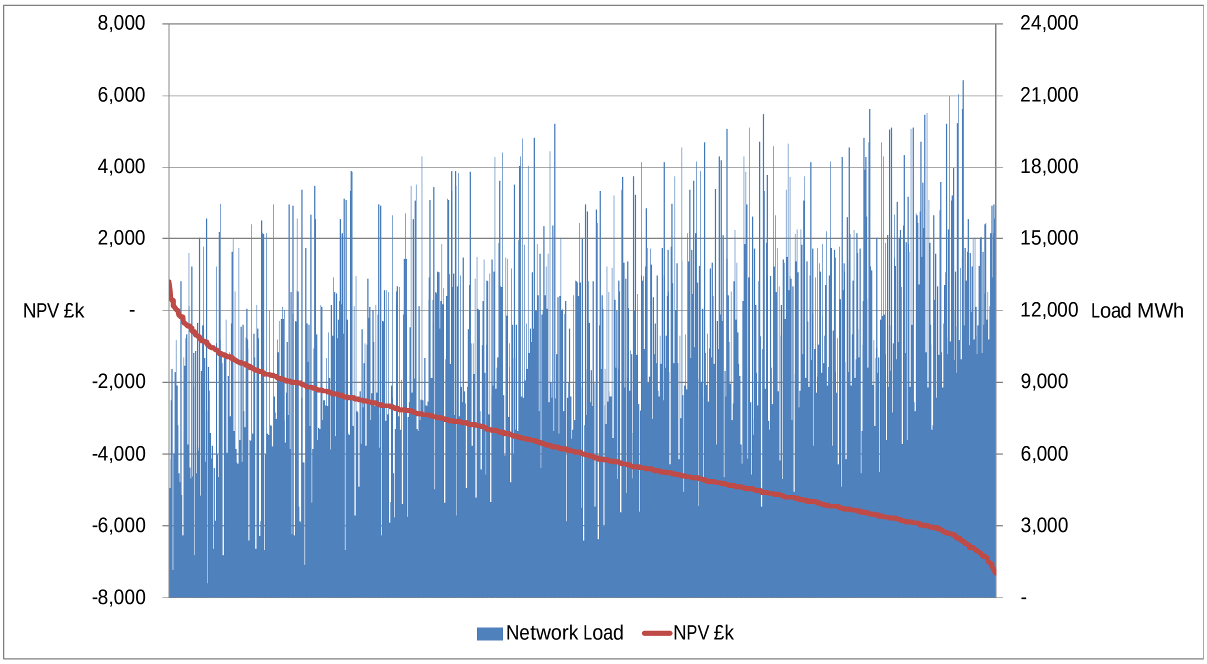
10.3.3 Parsons Brinckerhoff's modelling software tested each combination of the ten load clusters identified which amounted to 1,023 independent tests. The result of this analysis is presented in the figure below.

10.3.4 The figure shows for each test the net present value (in red) and the corresponding load (in blue). The results are sorted by net present value which is calculated over 25 year at 3.5%.

10.3.5 The results show that for all but a few possible load cluster combinations the net present value is negative at public sector return rates. This means that in the majority of cluster combinations the cost of providing district cooling is more expensive than a building self supplying.

10.3.6 The properties where the net present value is above zero are based on the connection of the few clusters which are close to the notional energy centre location.

Figure 10-3 Ranked net present value (25years, 3.5% discount rate) of each load cluster test and associated cooling load



Paddington Basin

10.3.7 In the Paddington Basin area as a whole, the total number of potentially viable existing buildings, taken as a group do not generate a network that delivers a financial performance above the threshold rate of the Treasury Green Book for the assessment of infrastructure projects. The graph above illustrates that it is the most compact schemes (i.e. those with the lowest total chilled water connected demand), that perform the best financially.

10.3.8 In this area there is limited potential for a significant amount of new load to be developed in the short term, given the extent of recent redevelopment in the area. **As such it is suggested that policy should encourage new developments to consider the supply / purchase of chilled water from immediately adjacent sites, but that the aspiration to develop a whole-area chilled water network does not appear to be justified in the short or medium term.**

10.4 Nova Victoria and surroundings

Area Description

10.4.1 This opportunity area contains a mix of use types including office, hotel, residential and retail. The opportunity area is home the Nova Victoria development and several major government buildings.

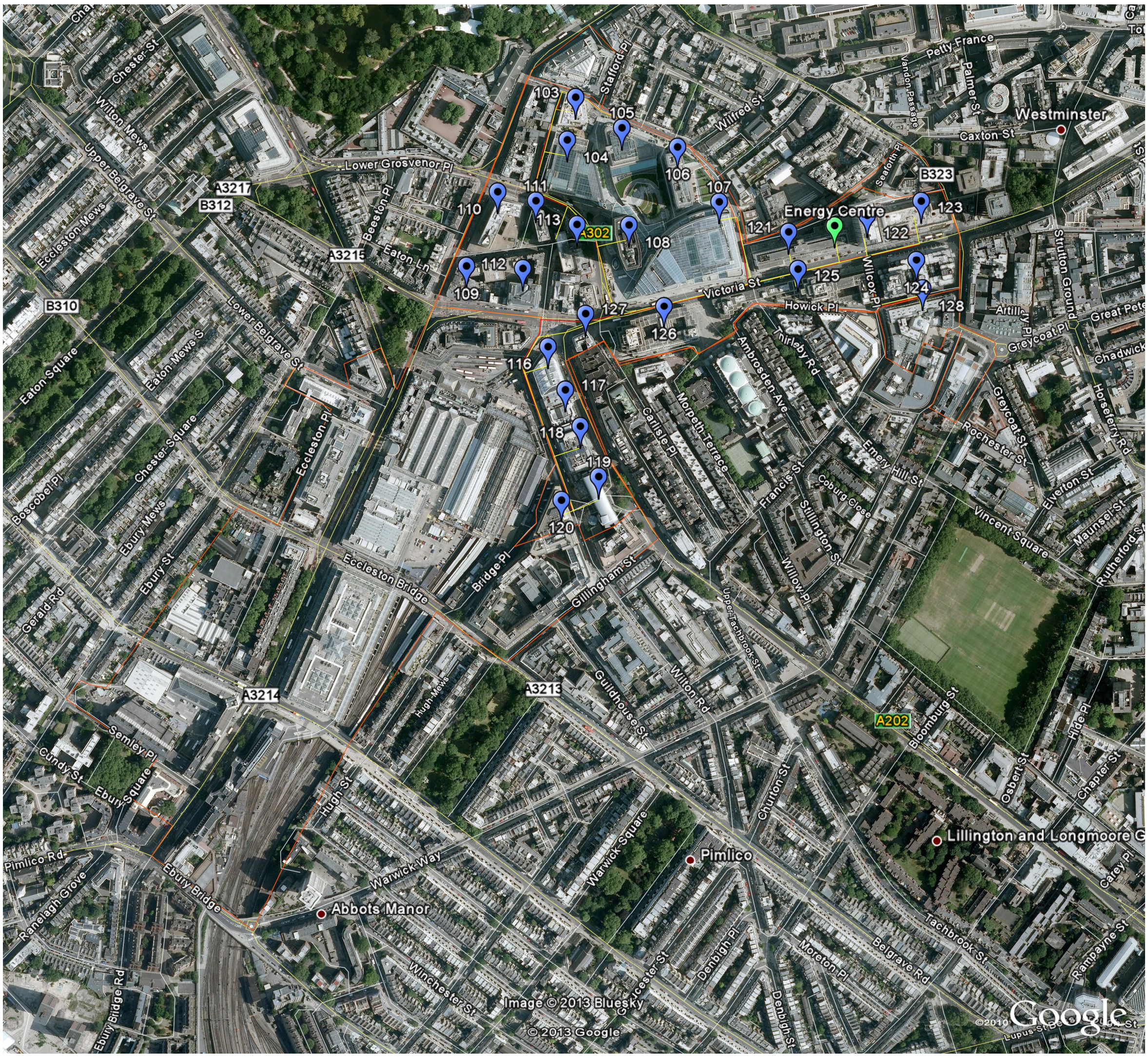
Potential Existing Loads

10.4.2 A network linking the loads identified was developed and is shown in the figure below. The notional location of the energy centre for the district cooling network is the Kingsgate Building next to the Westminster City Council building; however the energy centre building could be located at any point along the network, and it must be noted that this is a purely notional location, and does not imply any intention to take any space for chilled water provision within this site.

10.4.3 To the east of the energy centre location is the Westminster City Council building and three large office / retail developments. To the east of Wilton Road are several office blocks and to the north of Victoria Street are several office / retail developments. The area bounded by the red line in the figure below is the Nova Victoria development which has a single energy centre supplying five buildings.

10.4.4 The loads were then grouped into eight clusters and analysed by the Parsons Brinckerhoff's modelling software.

Figure 10-4 Victoria area and existing building stock potentially suitable for district cooling



<u>Modelling Analysis</u>

10.4.5 Parsons Brinckerhoff's modelling software tested each combination of the eight load clusters identified which amounted to 255 independent tests. The result of this analysis is presented in the figure below.

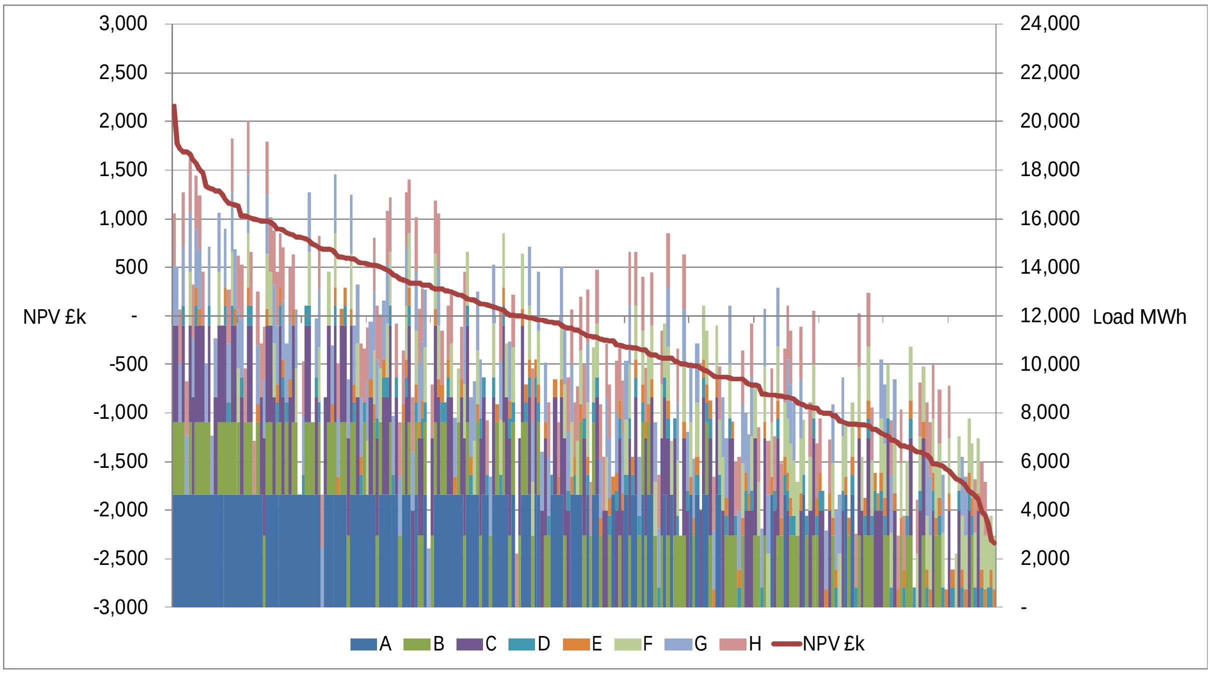
10.4.6 The figure shows for each test the net present value (in red) and the corresponding load (coloured bars). The results are sorted by net present value which is calculated over 25 years at 3.5%.

10.4.7 The results show that for some load cluster combinations the net present value is positive. This means that potentially there is value to be obtained through a district cooling network against a building only solution.

10.4.8 This analysis is influenced by the chosen location of the notional energy centre. However, having said that the cluster combinations which produce the largest positive net present value rely on obtaining all the loads along Victoria Street with the Nova Victoria development being particularly important.

10.4.9 The loads which lie furthest away from Victoria Street appear from the analysis not to be cost effective to be served by a centralised chilled water system, based on the decrease of the net present value when they are included.

Figure 10-5 Ranked net present value (25 years, 3.5%) of each load cluster test and associated cooling load



10.4.10 In the Victoria area the analysis has shown that at public sector return rates there could be a potentially viable scheme to serve multiple buildings along Victoria Street. This would require nearly all the buildings to connect. Such a scheme would rely on the connection of the Nova Victoria development to deliver a positive NPV at 3.5% discount rate.

10.4.11 However, whilst this analysis has modelled a central energy centre meeting the cooling load the Nova Victoria development has its own energy centre which meets the cooling demand of the five buildings in the development. With investment in new equipment at this development imminent (July 2013) and at other new developments along Victoria Street, a centralised cooling solution may be difficult to implement in the short term. However, as further development comes forward and plant replacement cycles come into play, it could become possible to develop a network around these loads. **On this basis, it is recommended that development in this area is certainly future proofed for district cooling connection, and that as strategic new development comes forward, an assessment of the potential to supply a cooling network is required.**

10.5 East of Oxford Street – Tottenham Court Road

Area Description

10.5.1 This area, which straddles the area controlled by Westminster City Council and the London Borough of Camden, is a particularly vibrant part of the city. The area contains mix of use types including office, hotel, residential and retail. Cross Rail is also part of the development in the area.

Potential Existing and Future Loads

10.5.2 The geographic spread of this area means that there is limited potential to connect together the cooling loads of new construction and known loads with centralised building systems into a viable area wide district cooling network. As such an alternative method of assessing the potential for district cooling is outlined below.

10.5.3 The figure below shows a skeletal network which covers the opportunity zone and picks up key identified existing loads. This initial network (which would not be viable due to the low density of cooling loads) provides the basis for the analysis outlined below.

10.5.4 This analysis focuses on when the circumstances required for a district cooling network to become viable in this area would be achieved. This would normally be based on assessment of the number of potential new loads coming forward each year and incrementally adding these loads to the notional network developed and ultimately advising at what point a scheme based on the accumulation of these and the initial loads would be viable.

10.5.5 In the district heating analysis carried out for the Soho area of the city (section 12.8) this type of analysis was carried out. The average area of each ‘large’ development in Soho was approximately 2,000 sqm (GIA).

10.5.6 For a district cooling network buildings of 2,000 sqm and with an annual load of 100MWh are too small to be viable in the context of a cooling network, when weighed up against the cost of the pipework connection (civil and pipework), the district cooling transmission mains, maintenance costs and billing costs.

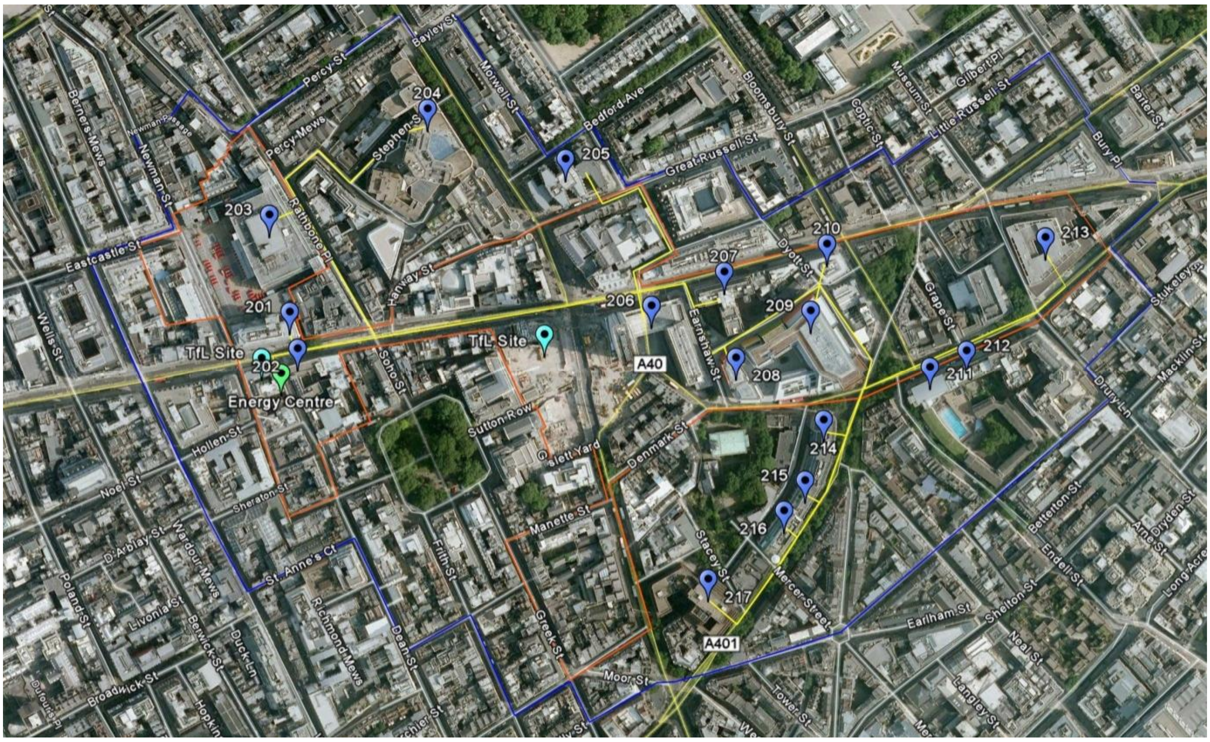
10.5.7 As the size of a connection increases the viability of that connection also increases as the semi-fixed costs of pipework installation, maintenance and billing is spread over a larger load demand.

10.5.8 In the next modelling analysis below the approach taken is to model the number of ‘very large’ scale developments required to develop the skeletal network into a viable district cooling network. This has been done by modelling separately the number of 10,000 sqm and 20,000 sqm developments required.

10.5.9 The key criteria underpinning the analysis are:

- Annual average cooling demand of 50kWh/m^2
- Average distance of each connection from the main network is 50m.

Figure 10-6 Tottenham Court Road area with skeletal network and assessment boundary



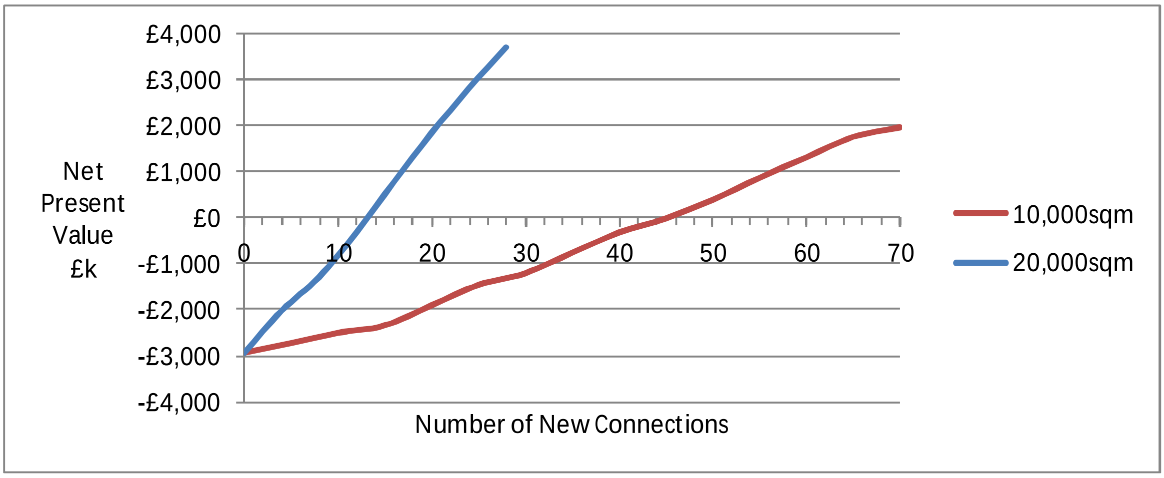
<u>Modelling Analysis</u>

10.5.10 The figure below presents the results of the analysis carried out. The net present value presented is calculated over 25 years at 3.5%.

10.5.11 The initial network based on existing properties outlined in the figure above is not viable, showing a net present value of -£3m over 25 years. However, as the number of new connections increases the net present value starts to increase. The figures on the graph indicate:

- If the average size of new development suitable for district cooling is approximately 10,000 sqm then it would require 45 such developments for a network to achieve a net present value of zero and 70 for a net present value of £2m.
- If the average size of new development suitable for district cooling is approximately 20,000 sqm then it would require 14 such developments for a network to achieve a net present value of zero and 20 for a net present value of £2m.

Figure 10-7 Ranked net present value (25 years, 3.5%) of number of new loads (and associated cooling load) required to achieve a viable network.



Tottenham Court Road

10.5.12 In the Tottenham Court Road area the analysis has shown that a large number of new developments are required to achieve an economically viable district cooling network.

10.5.13 Given the nature of the area which is already heavily developed it could potentially take many decades of requiring planning applicants (of sufficient size) to be district cooling ready before there would be sufficient number of connections (and thus area wide demand) to achieve a positive net present value at public sector discount rates.

10.5.14 As such it is difficult to justify a policy to support district cooling in this area on a wide-area basis.

10.5.15 An alternative approach which may lead to district cooling network in the future would be to encourage existing and new developments to assess the aggregation of supplies with immediately neighbouring sites in order to support the growth of hubs of centralised chilled water demand that could then lead to efficiencies of scale and more effective use of space in the area.

10.5.16 This support to encourage hubs of centralised chilled water demand could potentially develop into block level networks that could ultimately develop into a district cooling network over time. On this basis, the policy approach remains very similar – i.e. ensuring centralisation of cooling supply plant for larger development, and ensuring that operating conditions are compatible with technical standards (that need to be developed) and accessible to neighbouring developments (i.e. that there is a safeguarded route to connect to the chilled water supply headers).

10.6 Chilled water conclusions / policy implications

10.6.1 The analysis of the three opportunity areas has shown that establishing a viable district cooling network is difficult, requiring a very high density of loads to achieve a network with the potential for a positive net present value under whole life cost analysis. The reasons why this is more difficult than for heating include:

- Annual cooling demands are typically lower than the annual heating demands (with new offices as a possible exception to this generalisation)
- The utilisation factor of the plant and the network is lower than that of the equivalent district heating networks

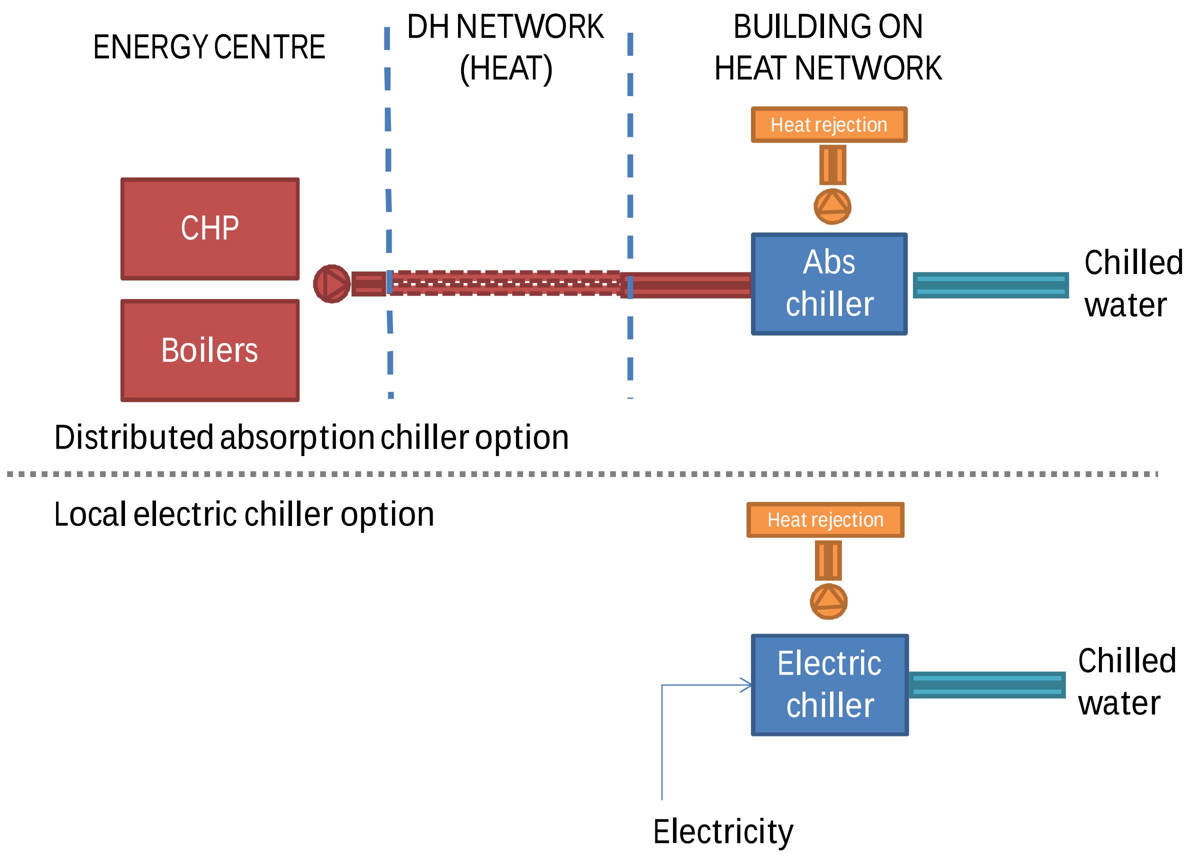
- The temperature difference between the flow and return pipework is lower than that used in district heating networks and cooling networks require larger (and therefore more expensive) pipework to deliver the equivalent amount of energy.

10.6.2 This analysis was based on the assumption that district cooling plant would utilise highly efficient natural refrigerant chillers. When compared with the standard building chillers which have a lower coefficient of performance this provides an operational energy and thus financial saving for district cooling over that of building level solutions. However this potential benefit is likely to be eroded in the future with the trend for buildings to utilise high performance chillers as a result of higher energy prices and requirements of building regulations. In addition a commercial district cooling provider would require a higher rate of return than that which is applied to public sector projects and this would require a larger subsidy or significant new load to be developed in order to be viable.

10.7 Chilled water provision via distributed absorption chilling

10.7.1 One option that is sometimes considered for the provision of chilled water is the use of distributed absorption chilling. This means running an absorption chiller supplied with heat from a district heating network. An illustration of a comparison of this approach with a 'traditional' high-efficiency electric chiller is shown below:

Figure 10-8 Schematic comparison of chilled water provision



10.7.2 The calculation shown in Appendix 20.6 illustrates the benefit that the use of absorption chilling can deliver. The calculation, which has used typical current efficient values for the various plant items and typical values for energy prices, shows that for the delivery of 1GWh of chilled water, a distributed absorption chiller system could deliver a cost saving of £8k and a carbon saving of 40tCO_2/ year. In terms of cost, this saving is not considered sufficient to payback either the cost of the capital installation of the plant, nor even the annual maintenance costs. The carbon savings, and indeed the cost savings figures are also very sensitive to the competing electric chiller system, which in the example calculation shown in the appendix has a seasonal COP of 3. This does not reflect best available technology. If a higher COP for the competing system is used, then the distributed absorption chiller system does not make any savings, it in fact delivers both a financial disbenefit and an increase in overall carbon emissions. **On this basis the use of distributed absorption chilling is not recommended**.

10.7.3 The balance of this system will also further worsen (in terms of carbon savings) as the grid progressively decarbonises. With an assumed electric chiller COP of 3, the grid only has to decarbonise to a level of 0.49kgCO_2/kWh (from the current level of around 0.52kgCO_2/kWh), for there to be no carbon advantage in the use of distributed absorption chilling.

11 ENERGY SOURCES FOR HEAT GENERATION

11.1 Heat source locations

11.1.1 The geography and built environment within Westminster is made up primarily of high-value buildings, or of protected green spaces. Neither of these two typologies represents a 'natural' choice of location for energy centres.

11.1.2 As a result, one of the key elements of the roadmap to 2050 in terms of DE for Westminster must include a clear route to the identification and procurement of heat source locations. Ideally these locations would resolve the paradox of being close to the highest densities of heat demand, whilst also having minimal impact on sensitive receptors in terms of noise, vibration, and local emissions.

11.1.3 No specific, immediate locations are suggested here, but the general approach adopted in this report is to consider basement spaces within developments coming forward as useable locations for the installation of energy generation plant. Screening parameters for EC locations could include such items as:

a Space

b Proximity to DH network routes

c Electrical network ability to integrate generation plant

d Gas network capacity

e Suitability of sites to accommodate flues to high level

f Sensitivity to noise / vibration

g Alternative fuel capacity – i.e. additional space for fuel storage / plant, ability to accept fuel deliveries, air quality restrictions, etc.

11.2 Technology choices (generalised analysis)

11.2.1 PB has considered conventional, proven technologies and other more innovative plant options. The following technologies have been considered on a generalised basis, given a 'typical' plant scale of 2.5MWth prime mover heat requirement[30]:

- Gas-fired CHP
- Biofuel CHP
- Organic Rankine Cycle CHP
- Biomass gasification and CHP
- Biomass anaerobic digestion (AD)
- Solid recovered fuels (SRF) or municipal solid waste (MSW)-fuelled CHP
- Heat pumps (on-site heat rejection or Thames as sources)

[30] Fuel cells are not considered here on cost grounds – the current initial cost of fuel stacks and their replacement means that this technology is not yet competitive with other forms of generation at this scale.

11.2.2 The assessment of these technologies has been carried out on a scored qualitative analysis basis (described below) as a means of providing a transparent approach to technology selection.

11.2.3 The choice of heat production technologies for the schemes is central to delivering both a viable scheme, and to also delivering heat that is sufficiently decarbonised for network customers to achieve planning compliance.

11.2.4 Kick-start networks – the choice of technologies suitable to match the early phase loads will be considered in the context of de-risking delivery i.e. choosing well-proven technologies that have a demonstrable track-record. Depending on scale, key technologies for this early deployment might include gas-fired CHP, biomass boilers, gas-turbine technologies, etc.

11.2.5 Rationalised supply – in later phases, the choice of heat production source may be influenced by the desire to increase the self-sufficiency of the new development area (i.e. using site-produced waste as a resource), and by the need to increase the proportion of renewable fuel used (in response to regulatory pressure and the need for increasingly high levels of carbon emissions reduction).

11.2.6 The assessment of technologies has been carried out by rating each candidate technology against a series of categories. These were:

- Carbon reduction potential
- Commercial viability (i.e. cost of heat generation)
- Proven track record
- Renewable fuel use
- Compactness of space requirement
- Lack of air quality impacts (inc from transport of fuels)
- Fuel supply chain security

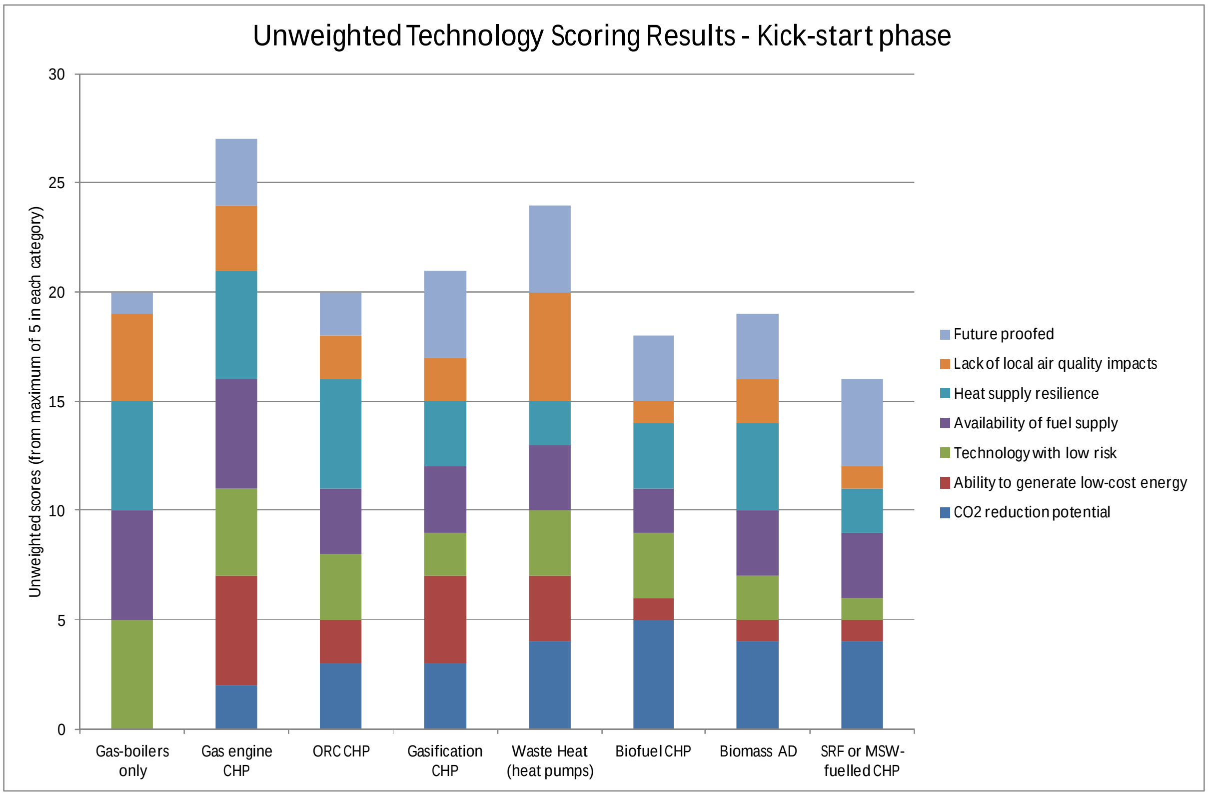
11.2.7 Each of these categories has been allocated a weighting suited to the phase of the scheme. The total weighted scores for each technology have then formed a ranked list of preferred options at each stage. The aim of this ranking is not to select a technology, but to illustrate which shortlist of technologies appear to offer the best match with the criteria listed.

11.2.8 Over the next 40 years we can anticipate substantial changes to the landscape of technologies that are considered ‘proven’. Hence our recommendations focus primarily on the ‘kick-start’ phase of the project.

11.3 Kick-start phases

11.3.1 The unweighted inputs into the technology scoring tool are displayed below:

Figure 11-1 Unweighted technology scoring chart – kick-start phase



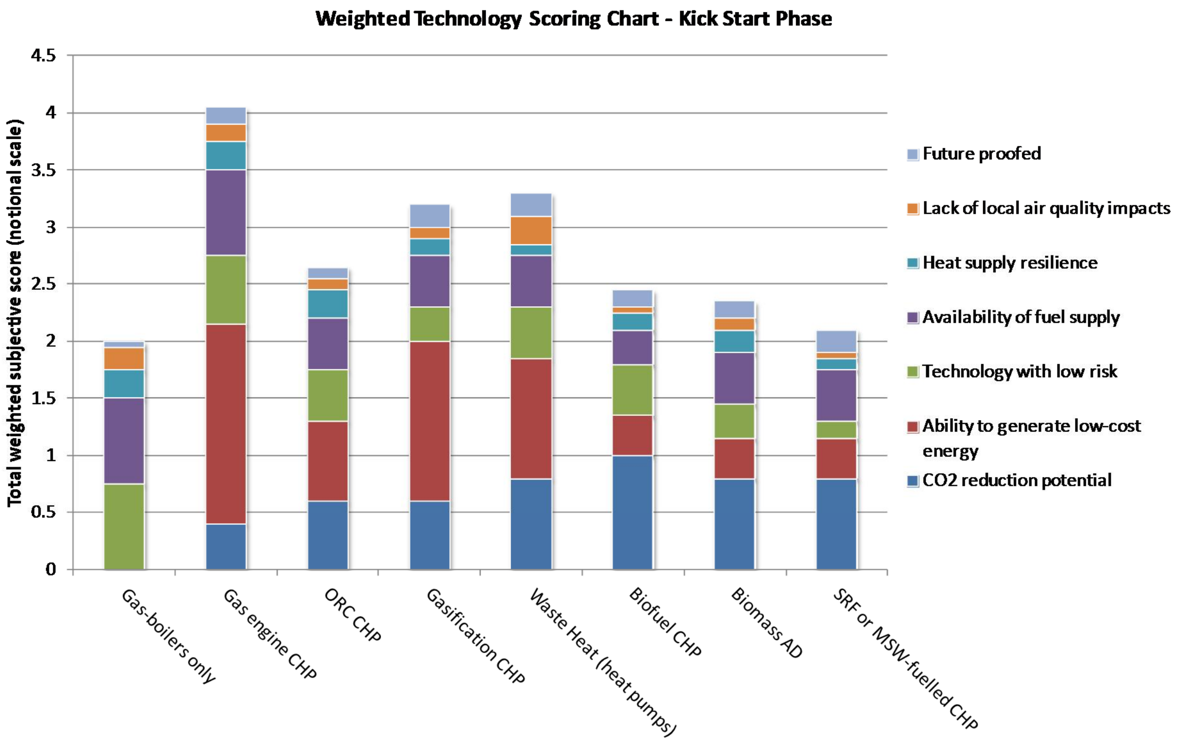
11.3.2 This chart illustrates the raw totals of the subjective scoring of technology that PB has carried out.

11.3.3 The following weightings where adopted for the kick-start network phase.

Figure 11-2 Kick-start phase technology scoring

	CO_2 reduction potential	Ability to generate low-cost energy	Technology with low risk	Availability of fuel supply	Heat supply resilience	Lack of local air quality impacts	Future proofed
Weighting	20%	35%	15%	15%	5%	5%	5%

Figure 11-3 Kick-start phase weighted technology scores



11.3.4 This chart suggests that the use of gas-CHP and possibly waste heat and gasification CHP are currently considered the most suitable technologies for the early phase network. This weighted scoring reflects primarily the proven nature of gas-fired CHP, and its ability to generate carbon savings at relatively low cost.

11.4 Later-phase heat supply (i.e. 2030 – onwards)

11.4.1 At this stage in energy masterplanning, the technology choice for later phases in the network growth is uncertain, and as it cannot be readily predicted which technologies will emerge to become 'proven' over the next 15 years or so, this category (technology with low risk) has been downgraded in its weighting. At the same time, the ability of technologies to deliver carbon savings against a decarbonised grid will increase in importance and hence this category has been given additional weight[31]. The scores and weightings for the later phases are shown below:

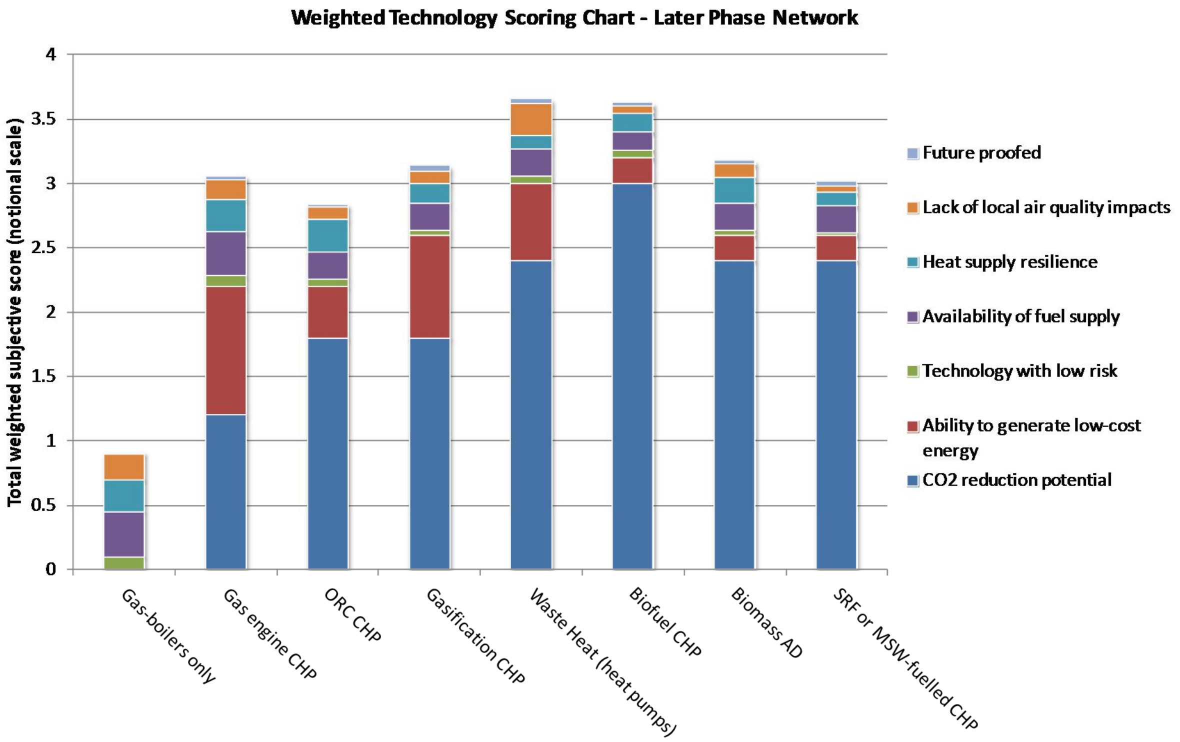
Table 11-1 Later Phase Technology Weightings

	CO_2 reduction potential	Ability to generate low-cost energy	Technology with low risk	Availability of fuel supply	Heat supply resilience	Lack of local air quality impacts	Future proofed
Weighting	60%	20%	2%	7%	5%	5%	1.0%

[31] It could also be argued that it is a reasonable assumption that taxes and incentives will make these technologies competitive with more carbon-intense technologies.

11.4.2 Weighted scores for this are shown below:

Figure 11-4 Weighted Later Phase Technology Scoring



11.4.3 This chart illustrates that the front-runner technologies for the later phases of the network expansion would appear to include the use of waste-heat resources (and heat pumps) and biofuel CHP technology.

11.5 Secondary heat sources

11.5.1 As noted in section 8.4 there is opportunity in the longer term for London to benefit from the recovery of heat that is currently rejected from various processes or available as a 'natural' resource. A study has been recently completed for the GLA entitled 'London's Zero Carbon Energy Resource – Secondary Heat' July 2013. A number of key points that come out of this document include:

- That there is great variability in secondary sources of heat, both in location, temperature and diurnal / seasonal availability
- The majority of heat available can only be made useful with a temperature increase via by a heat pump
- The carbon intensity of most secondary heat sources is lower than that of heat supplied via large centralised gas boilers
- The proposed flow temperature range for network operating temperature for DE networks served by secondary heat sources appears to be between 55 deg C and 70 deg C
- Regulation should ensure the design of building systems promotes the installation of underfloor heating and 'oversized' radiators to help deliver low temperature networks

- Planning guidance should highlight opportunities for secondary heat networks. Boroughs should be required to investigate the potential to utilise secondary heat sources as part of their energy masterplanning work.

11.5.2 It should be noted that this 'secondary heat' study makes the assumption that DE networks are already in place to absorb the output of these secondary heat sources, and that the networks are presumably operating at 70 deg C. This implies that a first key stage in rendering the use of secondary heat sources economic is to install a DE network system. As the report states: 'This study assumes that these networks would already be in place from pre-existing district heating networks fed from gas, CHP and energy from waste plants as it is considered that secondary heat sources are unlikely in themselves to be able to support the investment in heat networks' (London's Zero Carbon Energy Resource, Secondary Heat, GLA, Summary Report, p13). This energy masterplan therefore takes the position that the use of secondary heat may benefit the operation of DE networks in the future, but that their inception ('kick start' stage) should not be predicated upon the availability of these secondary heat sources.

11.5.3 An example of this order of precedence is perhaps illustrated by the Islington Bunhill District Energy Scheme, where a district heating distribution network has been implemented on the basis of the supply of heat from a gas-fired CHP engine, and where a study is now on-going to examine the potential to derive additional useful heat from a neighbouring primary substation and underground system ventilation shaft.

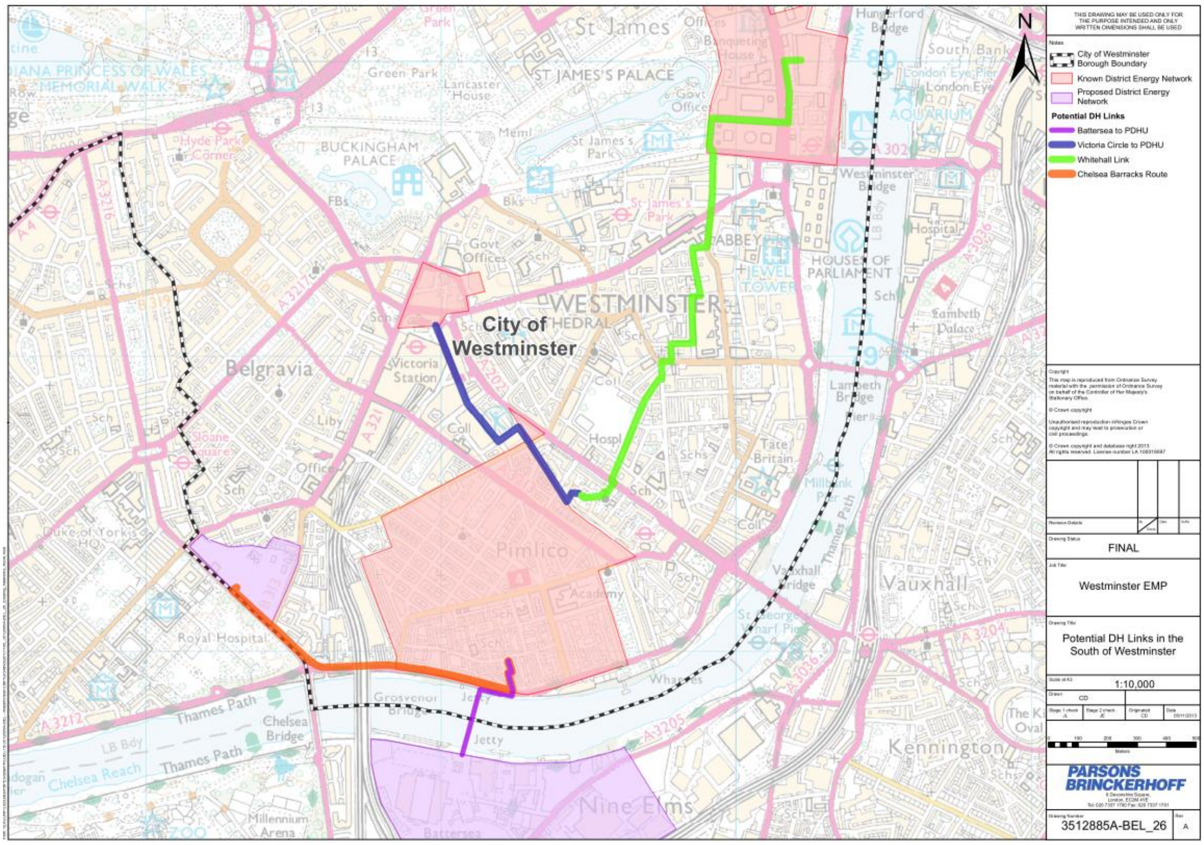
12 AREA SPECIFIC ANALYSIS

12.1.1 Given the different characteristics of the focus areas of this study and the borough as a whole, this section addresses potential strategies for approaching greater DE deployment on an area-specific basis.

12.2 PDHU, Battersea, Chelsea Barracks and WDHS

12.2.1 This section considers the southern part of Westminster, with some key existing DE assets and their potential interlinkage illustrated on the plan below:

Figure 12-1 Potential DE links in the PDHU area



12.2.2 PDHU

12.2.3 Key facets of PDHU as an entity as it currently stands are:

- Large customer base accessed through extensive district heating network
- Established heat supply charging mechanisms and customer care
- Gas-fired CHP plant in a physically constrained energy centre
- Large thermal store that is currently under-utilised
- Existing link across the Thames to Battersea Power Station

12.2.4 The physical dimensions of the existing PDHU energy centre mean that significant expansion, in terms of customer base is unlikely to be viable. This is because, as additional customers connect to the system, the percentage of low carbon heat supplied to individual customers would decrease. In order for a significant new customer base to see a continuing high level of low-carbon heat, additional generation plant would be required, and this cannot be installed in PDHU's current energy centre.

12.2.5 This is, in itself a rationale for making use of the existing potential heat supply link between PDHU and Battersea – i.e. new plant at Battersea could supply additional low carbon heat to PDHU, and this would allow for the continuing expansion of the PDHU customer base. However, this concept must be considered in the context of alternative scenarios as well:

- New energy centre for PDHU
- Supply of heat to / from WDHS
- Supply of heat to / from Nova Victoria to PDHU
- Supply of heat to / from Chelsea Barracks

12.2.6 The list above illustrates that there are multiple permutations of potential supply around the key developments / assets of this area.

12.2.7 However, in the technical context of DE deployment on a strategic basis, there are three key assets that stand out as unique and important in the wider context of DE deployment:

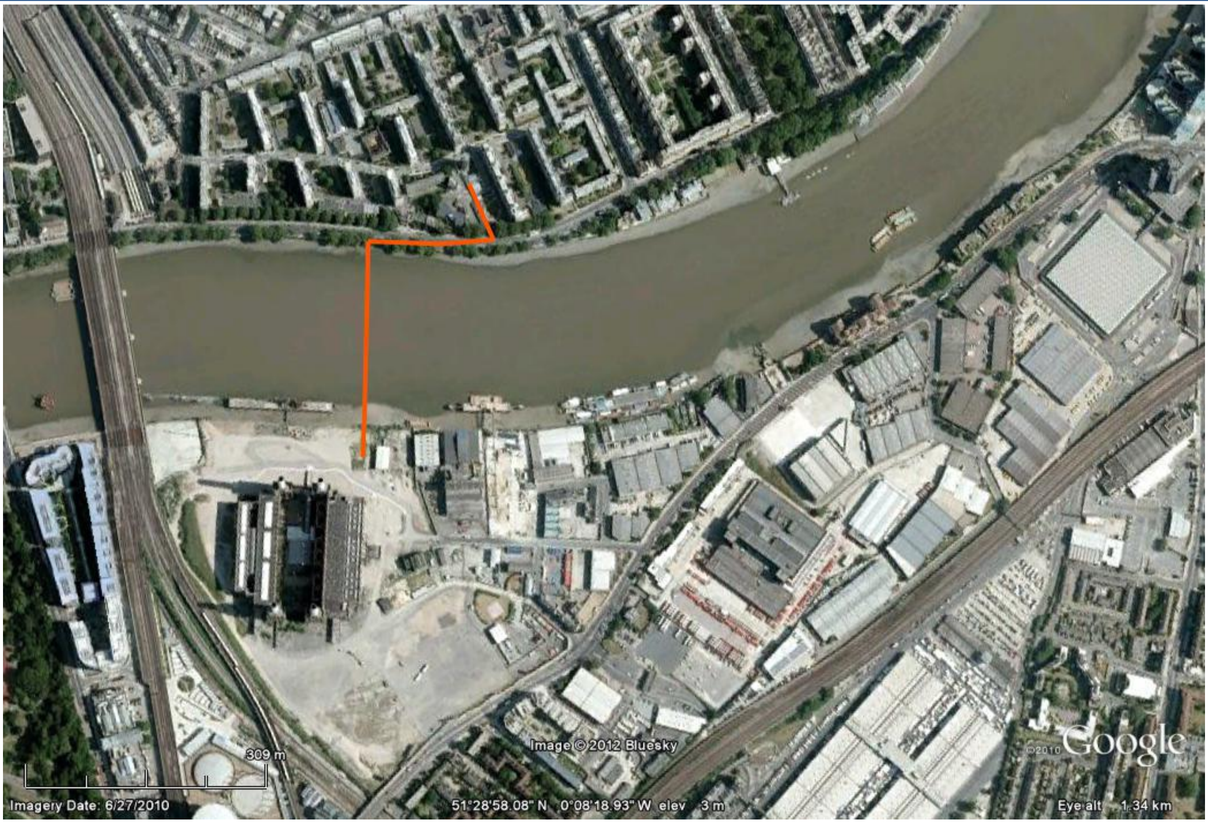
- The combination of space availability for energy centre plant (secured by S106 agreement by Wandsworth) and flue height of Battersea Power Station chimneys above sensitive receptors
- The extent of the existing DE networks in the area north of the river and the link across the Thames
- The thermal storage capacity (2,000 cubic metres) of PDHU that is unique in the UK.

12.2.8 **These three items, and in particular Battersea's heritage as a power station, suggest strongly that there should be a strategic push to make use of this location as a site for generation capacity that allows economies of scale to be maximised**.

12.3 Heat supply between PDHU and Battersea

12.3.1 Whilst the exact physical state of this link is not certain, it is believed that this link could be rejuvenated with minimal effort / expense.

Figure 12-2 Sketch of link between Battersea and PDHU



12.3.2 Given the existing link under the Thames to the PDHU system, in hydraulic terms Battersea Power Station and the PDHU are close neighbours, and it would be an enormous waste of an opportunity not to utilise the existing PDHU assets and heat customer base. In particular, for early years operation of primary plant capacity in Battersea, making use of the thermal store (and possibly the spare boiler capacity at PDHU) seems to be an opportunity that should be exploited. Equally, the ability to supply heat in early years of development to PDHU could allow for economic installation of larger, more efficient primary plant in Battersea. **PB therefore strongly recommends that any energy centre system developed on the Battersea Power Station site should link to PDHU via the existing network under the Thames**. Equally, any plans for expansion in PDHU should first assess whether the location of plant (or use of existing assets) at Battersea is a viable option (and vice versa).

12.3.3 The ‘rejuvenation’ of the link would not require substantial additional infrastructure, and it would be anticipated that the two systems (PDHU and the new network around Battersea) would be hydraulically separated. On this basis, the main elements of the installation would be ensuring that the pipes are in a suitable state for reuse, installation of plate heat exchangers to create a hydraulic separation interface, and controls modifications at PDHU to ensure that the thermal storage capacity can be utilised by the remote energy centre plant at Battersea.

12.3.4 The value of this link could also be enhanced by the connection of the PDHU system with the Whitehall District Heating System. This might further increase the potential availability of low carbon heat for export to Battersea, or alternatively the customer base that could be served by plant at Battersea. This potential benefit strengthens the recommendation to rejuvenate the connection between Battersea and PDHU.

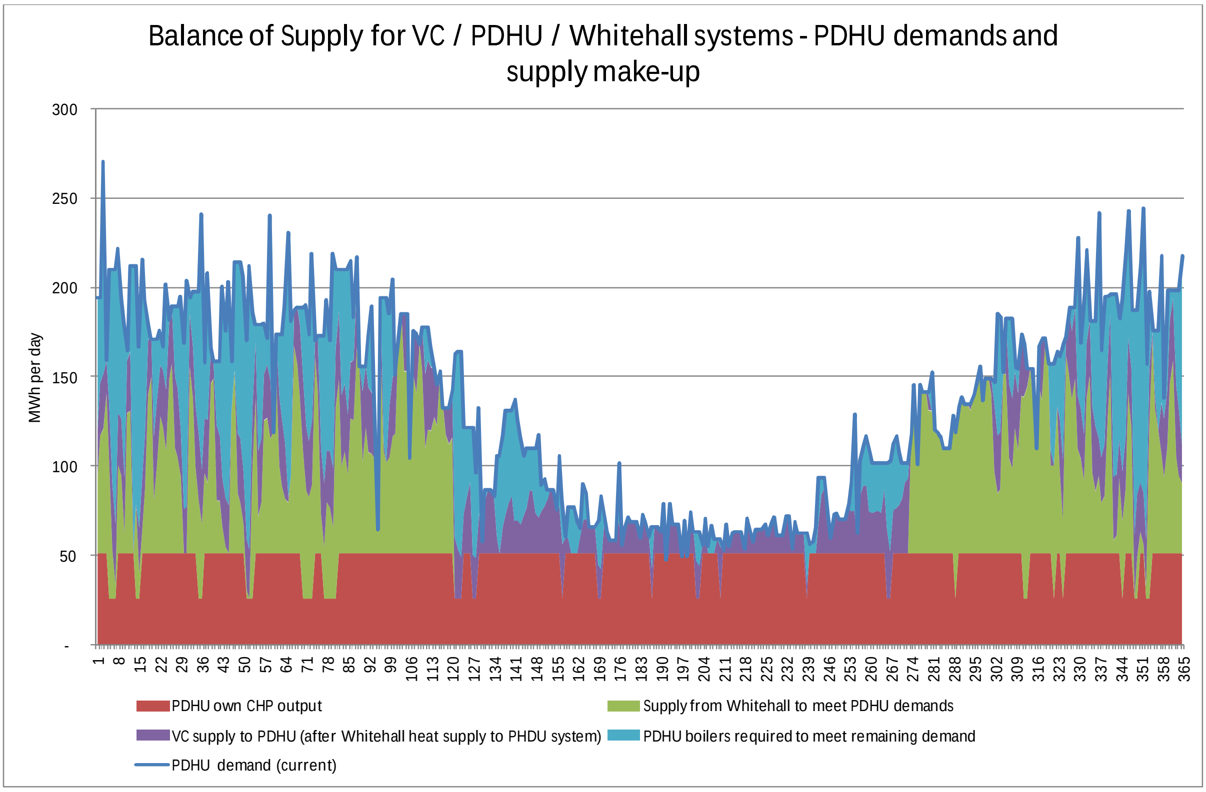
12.3.5 As noted above, a decentralised energy scheme for a major development (Nova) adjacent to Victoria Station is currently being implemented. There is the possibility of including a heat link to the Pimlico District Heating Undertaking. The value of this link (between Nova Victoria and PDHU) for the VNEB OA will depend on the balance between the supply plant capacity installed in the Nova system, and the demands on the PDHU system not met by PDHU's own CHP plant. Similarly to the potential upside benefits from a WDHS link, in PB's view the potential availability of additional low-carbon heat from the north of the Thames is a strong reason to ensure that a connection is made between PDHU and Battersea, in order that this plant can benefit from these future developments as customers.

12.3.6 Even if changes to the energy supply landscape north of the Thames do not transpire, the hydraulic connection of the two systems should allow Battersea-based primary plant to benefit from the use of the thermal storage asset that is located within PDHU, and possibly the existing customer base within Pimlico.

12.4 WDHS and PDHU

12.4.1 The interlinkage of PDHU and the WDHS has been the subject of many studies and analyses of viability (carried out on behalf of both the Government Procurement Service (or the Office of Government Commerce), and the GLA). The basic concept analysed has typically been the enhanced recovery of heat from the existing gas turbine within the Ministry of Defence energy centre, with distribution of low temperature heat to PDHU to help meet the winter season demands of PDHU from the gas-turbine generated heat. One variant of this analysis that PB has carried out is illustrated below.

Figure 12-3 Variant of PDHU demand met by PDHU, WDHS and Nova (VC) output



12.4.2 Figure 12-3 illustrates that under at least one of the potential operational scenarios that has been analysed there is considerable potential for WDHS generated heat (light green shading) to be usefully used within PDHU. However, the link between WDHS and PDHU is also long (in DE terms) and therefore costly. Analysis has generally shown that the viability of this link is marginal, and certainly that public sector support would be needed in its implementation.

12.4.3 Other aspects of the WDHS that are relevant to this masterplan are that there is current concern within the WDHS customer base surrounding the value that the system delivers, and also that there is concern within the Ministry of Defence that the energy centre is not best placed under their offices.

12.4.4 A new analysis of the potential of interconnection is currently (July 2013) being undertaken by the GLA, and this study can be expected to update the appraisal of the viability of this connection.

12.4.5 System complexity, compatibility and co-operation

12.4.6 Even in this small part of Westminster and its links to Wandsworth, it can be seen that without policy (or some other means of) intervention, there is the real risk that three or more private sector operators, in addition to GPS and PDHU would be involved in the operation of separate DE systems. Under this scenario it is difficult to envisage the framework policy conditions that could encourage meaningful collaboration and physical linkage of the different networks.

12.4.7 On the technical level, for new developments that might emerge in this area the DE Manual for London is valuable in establishing a set of technical parameters which new development should conform with. However, this does not solve the commercial problem of encouraging collaboration / linkage between systems.

12.4.8 This strongly suggests that policy intervention in some form would be desirable in terms of obliging networks to link. One way of achieving this would be to ensure that all networks within the area are controlled by the same body (e.g. WCC or an SPV under WCC's control or the GLA), effectively generating a technical incentive for that single body to rationalise supply plant to maximise efficiency. Given that there are some elements of these systems that are outside of WCC's immediate policy control (e.g. Battersea Power Station in Wandsworth and the associated Nine Elms Vauxhall network and WDHS), there are two potential routes:

- More direct policy involvement at a regional level (e.g. GLA)
- WCC policy intervention for those elements within the borough boundary / control, but another course of action would be required for cross-boundary requirements. It may be that the 'duty to co-operate' in the Localism Act 2011 can be applied to encourage appropriate joint working practices.

12.4.9 Public bodies cannot implement policies that are anti-competitive, and hence the selection of a particular delivery vehicle (i.e. WCC as utility) for these network linkages through policy is not possible. 'WCC as a utility' therefore has to be commercially competitive. The ability of WCC to access lower cost finance and its potential willingness to take a longer-term, more strategic view of commercial returns may allow a WCC delivery vehicle to be able to put in a commercially attractive offer for the operation of these systems.

12.4.10 Separation of supply and distribution

12.4.11 This part of London, where there are potentially multiple generators and several different potential flows of heat supply depending on season and time of day illustrates that perhaps a 'step-change' in DE market structure is required. The recommended structure for this would follow that of the electricity or gas markets i.e. where supply and distribution are separately managed. One option for Westminster that is therefore proposed is one where WCC takes control of key network linkages and acts as a heat *distributor*. It is envisaged that this role would be one where WCC would invest in the network assets and recover costs by charging for the delivery of heat through this network. This is considered further in the delivery section of this report (section 18).

12.4.12 A heat distribution business will only function when there is a need to transfer heat from one area to another i.e. where one sub-system is undersupplied and where there is a surplus of low carbon heat in another. Without policy intervention in some form, all new developments and existing sites will continue to operate in a state of self-sufficiency, and linkage of systems would be surplus to requirements. Hence, under this model, policy would be needed to intervene to create the short-term conditions that require heat transfer. The rationale behind this approach would be to lead to an aggregated, rationalised system where multiple large heat generators / customers feed into a network and supply and receive heat depending on seasonal / other considerations.

12.4.13 For example, this model might appear to be beneficial for the PDHU / WDHS link given current operational parameters of the two sets of existing plant. With various system improvements, there is potentially heat available to export from WDHS to PDHU during the winter / shoulder months (and during the night throughout the WDHS turbine operation period). However, during the summer, PDHU could potentially have low-carbon heat to export to WDHS.

12.5 PDHU / Chelsea Barracks

12.5.1 Formal Outline Planning Permission was granted for the masterplan of the Chelsea Barracks site in late 2011. A revised application was also submitted in 2011, and the revised Planning Statement[32] contains the following text:

Figure 12-4 Extract from Planning Statement - Chelsea Barracks

Energy Statement

3.58 The energy strategy remains as per the submitted applications but has been reviewed in light of the changes made to the scheme and feedback from WCC.

3.59 It is proposed that the development will connect to Pimlico District Heating Undertaking (PDHU) (subject to the Applicant and PDHU agreeing terms and conditions), as well as using CHP heating, ground source heat pumps and photovoltaics to achieve a combined reduction in the site carbon dioxide emissions 2,123 tonnes per annum. This equates to a site wide reduction of 31.6% below the benchmark figure. Should the PDHU connection not be possible the load will be met from onsite gas boilers. This will result in an increase in the site carbon dioxide emissions by approximately 88 tonnes per annum which is considered to be negligible.

12.5.2 The DE mains route proposed is illustrated in drawing 2671-CS-115 of the Utilities document accompanying the April 2011 amendment to the planning application[33].

12.5.3 This proposal to connect to PDHU would be desirable in the wider context of creating greater DE coverage within the borough and London as a whole. In particular, the DE mains route proposed would facilitate connection of properties around the Ebury Bridge Road, the Royal Hospital, and other large blocks towards Sloane Square. However, as the text states, this connection is subject to agreement of terms and conditions between the developer and PDHU, and it is not

[32] http://www.chelseabarracks.net/planning/downloads_revised/Addendum_Planning_Statement.pdf, accessed 11th June 2013

[33] http://www.chelseabarracks.net/planning/downloads_revised/Addendum_Utility_Strategy.pdf, page 13, accessed 11th June 2013

clear what would be acceptable from the developer's (Project Blue (Guernsey) Ltd) perspective.

12.5.4 PB would comment that this outline technical strategy as a concept is arguably sub-optimal, as the proposal appears to be that the PDHU connection will operate to supply heat to the Chelsea Barracks site only when on-site generation is not sufficient to meet demand, and with the additional potential to supply heat from Chelsea Barracks to PDHU to help increase the proportion of CHP heat in the PDHU heat supply mix. This strategy limits the volume of heat that will be transferred through the network, limits the avoided costs seen by Chelsea Barracks, and therefore erodes the potential commercial viability of this network link. However, it would be an excellent outcome for decentralised energy if this link is made, and the high density of the loads towards Sloane Square from Chelsea Barracks suggests that with an appropriate expansion strategy, that this might give rise to further customers joining the network over time.

12.5.5 From a policy perspective, there is limited scope and time to add weight to existing policies applicable to the Chelsea Barracks / PDHU link. The approach that is advocated for WCC is to work towards an outcome where:

- The secondary system designs of the development are compatible with a DE link (as per the London District Heating Manual)
- *Either t*he development is permitted a 'grace period' for the installation of CHP on the site (or at least for later phases) if the programme and detail of delivery allows this, in return for the connection of a peak-load link to PDHU, where the PDHU link becomes the primary source of heat for the development. This would only be workable sufficient boiler capacity is available at PDHU. *Or,* for a greater capacity of CHP at Chelsea Barracks to be installed, with more significant export proposed to the PDHU system, particularly during the winter months. This would have repercussions on other links to PDHU under discussion (i.e. Victoria Circle / WDHS).

12.5.6 It would be a great shame to 'miss' this expansion opportunity for the PDHU system, given that developments of the scale of the Chelsea Barracks do not occur very frequently particularly in such a beneficial location for system expansion.

12.6 Nova Victoria / PDHU

12.6.1 The immediacy of the customer base of PDHU, close to the Nova Victoria development, the certainty of the development's implementation, and the willingness of Land Securities (Nova Victoria developer) or the ESCo operator of the site to enter into an agreement with PDHU all suggest that the link between Nova Victoria and PDHU should be a successful enterprise. However, there is currently hesitation, uncertainty surrounding the value of the link, possibly caused by the complication of the WDHS connection and its contribution towards meeting heat demands on the PDHU system. However, PB strongly suggests that in this instance WCC / PDHU should adopt an 'opportunistic' approach – i.e. the opportunity to implement a link between these two areas will not arise again in the short or medium terms. Despite potential future plans for WDHS and PDHU links, these are only plans with very little solidity, whereas the link to Nova is a concrete proposal which could result in immediate positive impact for both the development and for PDHU, and strategically in terms of linking PDHU to another dense area of development.

12.6.2 In this context, the PDHU thermal store should again provide comfort. With the potential to charge the store at times of low demand, or during periods when the CHP supply is greater than system demand, there should be a degree of flexibility of operation afforded to all units connected to the PDHU system, particularly if a flat electricity tariff is successfully negotiated, such that night-time operation is viable.

12.6.3 In this context the potential of a WDHS to PDHU link should not be seen as a factor influencing the Nova Victoria to PDHU connection.

12.7 Westbourne Green

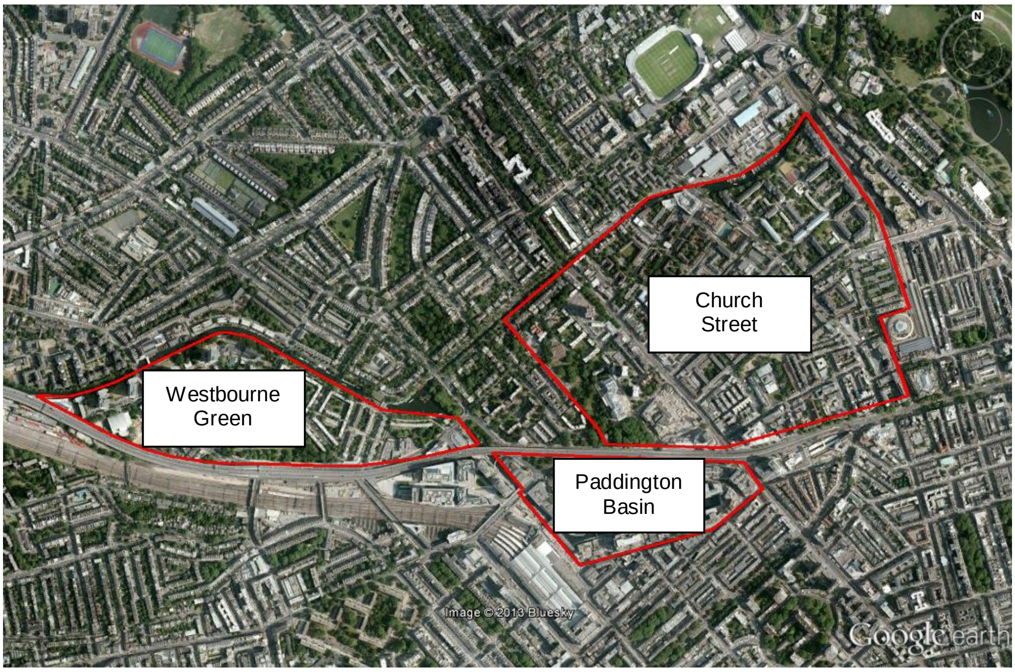
12.7.1 Westminster City Council has expressed a particular interest in a district heating network linking three areas in the vicinity of Paddington train station – Westbourne Green, Church Street and Paddington Basin.

12.7.2 The area around Church Street is scheduled for significant redevelopment in the coming years, whereas Paddington Basin has already undergone major redevelopment in the area to the west of the Hilton Hotel, with additional development planned in the near future. Westbourne Green is a primarily residential area to the west of Paddington Basin and Church Street, with six high rise tower blocks and localised development in consultation.

12.7.3 The presence of the six tower blocks at Westbourne Green, the hotel and the existing business and residential blocks at Paddington Basin could provide an anchor load from which to develop a district heating network. As such, this energy masterplan has assessed the viability of a scheme connecting these three areas with a single DE network.

12.7.4 The location of the three areas being assessed for connection is shown in Figure 12-5.

Figure 12-5: Three areas assessed for connection to Westbourne Green heat network



12.7.5 Load development - Church Street and Paddington Basin

12.7.6 The load development for the Church Street area was informed by work undertaken previously on behalf of Westminster City Council by Arup. A November 2012 report entitled *Church Street Area Energy Masterplan – Presentation of findings* provided an outline of the proposed development and phasing for the area, including two options for a district heating scheme connecting the various development sites.

12.7.7 The report detailed the location of development within Church Street along with the heat load and current phasing. There are also two existing housing estates that have been included in the report – Wharnecliff Gardens and Church Street 3 & 4.

12.7.8 In addition to the Church Street loads, the 2011 report presented heat demands for proposed development in the Paddington Basin area, which is located just to the south of the Church Street development area. Seven new developments and one existing development – Merchant's Square – were included in the report. It is noted that the eight heat loads presented do not represent the total heat load for Paddington Basin as there are several buildings already established in the area. Additional work was therefore required in order to generate a more complete picture of the heat loads within Paddington Basin.

12.7.9 Along with heat load and phasing data, the 2011 report presented an internal district heating network route serving the Church Street loads and Paddington Basin loads that had been included. Figure 12-6 shows the location of the development and the proposed internal DE route. This work has informed the wider strategic network modelling that was carried out in this study. The phasing and cumulative heat loads shown on the map are as follows:

12.7.10 The final build-out heating demand for the Church Street loads shown below and used in the modelling described hereafter is **51,696MWh/yr**.

Figure 12-6: Church Street development area and internal DE network from Arup report

12.7.11 Paddington Basin existing buildings

12.7.12 As described above, the 2011 Arup report included seven new buildings and one existing development – Merchant Square – in the Paddington Basin area. However, there are already a significant number of existing buildings in the area that have not been accounted for in Arup's report. Parsons Brinckerhoff therefore estimated heating demands for key existing buildings in the Paddington Basin development.

12.7.13 One of the key existing heat loads in the Paddington Basin area is the Hilton Metropole hotel, which consists of 1,054 air-conditioned bedrooms as well as a swimming pool, conference space, restaurant and bar areas. The shape of the building, which is on multiple levels, is such that it is not easy to calculate floor area based on the building footprint and the number of storeys. We therefore used a series of assumptions to calculate the annual demand as follows:

- 1,054 bedrooms at an average of 20m^2 per bedroom = 21,080m^2 of room space.
- Additional floor space (for communal areas, bar, conference rooms etc) = 35% of total room space = 28,458m^2 total hotel floor area.
- Good practice, luxury hotel heating benchmark from CIBSE Guide F = 300m^2/kWh.
- Assumed boiler efficiency = 80%
- Calculated hotel heating demand = **6,830MWh/yr**.

12.7.14 Other existing building heat demands were calculated using the same methodology as for the Soho area described in Section 12.8. GIS mapping was used to provide building footprints and heights, with an assumed storey height of 3.5 metres per storey and an assumed net floor area that is 76 percent[34] of the total building gross floor area. A map showing GIS outputs for Paddington Green is presented in Figure 12-7.

Figure 12-7: Map of Paddington Basin GIS output

12.7.15 The total calculated heating (inc hot water) demand for existing buildings in the Paddington Basin area, including the Hilton Metropole hotel is **15,231MWh**.

12.7.16 Westbourne Green renewal opportunities

12.7.17 As described previously, there are six electrically heated tower blocks at Westbourne Green. Discussion with WCC has highlighted the possibility of converting the heat supply in these buildings to wet systems served from a DE network, which would provide an anchor load for a network serving the Church Street and Paddington Basin areas. We were informed by WCC that each of the six tower blocks comprises of 125 flats with an annual heating demand of 10MWh per flat – 1,250MWh per tower block.

12.7.18 In addition to the tower blocks at Westbourne Green, there is a small amount of local development being discussed with residents and local stakeholders. These areas, and the proposed usage for each development, have been highlighted in a booklet for a neighbourhood masterplan ideas exhibition that was provided to

[34] Energy Consumption Guide 19, Action Energy, March 2003

Parsons Brinckerhoff by WCC. Parsons Brinckerhoff used this information to develop floor areas and apply heating benchmarks for future buildings extrapolated from existing building benchmarks in CIBSE's TM46 (2008) guide.

12.7.19 There are seven 'renewal opportunities' identified in the ideas exhibition booklet, all based around community based usage – retail, residential and community centre. Parsons Brinckerhoff used the architects' drawings in the brochure to estimate the building footprint for each development and estimated building height based on the same drawings or, where available, storey information in the booklet. New building benchmarks extrapolated from CIBSE existing building benchmarks were applied to the calculated floor areas with an assumed boiler efficiency (80 percent) to calculate the annual heating demand for each building/development. A summary of this calculation process is presented in Table 12-1.

Table 12-1: Westbourne Green regeneration area load working

Development Area #	Description	Footprint (m2)	Assumed storeys	Heated floor area (m2)	Usage type	Benchmark (kWh/m2) - inc efficiency	Annual demand (kWh)
2	Mix of shops & homes on old Community Ctr site. See Exhibition Booklet for details	1767	4	7068	Retail & resi	60	426,060
3	Nursey and Community Ctr	2522	1	2522	Day Ctr & Community Ctr	67	169,478
4	15 flat apartment block same height as college next door	N/A	N/A	N/A	Residential	N/A	49,625
6	Mix of shops & homes on Oldbury House site. See Exhibition Booklet for details	786	4	3144	Retail & resi	60	189,521
6	Community Centre	283	3	849	Community Ctr	67	57,053
7	5 storey block in L-shape. All resi. As specified in Exhibition Booklet	1374	5	6868	Residential	87	594,331
8	7 family-sized houses. 2 or 3 storey maisonettes	N/A	N/A	N/A	Residential	N/A	49,913

12.7.20 The total calculated heating demand for the Westbourne Green renewal areas is **1,536MWh/year**.

12.7.21 Westbourne Green existing tower blocks

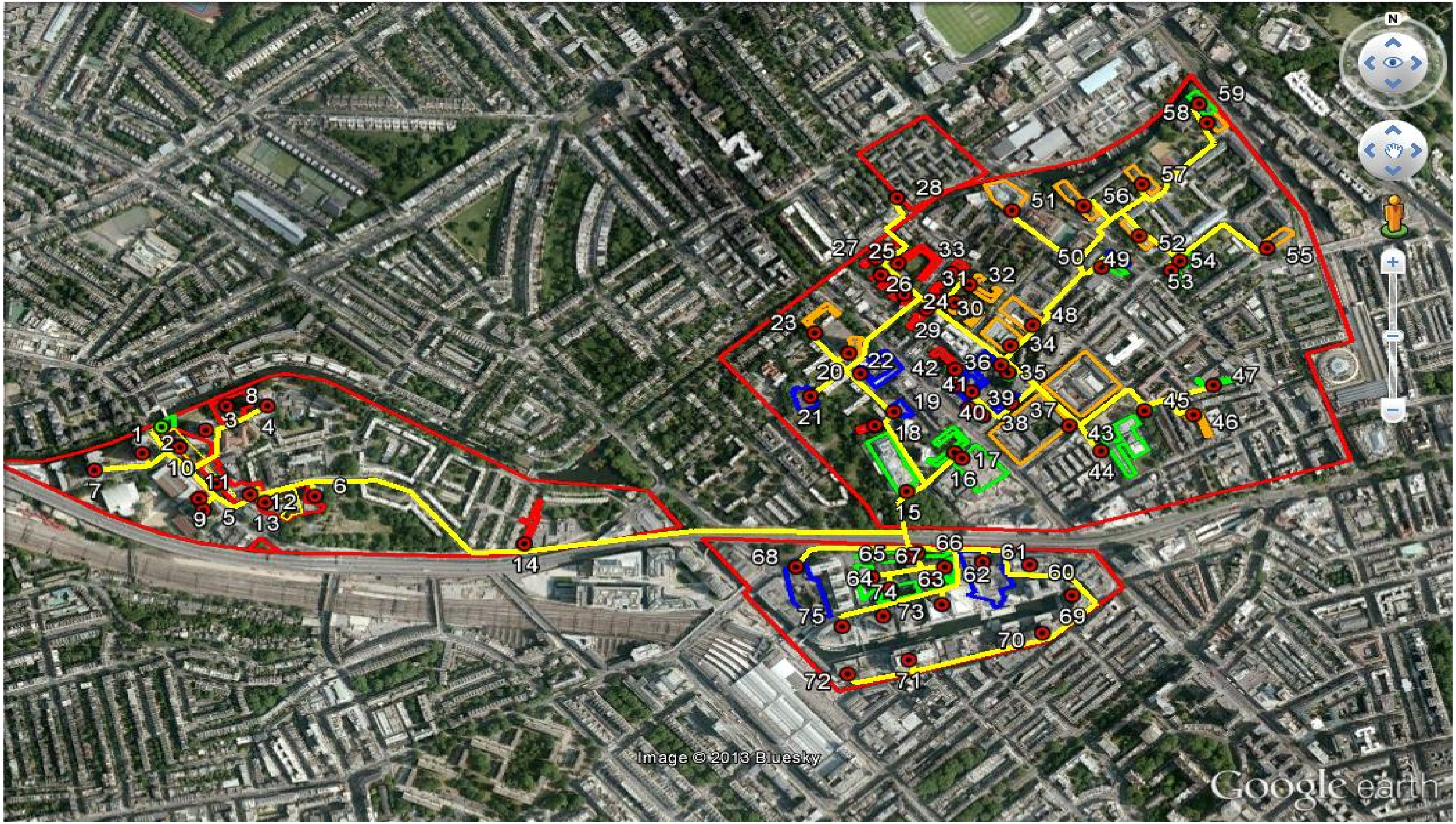
12.7.22 As described above, there are six existing tower blocks in Westbourne Green that are currently electrically heated. WCC advise that each tower block consists of 125 flats with a heating demand of 10MWh per flat. Each tower block has an annual heating demand of 1,250MWh/yr, so the combined existing heat load considered for connection to a scheme at Westbourne Green is **7,500MWh/yr**.

12.7.23 DE network modelling

12.7.24 The total combined heat load assessed for connection to the scheme, based on the analysis described above, is **75,963MWh/yr**. Having determined the magnitude of the loads available for connection, Parsons Brinckerhoff developed a district heating network to serve them.

12.7.25 We *notionally* positioned an energy centre in a section of one of the Westbourne Green renewal opportunity areas currently being proposed as a play area. This has been done on the basis both that the existing tower blocks could act as a first phase anchor load for the scheme and as WCC may be able to reserve space in the renewal areas for an energy centre through the planning process. It is noted, however, that the tower blocks will require conversion from electric heating to a communal wet system and this requirement may limit their viability to act as the anchor load. At this stage, any choice of energy centre location is indicative only and subject to further assessment and confirmation by WCC, and dialogue with stakeholders. As such, we have modelled an energy centre in Westbourne Green on the understanding that this may change. The network modelled is shown in Figure 12-8.

Figure 12-8: Westbourne Green DE network modelled



12.7.26 Parsons Brinckerhoff modelled the district heating network shown in Figure 12-8 using our in-house hydraulic modelling software. This tool requires, amongst other things, the peak heating demand at each node in order to size the pipe. In the absence of more detailed information on each heat load, we applied a load factor to the annual demand for each load in order to calculate the peak. The model then sizes the pipes according to user-defined parameters – specifically the maximum allowable pressure drop and the maximum allowable velocity along each pre-defined diameter of pipe. The model then sizes the network and calculates cost based on up to date pipe costs (£/metre) supplied by a pre-insulated pipework installer and built into our modelling software.

12.7.27 The network cost calculated according to the above methodology is **£10,740,000**.

12.7.28 CHP modelling

12.7.29 In order to assess commercial performance, we used our in-house CHP modelling to generate energy balance data for the scheme. A load profiling tool was used to distribute the annual heating demand for each load across an hourly profile for a full year according to building usage type. The performance of CHP plant was then modelled against this demand profile to determine the key heat provision, fuel consumption and power generation data for the CHP as well as the top-boiler heat requirement. The plant modelled was:

- CHP sized to meet approximately 70 percent of heat load over 6000 run hours, 8.32MWth CHP capacity;
- Maximum 1 allowable CHP start per day;
- 300m^3 of thermal storage;
- Top-up boilers sized to meet peak heating demand;
- 10 percent network heat losses.

12.7.30 The key energy balance results from this modelling process are presented below.

Table 12-2: CHP modelling key energy balance results

Item	Value (MWh)
Annual heat demand inc losses	83,560
CHP heat provision	45,822
CHP power generation	47,364
CHP fuel consumption	118,001
Boiler heat provision	37,728
Boiler fuel consumption	45,455

12.7.31 Commercial modelling

12.7.32 Having modelled the energy inputs and outputs of an energy centre providing heat to the DE network, we applied economic inputs to assess the commercial performance of the scheme over a 25 year project lifecycle.

12.7.33 Capital costs

12.7.34 Capital costs for the energy centre were based on a range of sources. Costs for key plant items (CHP, boilers and thermal store) were taken from recent supplier quotes; costs for the DE network itself were taken from DE installer quotes costs on a £/metre basis (note that these costs are not project specific); costs for all other items were based an energy centre of comparable proportions from a previous project for which detailed capital cost analysis had been undertaken. The total capital cost of the network and energy centre used in this modelling is **£23,827k**. NB this includes the full network extent as illustrated in Figure 12-8. A breakdown of capital cost items can be found in the appendices.

12.7.35 It has been assumed that the capital cost of converting the six electrically heated tower blocks in Westbourne Green to wet, communal systems will be borne by another budget[35]. It has therefore not been included in this modelling.

12.7.36 Utility costs

12.7.37 Utility costs for the commercial modelling were based on DECC utility price projections, which represent three changing utility price scenarios based on low, medium (central) or high deviation from current energy costs. The projections are based on likely changes in future energy markets and reflects a general trend in which there is a widening differential between gas and electricity prices. This is important for CHP as the widening ‘spark spread’ strengthens the argument for a technology that produces electricity from gas.

12.7.38 Parsons Brinckerhoff has used the central price projection scenario cost for industrial gas in our CHP modelling. The industrial gas price is appropriate as the ESCo operating the DE network will procure gas on a large scale compared to if the building owners/operators were purchasing gas for building/site use only.

12.7.39 Electricity export costs are based on the current wholesale value of electricity, which fluctuates around £50/MWh (5p/kWh). This value was also varied through time according to DECC’s central utility price projection scenario.

Heat sales price and connection charge

12.7.40 The heat sales price used in modelling revenue from connected loads was linked to DECC’s utility price projections central scenario retail gas price. The retail gas price has been used as it reflects the business as usual case for heat sales customers, wherein they would purchase gas for building/site use only. The heat sales price also includes the following assumptions:

- 83 percent boiler efficiency for business as usual heat provision;
- Avoided boiler maintenance compared to BAU – additional 10 percent on heat sales price;
- Avoided boiler replacement cost based on the centralised scheme top-up boiler costs (with a percentage uplift to account for the fact that individual boilers would be more expensive on a £/kW basis than the large centralised boilers) divided by heat sales over 20 year period. This reflects the unitised cost of replacing the boilers after 20 years of operation.
- A 10 percent reduction in the base heat sales price has been applied to offer heat sales customers a saving on their business as usual cost of heat.

12.7.41 In addition to the unitised cost of heat, a one-off connection cost was also applied to new developments to reflect the avoided cost of them providing

[35] Energy Company Obligation (ECO) funding may be able to assist in this arena, as the area is ‘Carbon Saving Community Obiligation’ eligible.

their own boiler plant and associated infrastructure (spatial requirements, flue etc). This was based on a cost of £200 per kW peak per development with a 50 percent capacity factor on the peak.

12.7.42 *Maintenance cost*

- A CHP maintenance rate of 0.6p/kWh of electrical generation was used in the commercial modelling. This is based on supplier quoted maintenance rates for the engine sizes modelled in this assessment.

- Boiler maintenance costs of £30k per year have been applied.

- DE network maintenance costs of 1 percent of the initial DE capital cost have also been applied.

- Maintenance costs have also been applied for several of the smaller plant items at a combined cost of £12.5k per year.

- A staffing cost for full-time energy centre maintenance cover has been included at an annual cost of £40k.

12.7.43 *Replacement costs*

12.7.44 Replacement cycles for the CHP and boiler plant have been included as follows:

- CHP: 70 percent of initial capital cost after 15 years for complete engine overhaul.
- Boilers: 100 percent of initial capital cost after 20 years for full replacement.

12.7.45 In addition, replacement costs for several of the smaller plant items have been included at a combined cost of £614k.

<u>Results and comments</u>

12.7.46 We assessed the performance of the Westbourne Green DE scheme based on the energy balance, economic inputs and assumptions described above. A discount rate of 3.5 percent was used.

12.7.47 The NPV of the scheme (assessed at 3.5% discount rate, 25 years), based on these inputs and assumptions, is **£2.16m**. This represents a commercial performance that is above the threshold Treasury Green Book rate for infrastructure projects, and indicates that it appears to deliver sufficient levels of return to pursue the concept further.

12.7.48 At the high level of assessment presented in this report, there are of course many levels of detailed investigation and design development to achieve anything akin to ‘cost certainty’. However, this is a strategic assessment, and the headline output of this analysis is that the interconnection of the three areas of Westbourne Green, Church Street and Paddington basin appears to offer sufficient commercial return to warrant further investigation and development.

12.7.49 Given the different stages of development progress across the different areas (and indeed of sites within these areas), the key recommendation is to ensure that where there is still the potential for policy intervention, to ensure that provision is made for future interconnection. This means that as developments come forward that:

- Routes for interconnection of these areas are safeguarded
- Viability of interconnection is reassessed as developments come forward along these routes
- Discussions are opened with developers around this concept
- Technical standards for the design of building secondary systems (as per the DH Manual for London) are implemented and enforced
- A suitable energy centre location is identified

12.8 Soho

12.8.1 Soho presents a more challenging landscape for a district heating scheme than many of the other areas considered in this study. As a densely occupied area with a high proportion of rented (or short-term lease) commercial properties and accommodation, relatively small buildings (often split into multiple occupancy), and busy thoroughfares, there is not a lot of accessible heat demand that could be considered favourable for connection to a DE scheme. This is found in the *Improving Historic Soho Environmental Performance* guide that was published by Westminster City Council in February 2013. For a copy please see - http://transact.westminster.gov.uk/docstores/publications_store/Improving_Historic_Sohos_Environmental_Performance_February_2013.pdf).

12.8.2 However, in order to test the viability of establishing DE networks purely on the basis of sites coming forward for development via the planning system, an approach for assessment of the potential for the dissemination of DE in Soho was developed. This considers the 'churn rate' for new development that could be made DE ready as part of the planning consent process. The methodology considers how a viable heating demand for a DE scheme could be established progressively through time as sites come forward for major refurbishment / development.

12.8.3 Load development

12.8.4 *First pass load development* - In order to determine the scale of heating demand in the Soho area, Parsons Brinckerhoff first used GIS mapping to determine the footprint and height of each building. Based on the height of the building, we made the assumption that there would be a storey for every 3.5 metres of the total height. We assumed that the building usage type in the area would be primarily made up of cellular, naturally ventilated offices (of the four office types in the Carbon Trust Econ 19 Guide). Econ 19 states that for this building type the net floor area is 76 percent of the gross. We therefore applied this percentage to each building footprint and multiplied it by the number of storeys to give a total heated floor area. We then applied a heating benchmark for standard practice office buildings from CIBSE Guide F, with an assumed boiler efficiency of 75 percent, to get an annual heating demand figure for each building.

12.8.5 This first pass methodology indicated a total existing annual heating demand in Soho of 59GWh.

12.8.6 *Development of DE viable load through time* - WCC provided data showing the number of major planning applications for the Soho area received over the last five years.

12.8.7 WCC's planning application data showed that there were 33 planning applications over the last five years within the Soho area. It has been assumed in this study that each of these applications would correspond to a site with an annual heating demand of 100MWh or more. This assumption is important in the methodology that follows, and it should be noted that this is considerably higher than the average demand across the borough (including residential properties, and also higher than the average demand for non-residential properties).

12.8.8 Using the existing Soho heat loads from the first pass load development, we were able to identify how many of the existing buildings have an annual heating demand of 100MWh or more. Effectively, this group of buildings becomes the proxy for potential future major planning applications in Soho.

12.8.9 Of the 1,904 buildings for which heat demands were calculated in the first pass methodology, 115 were estimated to have a heat demand greater than 100MWh. The combined annual heat demand of those 115 buildings is approximately 25.9GWh with an average demand of 225MWh.

12.8.10 If it is assumed that all of the major planning applications are designed to be DE compatible (i.e. anything with an annual demand over 100MWh should be connected), then we can say that there are 33 new connections available every five years, with an average load of 225MWh at each. That equates to something in the region of 7GWh of new demand every five years.

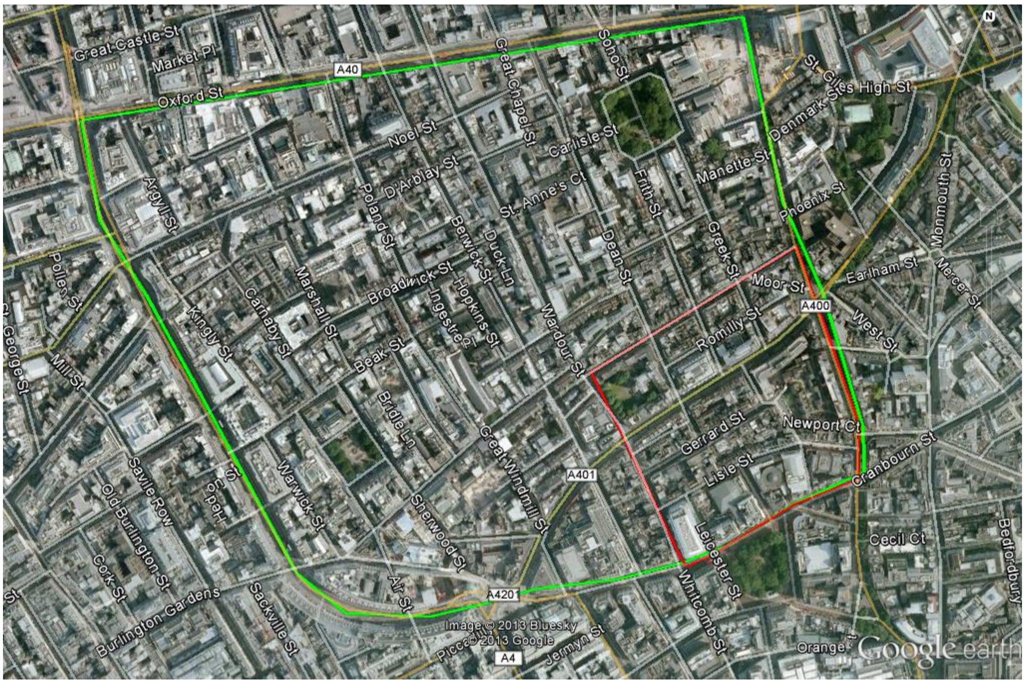
12.8.11 The key question is therefore how long it would take for there to be sufficient DE-ready development, given the cost of installing and operating a network, to create a viable scheme? And is this timeframe sufficiently realistic to require future developments to be DE ready on the understanding that a scheme has a reasonable chance of coming forward?

12.8.12 Modelling methodology

12.8.13 DE network viability depends largely on the magnitude of connected heat demands and the length of network required to link them. However, the location of that demand coming forward is unknown. The methodology adopted in this analysis therefore attempts to emulate the situation of a range of demands coming forward, in order to assess the point at which a scheme becomes commercially viable. This was done by designing a DE network consisting of multiple demand points and assessing different load combinations.

12.8.14 In order to make the quantity of data being assessed more manageable, we reduced the sample area size to a small section of the total Soho area. The tested area, shown in Figure 12-9 is 72,856m^2 (red), is 15 percent of the wider Soho study area (479,626m^2 - green).

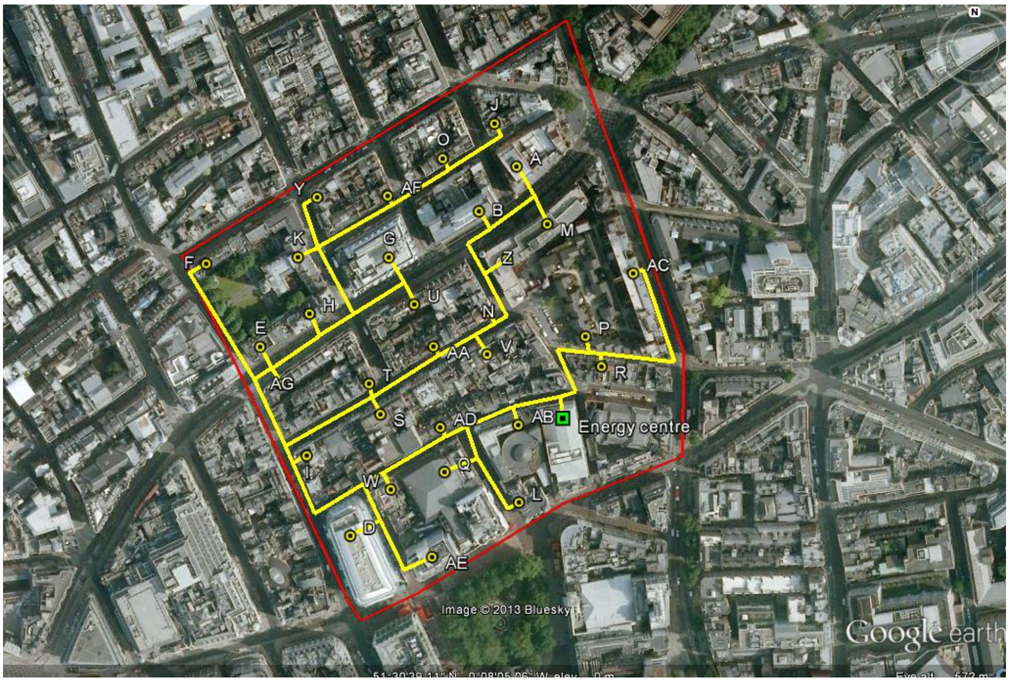
Figure 12-9: Soho study area (green) and test area (red)



12.8.15 Having determined that there are 33 major, DE viable, planning applications in the wider Soho area every five years, the number of DE viable applications in the smaller, tested area was reduced in line with the reduction in test area size, i.e. 15 percent of the total. The test area was therefore assessed with the availability of 5 new heat loads every five years, equating to approximately 1GWh of heat demand.

12.8.16 The notional heat network assessed is shown in Figure 12-10.

Figure 12-10: Soho 'test area' notional heat network



12.8.17 Testing load combinations for the notional network shown above was undertaken using our in-house modelling software. The model uses a numerical system (based on binary selection) to test possible combinations of loads within a pre-determined range. The model also calculates a capital cost for an energy centre, including CHP and top-up boilers, based on the size of the demand under each tested configuration.

12.8.18 There are 31 heat loads on the notional network shown in Figure 12-10, which equates to approximately 30 years of development based on the methodology described above. In order to limit the number of possible load configurations, we combined the loads into groups according to their proximity to the notional energy centre and tested the commercial performance of a scheme as the load density increases (i.e. as more of the heat loads are connected).

12.8.19 The load combinations were grouped according to their proximity to the energy centre. Figure 12-11 shows the grouping of loads as modelled in the commercial assessment that follows.

Figure 12-11 Soho areas for iterative testing

12.8.20 Commercial assessment

12.8.21 In assessing the commercial performance of the load combinations, various economic inputs have been included, as follows:

12.8.22 Capital cost inputs

12.8.23 We have assumed that the cost of an energy centre building would be avoided by requiring one of the major planning applications to provide space as part of their planning consent.

12.8.24 The cost of energy centre plant is calculated by the modelling software described above. Costs for all plant items are built into the software, which sizes the major plant and ancillary (pumps, controls, water quality maintenance items etc) items according to the network heat load. The cost of these items is then included in the final capital cost makeup for the scheme.

12.8.25 DE pipes have been sized for each load combination scenario using an assumed load factor (20 percent), which has been applied to the annual heat load for each connected building. The DE network costs have then been calculated according to pipe costs supplied by a DE installer for the London area. We have increased those pipe costs by an additional 50 percent to reflect the density of utility services in the Soho area, which will undoubtedly make trench excavation and DE routing a more time consuming (mostly hand-digging) and, therefore, expensive process.

12.8.26 Utility costs

12.8.27 Current utility costs for the commercial modelling were based on DECC utility price projections, which consist of three utility price scenarios based on low, medium (central) or high projections from current energy costs. The projections are based on likely changes in future energy markets and reflects a general trend in which there is a widening differential between gas and electricity prices. This is important for CHP as the widening ‘spark spread’ strengthens the argument for a technology that produces electricity from fuels that are cheaper than the retail cost of electricity – in this case, gas.

12.8.28 Parsons Brinckerhoff have used the average central price projection scenario cost for industrial gas over the 25 year project lifecycle in our CHP modelling. The industrial gas price is appropriate for the central operator of the scheme, as the ESCo operating the DE network will procure gas on a large scale compared to if the building owners/operators were purchasing gas for building/site use only. The offset cost of heat for individual building owners is calculated on the basis of the ‘services’ gas price in the DECC projections.

12.8.29 The electricity export cost used in the modelling is the 25 year average of the DECC utility price projections[36] central scenario wholesale electricity price – 6.82p/kWh. This value is higher than has been used in the modelling of other schemes, for example Westbourne Green; however this reflects the fact that a scheme in Soho would not come forward until much later, when there is sufficient load available. As such, we anticipate electricity wholesale prices to be higher in line with DECC projections.

12.8.30 Heat sales price and connection charge

12.8.31 The heat sales price used in modelling revenue from connected loads was linked to DECC’s utility price projections central scenario ‘services’ gas price. The average services gas price over the 25 year project lifecycle has been used as it reflects the business as usual case for heat sales customers, wherein they would purchase gas for building/site use only. The heat sales price also includes the following assumptions:

- 83 percent boiler efficiency for business as usual (BAU) heat provision (following refurbishment);
- Avoided boiler maintenance compared to BAU – additional 10 percent on heat sales price;
- Avoided boiler replacement cost based on the centralised scheme top-up boiler costs (with a percentage uplift to account for the fact that individual boilers would be more expensive on a £/kW basis than the large centralised boilers) divided by heat sales over 20 year period. This reflects the unitised cost of replacing the boilers after 20 years of operation.
- A 10 percent reduction in the base heat sales price has been applied to offer heat sales customers a saving on their business as usual cost of heat.

12.8.32 Maintenance cost

12.8.33 CHP maintenance costs have been included and are calculated by the model according to the size of the engine, which varies according to the load connection scenario being assessed.

[36] Based on the assumption that post-2030 that prices remain at the DECC projected 2030 levels.

12.8.34 A notional boiler maintenance cost of £30k per year has been applied, allowing for labour, parts and gas-safety inspections.

12.8.35 Annual DE network maintenance costs of 1 percent of the initial DE capital cost have also been applied.

12.8.36 Maintenance costs have also been applied for several of the smaller plant items. These costs vary according to the size of the items, which varies according to the load connection scenario being assessed.

12.8.37 Replacement cost

12.8.38 Replacement cycles for the CHP and boiler plant have been included as follows:

- CHP: 70 percent of initial capital cost after 15 years for complete engine overhaul.
- Boilers: 100 percent of initial capital cost after 20 years for full replacement.

12.8.39 In addition, replacement costs for several of the smaller plant items have been included. These costs vary according to the size of the items, which varies according to the load connection scenario being assessed.

12.8.40 Modelling Results

12.8.41 Based on the projected average development heat load (225MWh/yr) and the economic inputs described above, we assessed the commercial performance of a Soho DE scheme with increasing load density. The results of that modelling are presented in the following table (ranked in NPV order).

Table 12-3: Soho test DE scheme NPV performance at increasing load densities

AREAS SWITECHED ON OR OFF																NPV result
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	(25 years,
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	-£2,343
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-£2,471
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	-£2,624
1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	-£2,784
1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	-£2,994
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	-£3,072
1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	-£3,268
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-£3,413
1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	-£3,545
1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	-£3,800
1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	-£3,902
1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	-£4,100
1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	-£4,153
1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	-£4,248
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	-£4,255
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-£4,430

12.8.42 The results above show a scheme that generally decreases in viability as the number of connected loads increases. Although this seems counter-intuitive, it reflects the fact that the heat load added to the scheme with each new connection is insufficient to pay for the additional infrastructure required to serve it.

12.8.43 This is partly a result of the increased network costs included in the modelling of the Soho scheme, which reflects the complicated civil engineering works required to route DE mains through streets that will already contain a high volume of other utilities service infrastructure.

12.8.44 This analysis, based on one on the most heat dense areas of the borough, and one of the areas with the highest rates of planning applications coming forward illustrates that the establishment of DE systems on the basis of planning applications coming forward alone is unlikely to be commercially viable, even with aggregating the demands from developments coming forward over decades. This analysis is taken forward in the 'Rest of the borough' analysis where a more widespread level of DE take-up (also assuming connection to sites not coming forward for planning) is modelled.

12.8.45 Other options

12.8.46 It is clear that there is a high density of restaurants and other food retail outlets in Soho, and that there is a large volume of food waste generated through this market segment. One 'alternative' option for the area could profit from this food waste as an energy source, and return useful outputs to local businesses. The following potential benefits of this notional system (based around anaerobic digestion – AD) are noted:

- The generation of an affordable and secure supply of heat and/or power for social housing/community facilities and small businesses and possibly also power to electric vehicle charging points, thereby reducing fuel poverty and energy costs to businesses
- Reducing CO_2 emissions from the built environment, helping WCC to meet carbon reduction targets and potentially dovetailing with emerging plans for the development of decentralised energy across the City
- Making beneficial use of a waste product, thus helping WCC to meet its statutory waste management obligations stemming from EU Waste Directive (by creating new waste management capacity) as well as reducing waste transport movements across the City (and the associated air pollution) and waste to landfill
- Reducing food waste collection costs for local businesses
- Generating soil fertiliser as a by-product, thus displacing the need to transport into the City higher embodied energy forms of fertiliser (e.g. for the Royal Parks)

12.8.47 As a technology small-scale containerised AD is entirely compatible with DE networks; in fact the existence of a heat network is a facilitating factor as it potentially provides a permanent heat source/sink which would allow the AD process to be optimised: excess heat from the AD's CHP can be dumped into the network and when the AD CHP is down, the network could supply heat as required to aid the digestion process. In addition the heat network could be used on start–up to help raise the digester to operating temperature.

12.8.48 As a concept this arrangement clearly has excellent potential, but it will be in the detail of delivery that this technology must be proven. The economic viability of a scheme of this nature (e.g. anaerobic digestion and CHP) will be helped by support from the Renewable Heat Incentive[37], but the scale of installation is likely to be restricted by physical constraints in Soho, and hence capital costs on a per kWh of output basis are likely to be high. Equally, how a scheme of this nature deals with the logistics of waste transport, odour control, feedstock consistency, pre-processing

[37] RHI support is understood to be currently limited to installations below 200kW, which encourages the type of small-scale plant that would be suitable for urban installation.

requirements, and waste collection / storage in the event of plant failure will be critical.

12.8.49 In terms of overall outputs, initial figures indicate that CHP capacities in the sub-100kWe range are likely to be the maximum scale implementable. Given a total target for installed capacity in the tens of megawatts, this technology will only make a minor contribution towards overall borough targets for DE.

12.8.50 A research consortium including Westminster City Council, and funded by the Technology Strategy Board, is currently underway in order to test the feasibility of these small-scale AD-CHP plants in particularly built up areas, in this case Soho. They aim to address many of the issues outlined above and report back to TSB at the end of October.

12.9 Kilburn South

12.9.1 The Kilburn South development area is predominantly in Brent. However, this development area is effectively surrounded by the border to Westminster on three sides, and is bordered by the railway line to the north. The Kilburn South development masterplan is shown below[38]:

Figure 12-12 Kilburn South development area

SOUTH KILBURN REGENERATION PHASES TO 2025

12.9.2 The development as a whole is anticipated[39] to have a demand of approximately 9GWhth (heat) based around anticipated development of

- Residential 2,411 units
- Commercial 1,700 m^2
- Educational 3,359 m^2.

12.9.3 A site of this scale will be required to have a site-wide district heating distribution system. The following image from GoogleEarth illustrates the masterplan area and the surroundings.

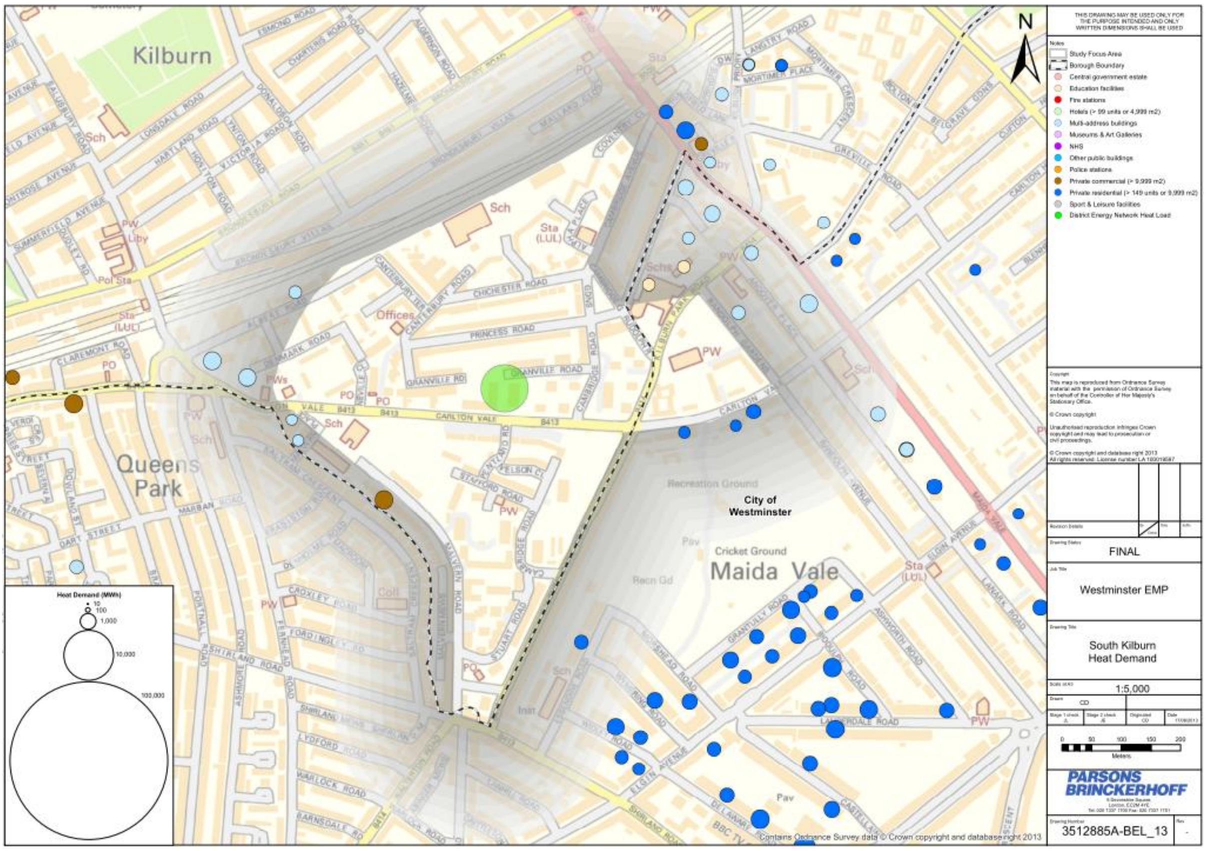
[38] http://www.skpartnership.net/master-plan.html, accessed 11th June 2013
[39] ITT clarification responses, LB Brent, issued 19th April 2013.

Figure 12-13 Satellite image of area surrounding Kilburn South

12.9.4 This illustrates that the area surrounding the development within Westminster is predominantly residential, terraced housing (to the south and west). There is a certain level of retail / commercial and new residential development to the east around Kilburn High Road (Brent). The sites that would appear to offer immediate opportunity to provide synergistic benefit to a DE system are the schools and residential blocks that are immediately outside the masterplan boundary, and within the Westminster Borough boundary – i.e. St Augustine's Church of England Secondary and Primary schools, and Torridon House in particular. In particular the redevelopment of the Tollgate Estate will deliver opportunities for land for energy centres and also heat loads for residential development.

12.9.5 The known heat demands of the area are illustrated on the map below:

Figure 12-14 South Kilburn area (showing borough boundary and identified heat demands)

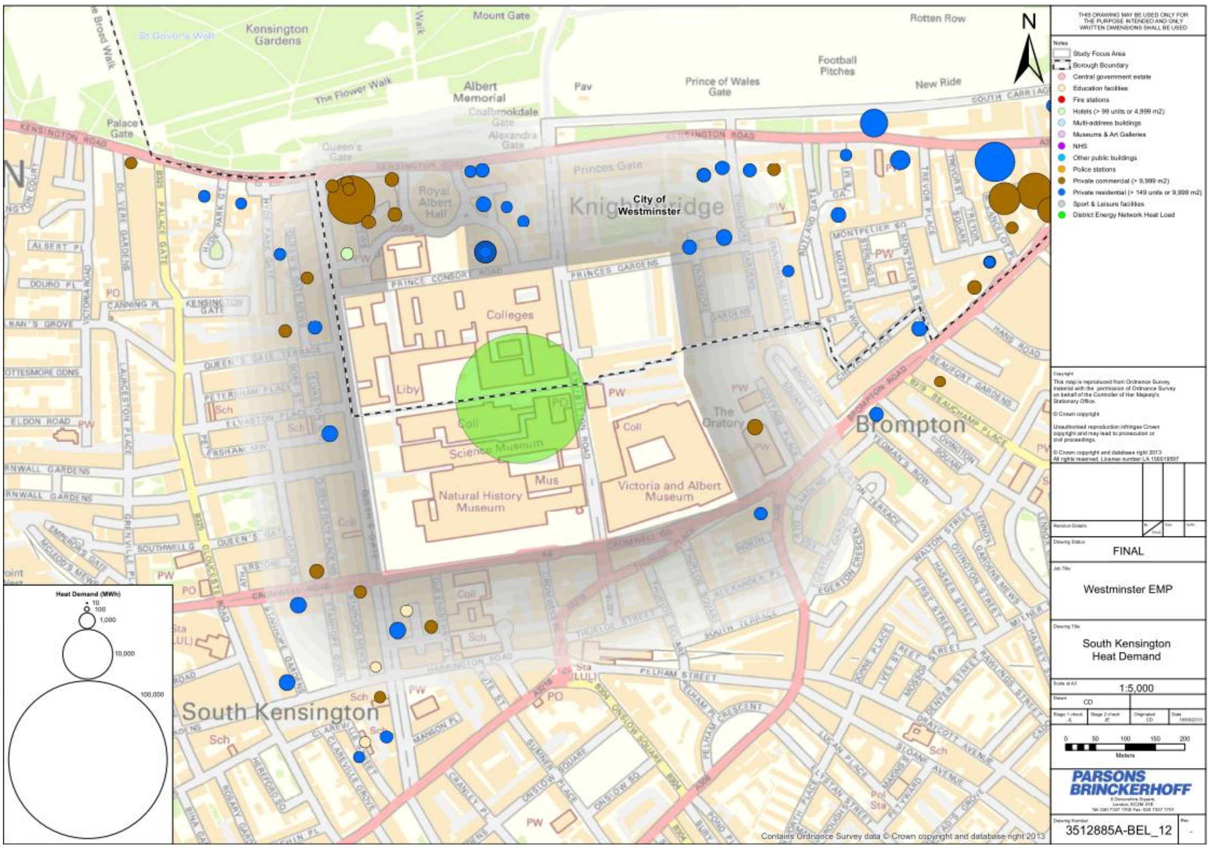


12.9.6 **The approach recommended for WCC in this area is therefore to engage with Brent Council to try to facilitate the examination of the potential for the South Kilburn masterplan DE system also to link to these loads.**

12.10 Museums area, South Kensington

12.10.1 There are existing site-wide heat distribution systems operational at both the Science Museum / Imperial College, and within the Natural History Museum and Victoria and Albert museum. The 'museum' area straddles the borough boundary to Kensington and Chelsea. The loads and borough boundary of this area are illustrated in the plan below:

Figure 12-15 South Kensington museums area map (showing borough boundary and heat demands)



12.10.2 Natural History Museum and Victoria and Albert Museum

12.10.3 The Natural History Museum's energy centre is now operated by an ESCo, and the ESCo's website[40] contains the following summary of the history of this site:

"The Central Boiler House (CBH) at the Natural History Museum has had a long operational history going back to the 1880's. Originally a coal-fired installation it until recent times provided the core heating for the South Kensington Cultural and Academic Estate comprising The Natural History Museum, The Victoria and Albert Museum, Imperial College and The Science Museum. The installation was most recently upgraded in the early 1980's, some 25 years ago and at this time it comprised of 4 large duel fuel Danks water-tube boilers totalling 42MW of heat output at 130°C.

However in 2000 Imperial College and the Science Museum withdrew from the heat network leaving the CBH with only half its original load. Imperial College was the largest load of the four institutions at 45% and with their increasing estate combined with major power growth, they opted for their own

[40] http://www.vitalenergi.co.uk/CaseStudy_nhm.html, accessed 12th June 2013

dedicated CHP installation. This left the Natural History Museum (NHM) and the Victoria and Albert Museum (V&A) as relatively minor consumers each with approximately 25% of total heat consumption. Removing half of the heat consumption inevitably led to underutilisation of the existing plant, 2 Danks boilers were mothballed and the reduction in economies meant fixed and variable cost increases, resulting in the cost of heat for the remaining parties rising from 1.8p/kWh to 2.7p/kWh in 2000."

12.10.4 The alterations to heat supply that have been undertaken since the appointment of an ESCo include the conversion from the previous high-temperature hot water distribution (130 deg C flow temperature) to a low-temperature (LTHW) system operating at 95 deg C flow and 65 deg C return. This has delivered benefits to the museum, and also to this energy masterplan, also increases the compatibility of this system with wider, future district energy networks. The ESCo is in a 15-year agreement for the supply of energy to the NHM (understood to have started around 2006), and hence a potential 'break-point' for the introduction of an alternative supply for the NHM will occur around 2021.

12.10.5 Imperial College and Science Museum

12.10.6 Imperial College and the Science Museum are understood to continue to operate a heat distribution system that is made up of a combination of steam and medium temperature hot water (MTHW). There are a series of tunnels underneath these institutions that contain the distribution pipework for these systems, not all of which are easily accessible.

12.10.7 The supply of steam and MTHW from a remote energy centre to Imperial College is not considered feasible, as this would imply the need for steam / MTHW in the public domain that would be challenging from a health and safety perspective. There are very few examples (if any) of steam distribution in public highways in this country. Equally, there is no evidence (to PB's knowledge) of the feasibility/viability of conversion of the existing steam (and medium temperature hot water) distribution system within the campus to lower temperature distribution. Hence from an energy masterplan perspective, the only options for making use of the assets of this system would be:

- Taking a supply of steam / MTHW to Imperial College / Science Museum through rejuvenation of the link with the Natural History Museum

- Expansion of the existing heat distribution system to supply other loads. This could be implemented by the introduction of heat exchangers (converting steam or MTHW to LTHW) within the existing site plant rooms, and then distributing LTHW further to additional satellite loads.

12.10.8 Museum area as a whole

12.10.9 There are a number of significant aspects of this area in terms of an overall energy masterplan for Westminster.

- This area houses a small number of institutions with cumulatively a very significant heat demand that is accessible from a small number of existing centralised energy centres

- There is a mix of heat supply conditions operational in this area

- These are institutions with the potential to enter into long-term agreements for the supply of energy – i.e. with stability and a long-term likelihood of continued operation at these sites

- The Natural History Museum has a large energy centre (physically), which could potentially house a step-change in plant capacities

12.10.10 The magnitude of the demands in this compact area give rise to two opposing trends in terms of the borough being able to further benefit from system efficiencies through expansion. On the one hand, the existing demands correspond to existing high efficiencies of heat generation, and hence the commercial case for displacing these existing supply mechanisms through another source would likely require a 'step-change' technology. On the other hand, the existing high efficiency of supply also means that expansion of heat supply to other neighbouring areas could be achievable with only marginal change of existing operational strategy or plant.

12.10.11 The key impediment to expansion of supply to other areas by the operators of the plant at these different institutions is considered to be the fact that energy supply is not the core business of these institutions. The Natural History Museum, for example, would be anticipated to have little interest in housing large heat and power generation plant within its complex when it would only see marginal benefit (commercially), and could experience disruption from plant installation and additional inconvenience from the increased magnitude of operations etc.

12.10.12 From the perspective of technical opportunity, the most appealing direction for expansion would be towards Hyde Park Corner from the Museum's area – i.e. passing through the heart of retail Knightsbridge and its high-density commercial outlets and hotels. Retail premises do not normally represent a desirable type of customer for DE systems, as occupancy frequently changes, and there is typically an unwillingness to enter into long-term heat purchase agreements. Landlords do not see any direct benefit from conversion to a DE system (from the default of electric heating), as it is normally the tenant which would pay the heating bills[41]. However, there are some large establishments in this area, where it could be expected that owner-occupiers would have an interest in decarbonising their heat supplies through connection to a DEN.

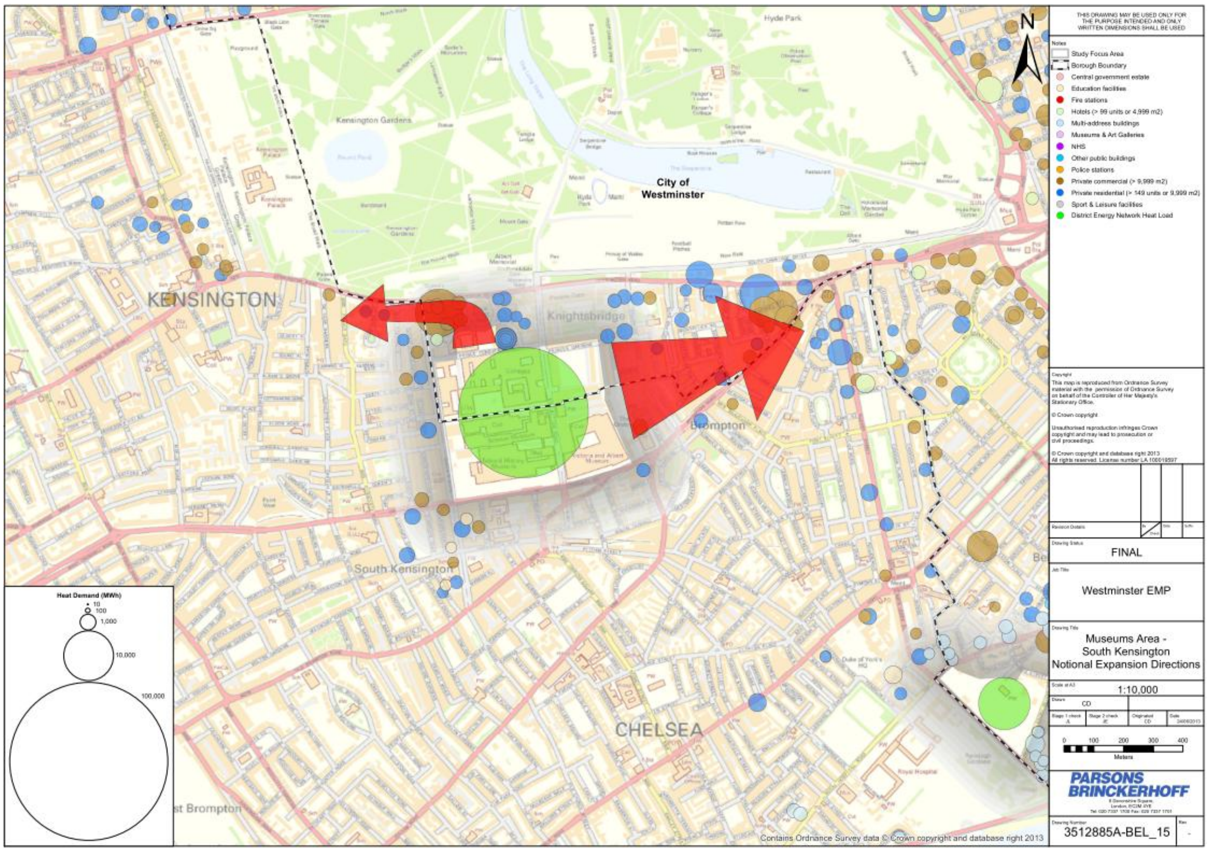
12.10.13 Given the commercial difficulty of expanding through this retail market, it may be more achievable to plan connections on the route towards the Royal Marsden Hospital, passing through SW3 where there are understood to be numerous communally heated mansion blocks. Liaison with the Royal Borough of Kensington and Chelsea would be required to solidify proposals here and maximum the potential expansion of this system.

12.10.14 The recommendation that flows from this discussion above is that policy should be implemented to protect the design and future compatibility of developments and refurbishments particularly along the corridor joining the museum's area towards Victoria (via Hyde Park Corner) and toward the Royal Marsden Hospital. I.e. major refurbishments should be carried out in such as way as to ensure that the full heat demands of the premises in question can be connected to a DE system, and operate at temperatures that are compatible with a DE solution.

[41] It might be possible to charge slightly higher rents for a shell that has demonstrably lower heating costs, but this benefit is considered marginal in the context of the high-value retail premises of the Brompton Road and surroundings.

12.10.15 A proposed strategy for the area would be to open discussions with the Natural History Museum to assess their level of engagement with the concept of housing additional energy supply plant within their existing energy centre. These discussions could focus on period following the termination of their existing contract – i.e. approximately 2021 onwards. This should be accompanied by engagement with applications coming forward along the corridor towards Hyde Park Corner, ensuring that as many loads as possible are made compatible with an expanded supply system. An exact route for a DE system and its extent cannot be speculated upon at this stage, but the general extent and concept for this expansion is illustrated below:

Figure 12-16 Potential museums' area notional expansion



12.10.16 This concept would require support from across the borough boundary to Kensington and Chelsea, and hence engagement with this neighbouring borough would be essential to maximise the potential of this expansion. **It is recommended as an action that Westminster City Council work closely with the Royal Borough of Kensington and Chelsea to enable this district energy scheme to be realised.**

12.10.17 1851 Estate Carbon Reduction Masterplan

12.10.18 In addition to conventional DE network, consideration has also been given to a proposal for an Aquifer Thermal Energy Storage (ATES) system serving the so-called '1851 Estate', which consists of Imperial College, Natural History Museum, Science Museum, V&A Museum, the Royal Albert Hall, the Royal College of Arts and the Royal Geographic Society.

12.10.19 The proposal, which has already received around £3m of Treasury funding, has three key deliverables:

- Installing a large underground heating and cooling network (ATES) to reduce waste and improve efficiency;
- Carbon awareness campaigns and the adoption of a low-carbon culture;
- Implementing energy demand and carbon reduction measures, including low energy lighting and heating upgrades.

12.10.20 ATES technology stores heat energy in an underground aquifer so that it can be used when it is needed. In simple terms, the hot and cold water from the wells would be distributed to localised energy centres in (or near) buildings. The energy centres would contain heat pumps that would operate only when necessary to upgrade the heat for heating or cool down the cold water for cooling. The system would operate in free cooling mode for as long as possible.

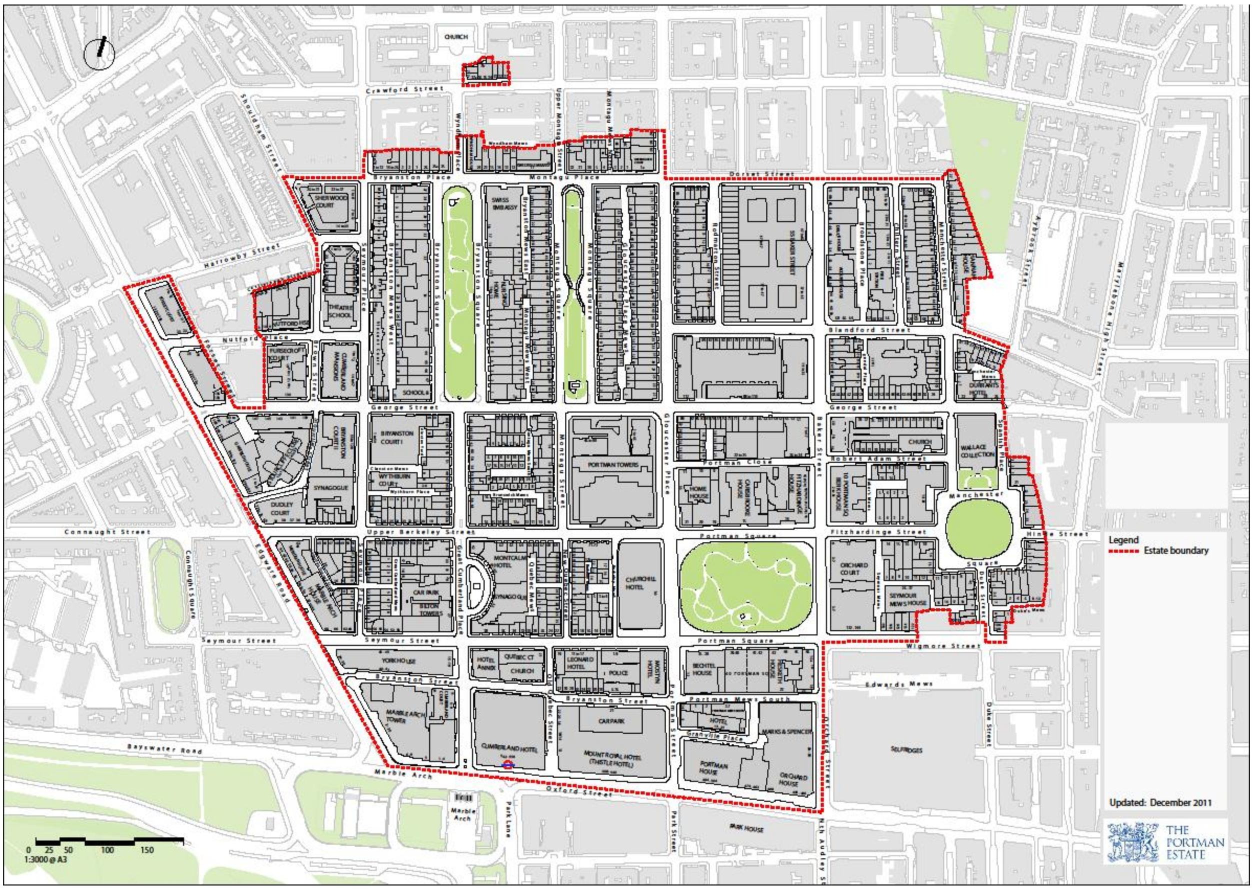
12.10.21 A network with ATES technology as its primary heat source could not viably operate above LTHW temperatures and, in order to maximise efficiency and carbon savings, would operate as near to the aquifer hot well temperature as possible (i.e. with as little heat pump requirement as possible). This presents a problem for some of the 1851 Estate as current heating systems at, for example, Imperial College and the Science Museum, are a mixture of steam and MTHW. In order to operate an estate-wide heating system with ATES as the primary heat source, these systems would have to be converted to LTHW.

12.10.22 It is understood that there has not been significant recent progress on the ATES network. Although unconfirmed, PB speculates that this may well be due to the cost of converting several of the 1851 Estate premises from higher temperature (MTHW or steam) systems to LTHW. It is certainly credible that this cost, combined with the cost of the ATES technology itself may make the project prohibitively expensive.

12.11 Portman Estate (Marble Arch)

12.11.1 The Portman Estate owns a significant portion of the buildings within the area illustrated below, just to the north of Marble Arch / east of Edgware Road.

Figure 12-17 Portman Estate



12.11.2 Within this zone, an estimate of current heat demands as per the National Heat Map is reported[42] to be 111GWh. The dominant demand types are identified as residential, commercial, government and hotels. The density of existing demand in this area is 252kWh / m^2, which is higher than the borough average (157kWh/m^2).

12.11.3 Some key aspects[43] of this area are:

- The majority of the residential units are heated through individual gas fired boilers
- A total of 60 building blocks of various sizes and ownership have been identified as potential connections to a DE scheme within the Estate, of which 41 will not be subject to any major refurbishment in the medium-long term, 2 will undergo major refurbishment within a period of 0 to 5 years and 17 will undergo major refurbishment within a period of 5 to 10 years

[42] Portman Estate DE Preliminary Analysis (presentation), Roberto Gagliardi La Gala, 20th February 2013, GLA
[43] ibid

- Some of the site's main roads have vaults below street level which could potentially house district heating (DE) pipes

- Four locations have been identified as potential sites for a permanent Energy Centre: the basement of the Marble Arch Tower, the basement of the Mount Royal (Thistle Hotel), the Portman Square park, and the underpass between Oxford Street and Hyde Park. One location has been identified as potential site for a temporary Energy Centre: the Seymour Leisure Centre.

- Two existing CHP plants are installed in the vicinity of the site boundary (Selfridges and Seymour Leisure Centre)

12.11.4 A phased approach to DE growth is suggested, progressing roughly west to east, based on the short-term phased development anticipated, and the schedule for wider area redevelopment in the longer term.

12.11.5 The key result of the analysis carried out by the GLA is that the concept appears to offer a positive NPV that is above the threshold suggested in Treasury Green Book assessment for infrastructure projects.

12.11.6 More detailed assessment of the opportunities and potential approach that could be adopted for this area is required.

12.11.7 This is an area where the commercial requirements of the principal landowners / developers and the strategic objectives of Westminster CC may collide. The long-term nature of the infrastructure investment may not suit the developer's view of risk / return, and this may be at odds with the opportunity that the area represents and WCC's aspirations to help meet mayoral decentralised energy targets. In this context, WCC should consider means through which this potential conflict of rationalities can be resolved. Options might include:

- De-risking the network installation by taking on the role of heat network installer / operator (and then ensuring that a supply / demand imbalance is created that means that the network will be used)

- Using CIL funds to assist in the installation costs to increase viability of scheme to level that interests the private sector

- Work with the landowner to procure a third-party ESCo to provide energy to the area as a concession

- Form a partnership working arrangement, where the local authority takes on a mediator role with the principal landowner and other developers in order to secure connection of other plots to an emerging system, but where the investment is made by the landowner

12.11.8 Irrespective of the route taken, the likelihood of success of DE in an area such as the Portman estate will be increased with the early establishment of the vehicle that will deliver it. Hence whilst development is currently at an early stage here, it is strongly recommended that in this area, where the viability of a network seems highly likely, that early discussions are held with Portman Estates to establish what type of approach would best match their business model. **Westminster City Council should work in partnership with the Portman Estate to deliver shared objectives that support district energy.**

13 'THE REST OF THE BOROUGH'

13.1.1 The sections above have addressed potential for DE expansion in specific areas of Westminster. However, there is equally a case for a more generalised push towards DE compatibility in the remainder of the borough, in order that, with time, a more coherent energy supply system can be implemented. From a purely geographical and numerical perspective, it is this category that contains the most residents and business and hence gives rise to the majority of carbon emissions in the borough. Hence it is arguably the most important geography that is discussed in this report.

13.1.2 On the other hand, as development comes forward in an unpredictable fashion, the difficulty in terms of DE roll-out is the challenge of identifying a 'kick-start' cluster. How can a cluster of loads be identified that has sufficient heat density (given the prevailing energy prices, plant costs, etc.) to justify the start of a DE scheme? If left to the market, how would a particular applicant for the development of a site know that their site takes the cumulative heat demand density to a level where a networked system may be viable? This indicates that if there is a desire within WCC to actively encourage multiple small-scale networks to emerge, then there is a need for WCC to create an active database of properties / premises that are compatible with DE supply. But how can thresholds of viability be assessed, and networks then implemented?

13.1.3 Section 7 of this report (addressing barriers to DE), illustrates that two of the difficulties for early phase DE projects is the capital cost of implementation and the cost of viability studies to take projects towards procurement.

13.1.4 Overcoming these two key barriers will require some mechanism to raise capital. Given that the concept is for fundamentally wider systems than can be expected to be funded by a site-specific development, it is clear that another mechanism outside of the planning application / S106 system is required. The current key option for this would appear to be Community Infrastructure Levy (CIL) funding, although 'Allowable Solutions' may also emerge as a possible mechanism for raising funds. The CIL can be applied across all developments within a borough on a unitised basis, and the funds raised can be applied to non-development specific infrastructure improvements. Furthermore, there is no time limit on the spending of CIL contributions. These factors to a large extent decouple developer contributions from a district heating assessment and development timeframe, allowing local authorities more flexibility in the use of funds.

13.1.5 As previously stated, the rate, location and scale of development within a London borough is unpredictable, making any assessment of district heating viability outside of a designated development or opportunity area a difficult and inevitably inaccurate exercise. Therefore, generalised principles are required to guide how development should be considered in order to maximise efficiency in energy delivery.

13.1.6 One starting point for determining a recommended form for the roll-out of decentralised energy within the borough is a scale of energy centre from which to supply 'kick-start' networks.

13.1.7 This is considered from the perspective of balancing a number of factors:

- Capital costs
- Efficiency of generation
- Utility economies of scale
- Space requirements (particularly relevant in Westminster where space attracts such a high value).

13.1.8 The concept is to try to identify a ‘critical scale’ of energy centre that allows the benefits of increasing efficiencies, increasing space efficiency and utility costs to be balanced against increasing capital cost and demand-side risk with larger schemes (i.e. it is much more difficult to ‘kick-start’ a scheme with many customers, than it is one with a smaller customer base).

13.1.9 This section looks at the cost / value of utilities in the context of different scales of decentralised energy scheme. A range of CHP sizes from 100kWe to 5MWe have been used as a basis for calculating the scale and cost of energy centre plant; the energy balance; and the utility price bands implicit from a given engine size. A whole life cost analysis has then been undertaken for each engine size based on the outputs of these calculations; and the resulting NPV gives an indication of the capital that is available to develop the district heating infrastructure, the cost of which has been excluded from the first stage of this analysis.

13.1.10 The various methodologies used for calculating the inputs to this modelling approach are detailed in the following sections.

13.2 Energy centre capital cost

13.2.1 There are a number of fixed cost elements in all energy centres. The following is a table that illustrates an approximation of some of these elements. It is acknowledged that many of these items will vary somewhat with scale of energy centre, but the proposition made here is that these items are sufficiently small to not significantly alter the overall conclusions drawn here.

Table 13-1 Assumed fixed capital cost items in EC development

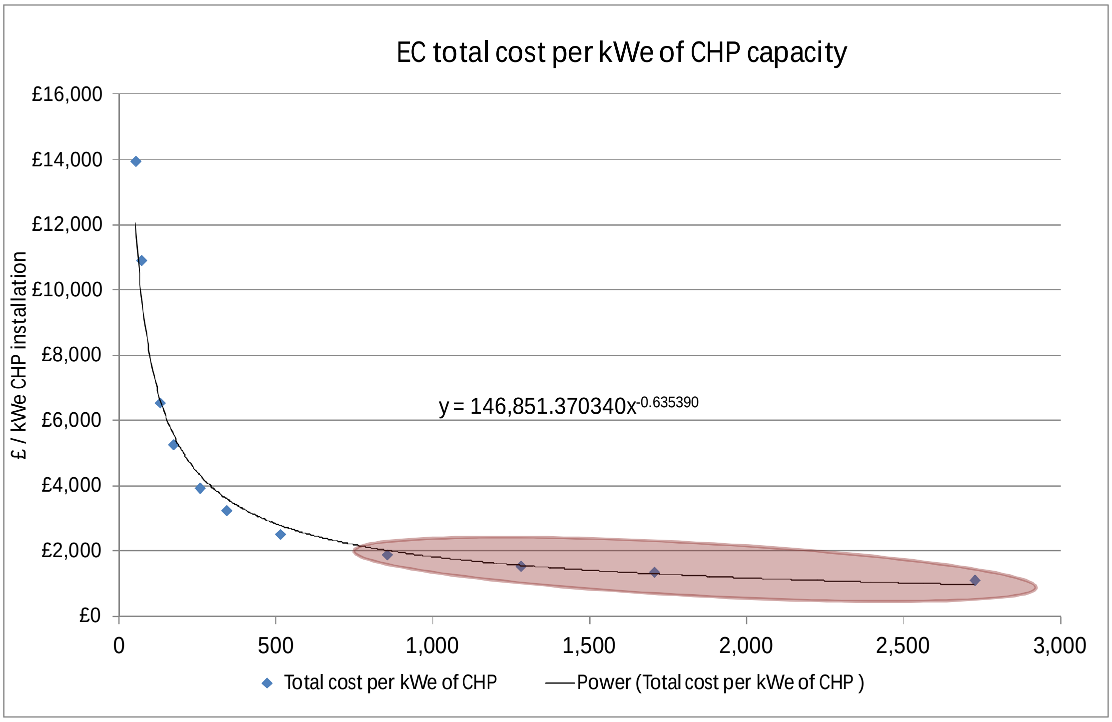
System	Item	Cost
LTHW	System pumps supply & install	£31,782
	Duplex filter supply & install	£28,380
	Sidestream filtration	£20,000
	Insulation	£50,000
	Commissioning	£20,000
	Plant handling	£5,500
Water system	Hot & Cold system supply and install.	£8,000
	Softening plant supply & install	£3,000
	2 off volume meters supply.	£2,000
	System insulation.	£1,000
Electrical rooms, control room & welfare ventilation system	Supply & extract fans supply.	£5,000
	Supply & extract fans install.	£750
	Supply & extract automated fire dampers supply.	£1,072
	Supply & extract automated fire dampers install.	£188
	Supply & extract attenuators supply.	£2,475
	Supply & extract attenuators install.	£564
	Supply & install supply & extract ductwork systems and supports.	£8,000
	Thermal insulation to supply & extract ductwork	£3,000
	System Commissioning.	£1,500
Plant control systems	Supply & install instrumentation.	£106,623
	Supply & install cabling system, components, containment and support.	£46,035
	Supply and install local area panels.	£22,207
	Supply and install head end panels and operator interface.	£12,000
	Supply and install software programming and graphical display.	£16,500
	System Commissioning.	£16,500
Services	Telecommunications	£1,000
	Water Connection	£5,000
	Drainage Connection	£5,000
Professional fees	M&E design fees	£80,000
	Permitting / environmental fees	£20,000
	Structural design fees	£25,000
TOTAL		**~£548,000**

13.2.2 There are a number of further items that have been assumed to vary significantly in cost with EC size. The variations of these items suggested are contained within the appendices to this report. The items whose cost has been assumed to vary with scale are:

- CHP plant
- Boilers
- LTHW ancillary
- LTHW pipework (within EC)
- Flues.

13.2.3 Taking the sum of these elements, the following curve of total plant costs against CHP scale has been derived.

Figure 13-1 Notional EC capital cost by CHP size



13.2.4 This chart shows that this notional curve of specific cost flattens significantly when scales in the region of 750kWe to 1MWe CHP output or more are reached.

13.3 Efficiency of generation

13.3.1 Thermal and electrical efficiencies vary according to scale of CHP. The modelling approach used in this analysis uses a range of engine sizes from a well known engine manufacturer as a starting point for calculating the cost inputs and scale of scheme with a given engine size as the prime mover. The efficiencies of those engines have therefore been included in the analysis to create a realistic model of engine outputs at different scales. The engine sizes used and their efficiencies are presented in Table 13-2 Engine size range used in analysis.

Table 13-2 Engine size range used in analysis

Engine thermal rating (kW)	Engine electrical rating (kW)	Fuel input (kW)	Thermal efficiency	Power efficiency	Heat : Power ratio	Manufacturer	Model
165	100	335	49.3%	29.9%	1.65	Ener.G	ENER·G 100
345	210	692	49.9%	30.3%	1.64	Ener.G	ENER·G 210
428	400	1,041	41.1%	38.4%	1.07	Edina	TCG2016CV08
654	600	1,571	41.6%	38.2%	1.09	Edina	TCG2016CV12
856	800	2,077	41.2%	38.5%	1.07	Edina	TCG2016CV16
1,185	1,200	3,023	39.2%	39.7%	0.99	Edina	TCG2020V12
1,571	1,560	3,960	39.7%	39.4%	1.01	Edina	TCG2020V16
1,977	2,000	5,036	39.3%	39.7%	0.99	Edina	TCG2020V20
2,560	2,658	6,665	38.4%	39.9%	0.96	Jenbacher	JMS616GS
3,155	3,349	8,331	37.9%	40.2%	0.94	Jenbacher	JMS620GS
3,766	4,031	9,936	37.9%	40.6%	0.93	Jenbacher	JMS624GS

13.4 Scale of demand

13.4.1 Based on the output of the engines listed in Table 13-2, a rule of thumb has been applied to calculate the scale of heat demand for a network with a given engine size as the prime mover.

13.4.2 A broad brush, first pass approach to sizing CHP for a given heat demand is to assume that the engine will serve 70 percent of the heat demand with 6,000 hours of output. By reversing this rule and applying it to each engine in the range, an indicative heat demand can be calculated, as follows:

*Annual heat demand (MWh) = (engine thermal rating (MWth) * 6000 run hours) / 70%*

13.4.3 The quantum of heat served by the CHP and the back-up boilers can be calculated using a variation on the same assumption, i.e. CHP heat provision is 70 percent of the total annual heat demand. The difference between the total heat demand and that which is met by the CHP is the quantum of heat served from back-up boilers.

13.4.4 Fuel consumption for the CHP and boilers has been calculated using the efficiencies listed in Table 13-2 in the case of the CHP; and an assumed boiler efficiency of 83 percent.

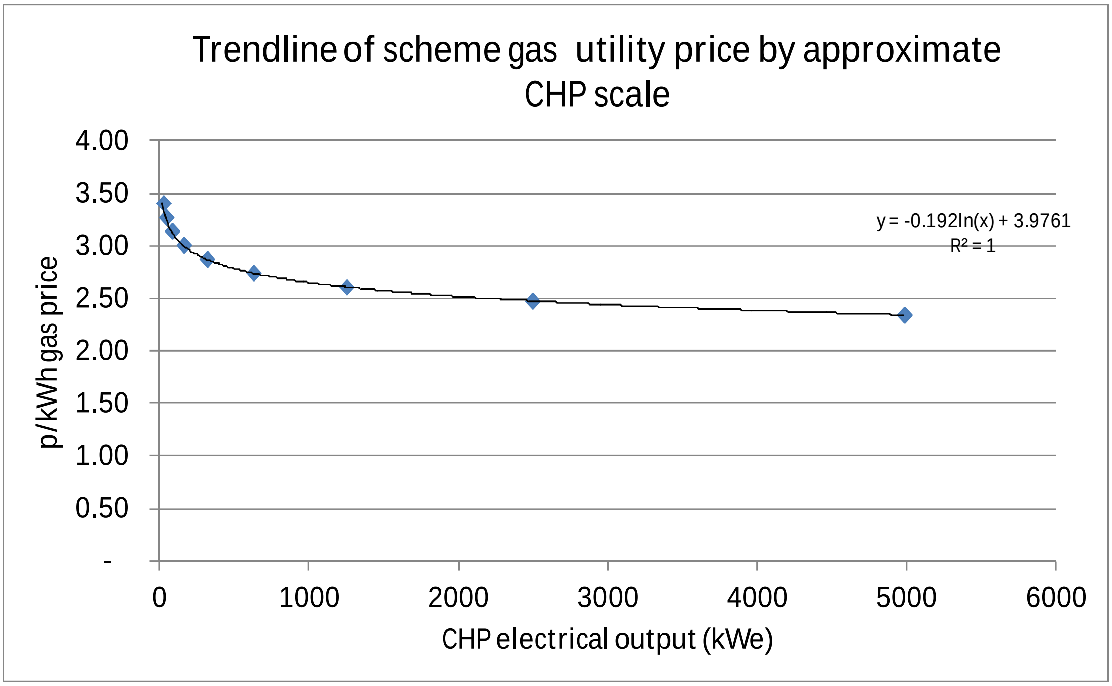
13.4.5 Note that DE distribution losses of 10 percent have been assumed in the calculation of total fuel consumption, i.e. it would take 10 percent more plant operation in order to meet the calculated heat demand.

13.5 Utilities economies of scale

13.5.1 Gas prices have been derived from the average of 2012 quarterly prices from the 'UK Quarterly Energy Prices (QEP), March 2013'. There are several scales of gas consumption under the QEP, which determine the unit cost of gas – i.e. the greater the demand, the lower the unit cost of gas. Parsons Brinckerhoff has applied the appropriate gas cost to the fuel demand calculated for each modelled engine size, as described in Section 13.4. The mid-point consumption has been used for each QEP category in the range, i.e. for 'medium' consumers with a QEP stated range of consumption between 2,778MWh and 27,777MWh, the consumption that has been used to plot a trend curve of cost was 15,278MWh.

13.5.2 The following chart illustrates the predicted derived gas utility prices for different scales of gas consumption under the assumptions and methodology described above:

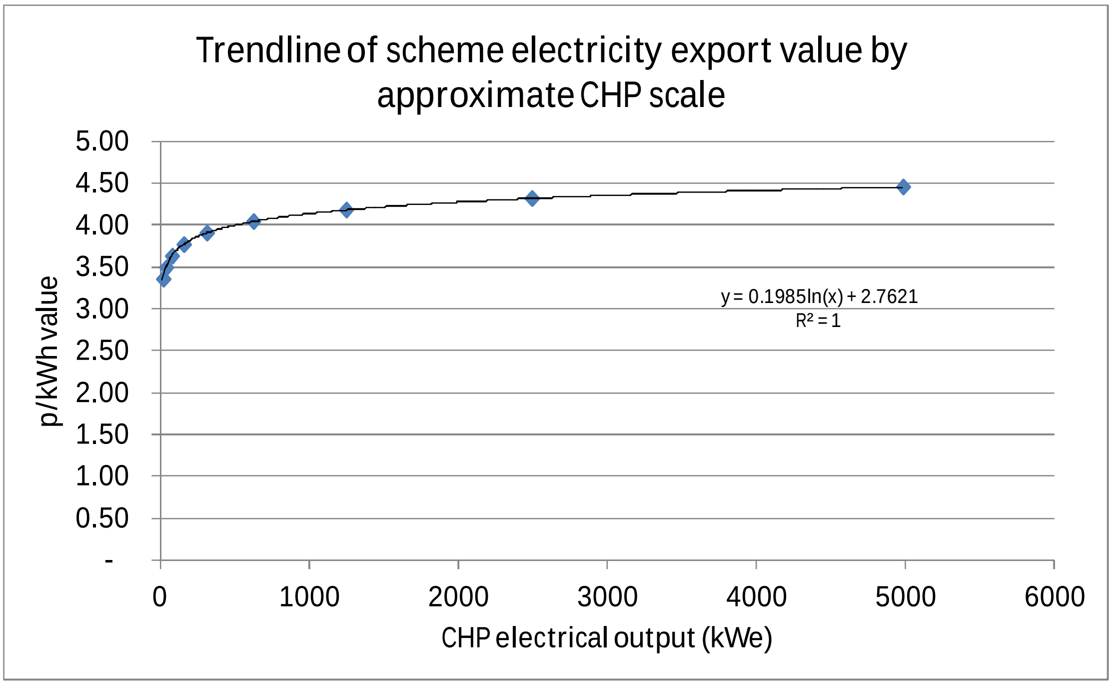
Figure 13-2 Trendline of gas utility prices by CHP scale



13.5.3 This chart suggests that gas utility prices drop sharply in the range to approximately 750kWe CHP, and thereafter drop more steadily.

13.5.4 A more tentative extrapolation of electricity export values has also been undertaken, where the shape of the curve is based around the inverse of the trend for power import, and the upper band of export prices has been derived from Appendix F of the DECC Updated Energy & Emissions Projections - October 2012, central scenario. This analysis shows the following trend with CHP size, assuming that all generated power is exported:

Figure 13-3 Electricity export projected price trend with scheme size



13.5.5 Similarly to the gas-import curve, this trendline illustrates that there is a significant shift in prices upwards up to around 750kWe scale, and that thereafter, there is a less pronounced benefit in increasing CHP scale.

13.5.6 In order to determine an appropriate value of gas and electricity for a given CHP size, the relationships between CHP rating and utility prices shown in the equations in Figure 13-2 and Figure 13-3 have been used.

13.6 Heat sales price

13.6.1 The heat sales price used in this assessment is based on the QEP gas price for 'small' scale consumers. This reflects the fact that the assumed 'business as usual' alternative to a DE scheme would be for each heat customer to have their own on-site boiler.

13.6.2 A boiler efficiency of 80 percent has been applied to the gas price, reflecting the efficiency of business as usual heat provision, and an additional 50 percent uplift has been applied to account for the avoided cost of boiler provision, replacement and maintenance for each heat customer.

13.6.3 The year 1 heat sales price for all scales of development in this analysis is 6.8p/kWh.

13.7 Utility price changes through time

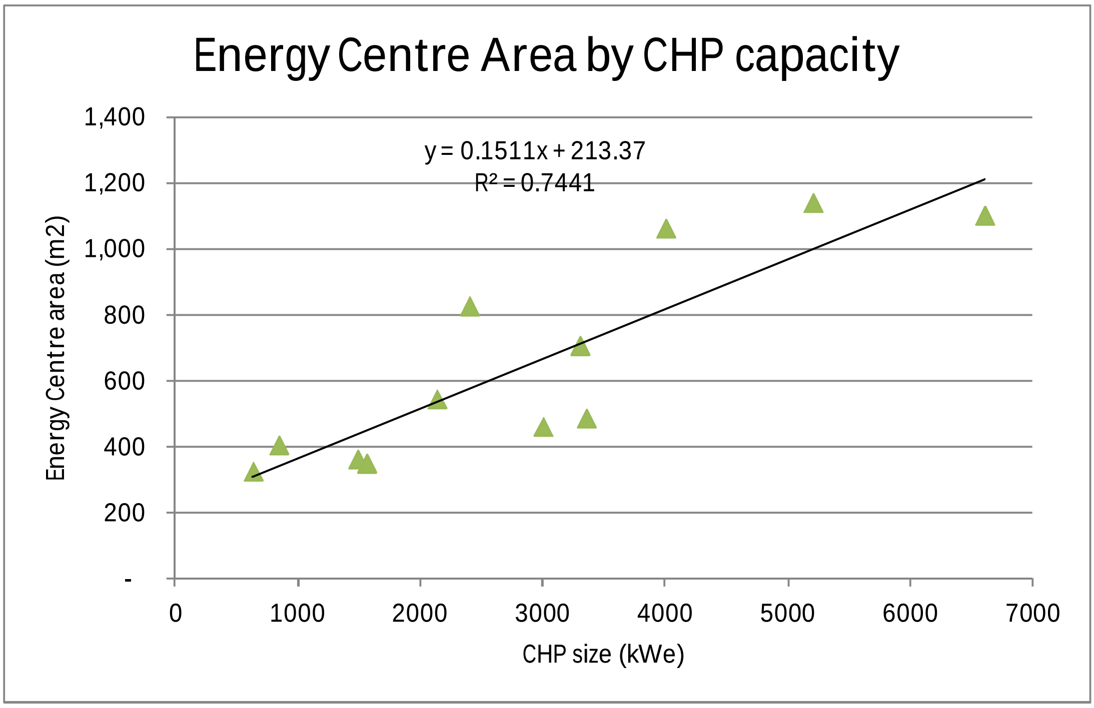
13.7.1 As with the rest of the analysis in this study, the percentage variations in DECC's central utility price projection have been applied to the current (i.e. 2013, which is assumed to be year zero) gas and electricity prices. This approach accounts for future changes in gas and electricity costs in the modelling of commercial performance.

13.7.2 The changes in gas price through time also feed through to the heat sales price as it is based on the cost of gas.

13.8 Energy centre size and cost

13.8.1 The following graph represents a compilation of energy centre floor areas for schemes with different scales of CHP plant.

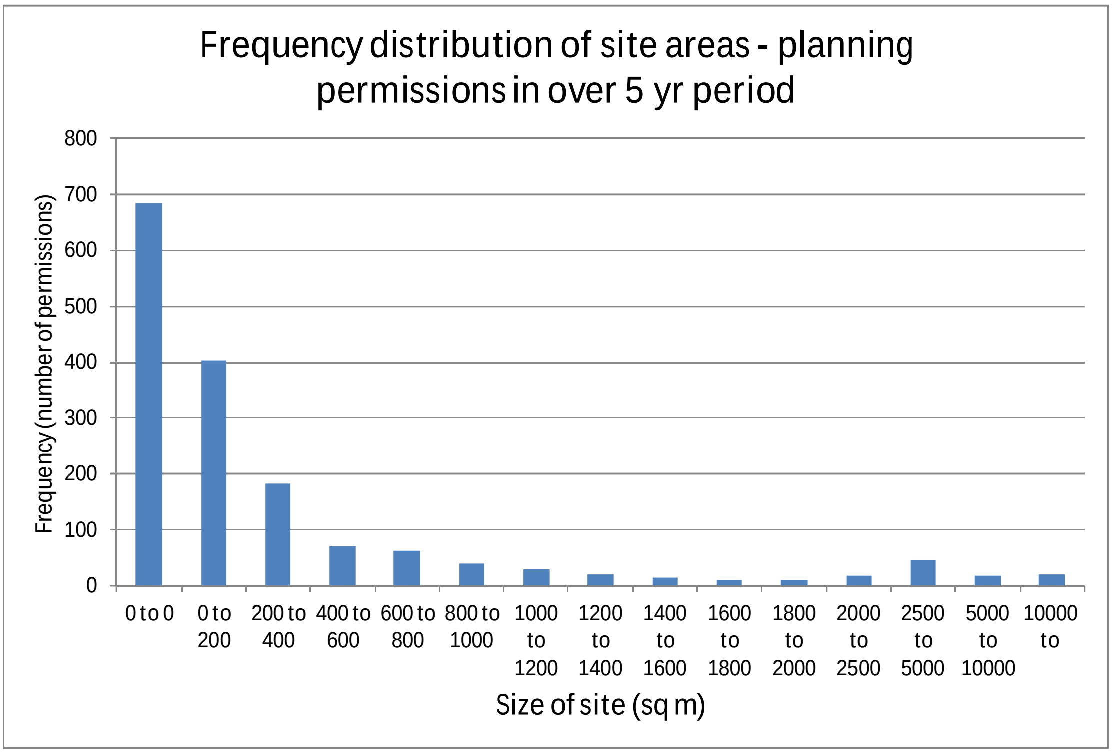
Figure 13-4 Energy centre footprint by CHP capacity



13.8.2 This Figure 13-4 indicates that there is a fairly wide spread of area data points for different CHP capacities, which to some degree at least can be explained by both local constraints (i.e. energy centres cannot always be optimally space efficient given existing structural beams etc..), and also by different levels of top-up and standby plant capacity for a given CHP capacity (i.e. different load factors of demand). In terms of suitability of different energy centre scales for implementation in Westminster, the figures illustrated above in terms of the footprint required have been compared with the scales of development sites that have come forward over the last few years.

13.8.3 On the basis that the roll-out of energy centres is most likely to be implementable in basement spaces, the plot areas of sites typically coming forward for development have been analysed. This analysis is based on the major planning permissions granted over a period of around 2/4/2008 to 3/7/2013, a period of just over 5 years. Over this period the following histogram of site areas results:

Figure 13-5 Site size frequency distribution



13.8.4 A number of aspects of these data should be noted: First, there are 685 sites without site size data (or with size of zero) – corresponding to around 42% of those analysed – the reasons for this may relate to the type of application. Second, at the other end of the spectrum there are a number of entries where the site area seems to be expressed in alternative units (perhaps sq ft). However, the key aspect of this data that should be noted is that in the site area range that would suit a CHP installation of around 1MWe or larger (i.e. circa 400sq m and above), there are around 320 sites that came forward over the last 5 years. This implies an annual average rate of permissions of around 64 per year. This report therefore makes the significant assumption that all of these permissions would have space that might be available for use as an energy centre. This is arguably optimistic, but even if only a fraction (e.g. 10%) were assumed to be suitable for housing energy plant, that fraction would still represent 6 suitable sites each year coming forward. Over a period of years this would accrue to a significant number across the borough as a whole. On this rough basis, it is proposed that there is likely to be a sufficient number of sites (of sufficient scale) to house energy centres that could be anticipated to come forward to house 'kick-start' decentralised energy centre plant.

I.e. the number of applications coming forward is not considered at this stage to be a significant constraint to DE deployment in the context of the strategy proposed in this report.

13.8.5 It is assumed that WCC would be required to rent space for an energy centre, so the cost of this space has been included in the analysis. The cost has been determined using a high level assessment of current rental prices for commercial space in Central London, which indicates that an annual rental cost of £125/m^2 is appropriate. This unit cost has therefore been applied to the energy centre scale determined using the methodology described above to calculate total energy centre space rental cost.

13.9 Critical minimum scale for kick-start networks

13.9.1 The analysis above incorporating efficiency, utility cost, and capital cost trends suggests that there is a critical minimum size range for kick-start networks in the region of 750kWe to 1.5MWe gas-fired CHP. There is a trend of further improvement beyond this scale, but larger scale also implies greater space requirements, more capital cost and higher risk. In the context of developing 'kick-start' networks where de-risking is critical, keeping the scale to a sensibly low level is considered an appropriate approach.

13.9.2 The analysis outlined below argues for kick-start networks larger than this 'critical minimum' scale, in order that the individual number of schemes does not start to become unmanageable.

13.10 Potential for roll-out of DE within 'Rest of Borough'

13.10.1 In the sections addressing individual areas we have considered potential expansion of existing systems to encompass neighbouring loads. This is speculative, but represents a route that is likely to be more commercially efficient than the alternative of creating entirely new kick-start networks (with all the associated inertia associated with legal agreements, funding, energy centre design, etc.).

13.10.2 In summary the following table represents our estimates of potential speculative expansion of existing (or planned) DE system in the context of overall targets for the borough (the London 2025 target and its extrapolation to 2050).

Table 13-3 Existing DE system expansion potential estimates

System	Existing load (MWh p.a.)	Estimated total supply with expansion (MWh p.a.) 2025	Estimated total supply with expansion (MWh p.a.) 2050
PDHU / WDHS / NOVA Victoria links	52,400	92,400	95,400
Imperial College, Science Museum[44]	33,800	43,800	63,800
Other identified areas of DE growth (Church street, Chelsea Barracks, etc.)	n/a	104,348	120,000
TOTAL	**86,200**	**136,200**	**159,200**
Approximate borough 2025 target (MWh)	n/a	866,000	n/a
2025 shortfall (only considering existing DE scheme expansion)	n/a	625,452	n/a
Notional borough 2050 target (MWh)	n/a	n/a	2,350,000
2050 shortfall (only considering existing DE scheme expansion)	n/a	n/a	2,070,800

13.10.3 The shortfall in DE generation outlined in approximate terms in the table above for the two points in time of 2025 and 2050 can only be made up from new DE generation capacity. A number of proxies can be used to illustrate the magnitude of this shortfall.

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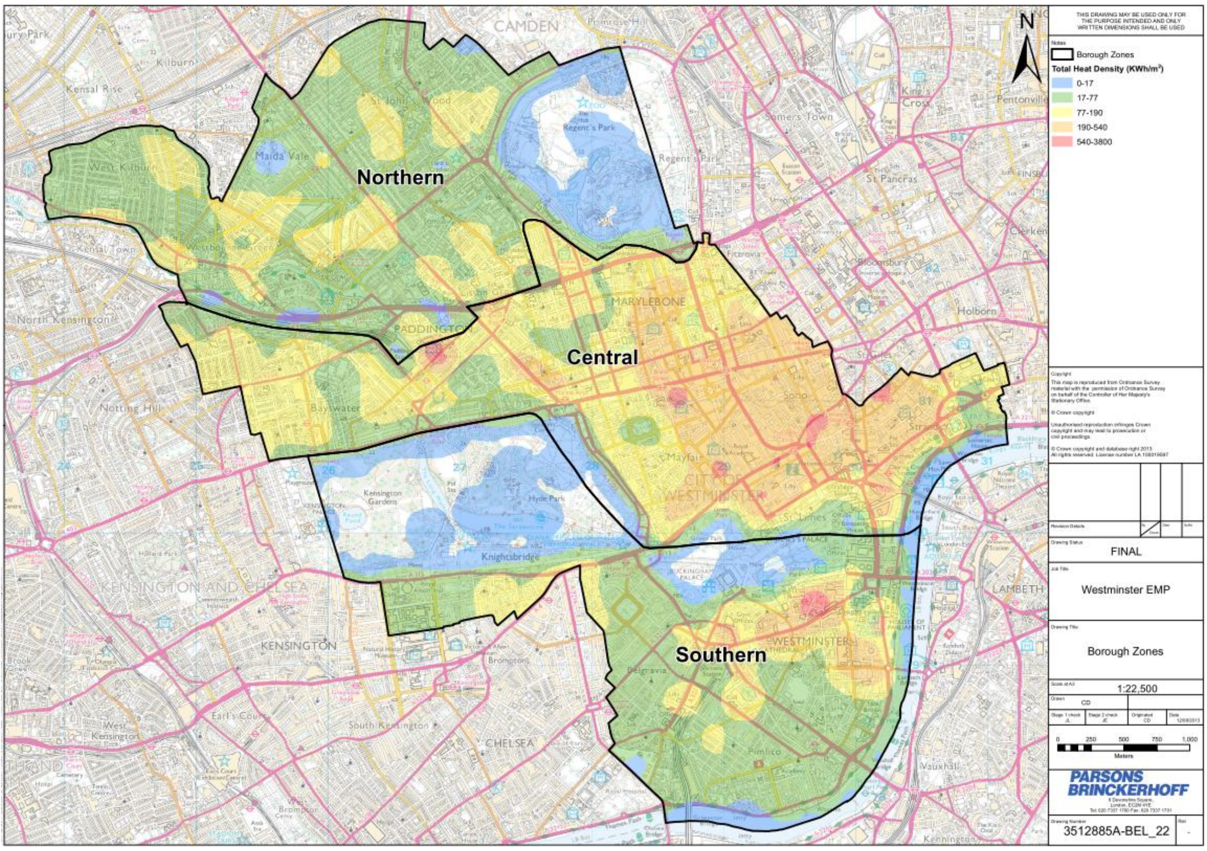
13.10.4 First, if the existing PDHU system is used as proxy for the density of DE that might be expected to develop in areas of comparatively lower density (i.e. the northern and southern parts of the borough highlighted below, excluding the Victoria Street area), then the following can be noted:

Figure 13-6 Borough zones by approximate heat demand density



- The PDHU system covers an approximate area of 530,000sq m, as illustrated below:

Figure 13-7 PDHU area - derived from National Heat Map website

- This area has a total demand of 78GWh heat p.a. (National Heat Map)
- The existing PDHU system generates approximately 50GWh of heat p.a.

13.10.5 The areas of Westminster outside of know DE zones, and with a similar approximate heat density to PDHU amount to 3,800,000 m2 (north of M40 / Euston

Rd) plus 3,100,000m2 (south of Parks / Westminster) = 6.9million sq metres[45]. If equivalent systems to PDHU were rolled out in all of these areas with the same degree of penetration, this would equate to around 13 systems of PDHU capacity, and a total annual heat output of around 650GWh of heat.

13.10.6 On a simplistic basis, if roll-out is scaled in line with the overall 2025 and extrapolated 2050 borough target, this implies around 4 schemes of PDHU's size by 2025 (and 13 by 2050).

13.10.7 In addition to this, if kick-start networks are implemented in the higher-density areas of the borough (i.e. the central area stretching from Notting Hill through Edgware Road, Mayfair, Noho, Soho, Strand, and Aldwych, which has a total area of 7.5million sq m (excluding parks)), in order to meet the shortfall between the 2025 target and the implied contribution of existing systems and 4 new 'PDHU-scale' systems, a further approximately 500GWh of heat contribution from DE is required by 2025.

13.10.8 This total demand has been notionally assumed to be met by schemes emerging at a rate of 2 per year – implying a heat demand per scheme of approx 21GWh. This implies a scheme CHP scale of around 2.5MWe.

13.10.9 In order to aggregate demands of 21GWh, substantial DE networks would have to be implemented. The extent of each network has been calculated on the basis of the level of penetration that would have to be attained within a given area on the basis of the target for DE to be achieved. For example, across the central band of the borough, the total heat demand is estimated by the National Heat Map is 1,970GWh, with 70,767 address points- corresponding to an average demand per address of 27.8MWh. In order to generate a total demand of 21GWh, this implies the connection of 755 average addresses, made up of a mix of domestic and non-domestic customers.

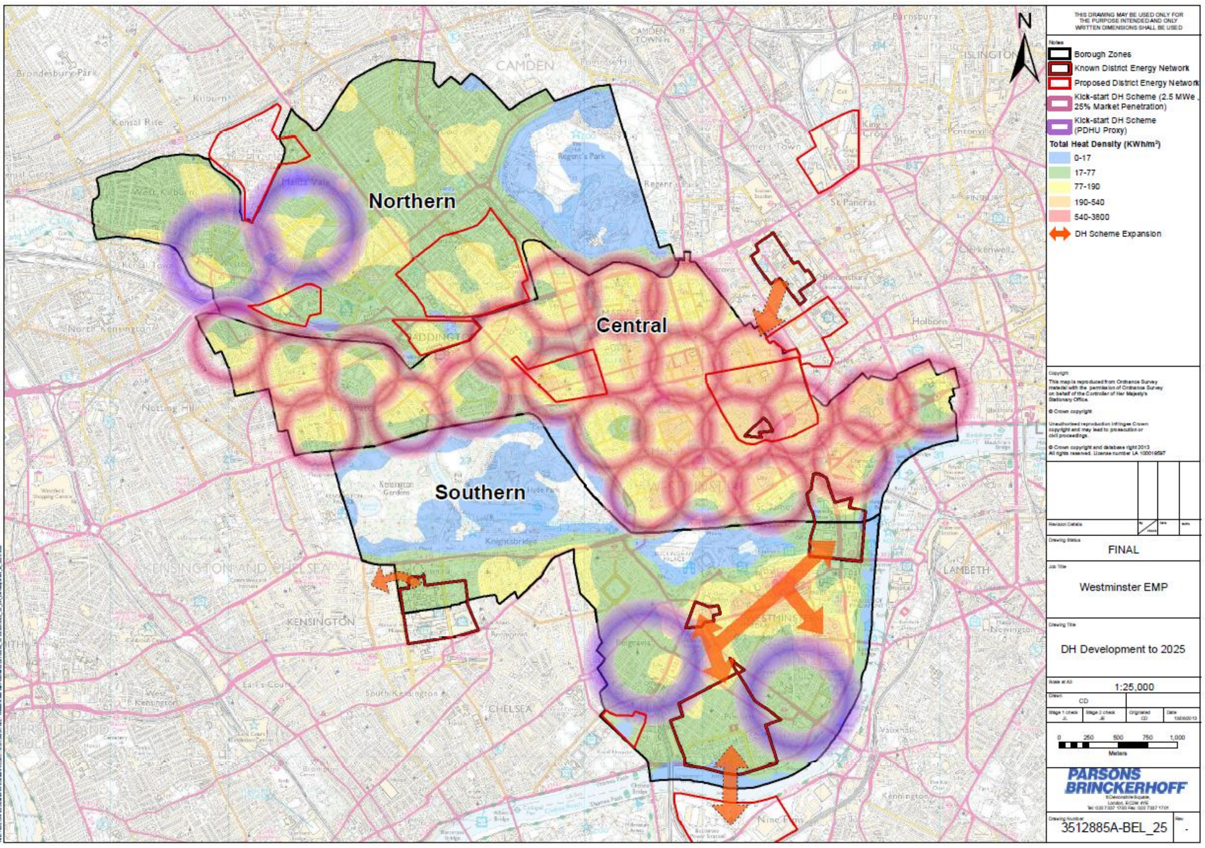
13.10.10 If the further assumption is made that the penetration of DE must slowly grow in line with the target for 2025 and the extrapolated target for 2050, then on average approximately 1 in 4 (i.e. 25% of properties) must connect by 2025 and 3 in 4 properties must connect to DE by 2050. This set of assumptions allows the scale of the networks that are required to meet targets to be identified.

13.10.11 In the central band of the borough, for example, the total area that contains 70,767 address points covers an area of approx 6,818,000 m^2. This implies a density of 96sq m per address. On the basis of a DE network by 2025 emerging on the basis of 1 in 4 properties connecting, and this address density – the implied area of network coverage is 291,000 m^2.

13.10.12 Coverage of the central band of the borough with schemes of this scale is notionally illustrated in the diagram below:

[45] This figure also excludes the existing area of PDHU and other DEN identified schemes.

Figure 13-8 Illustration of growth to 2025

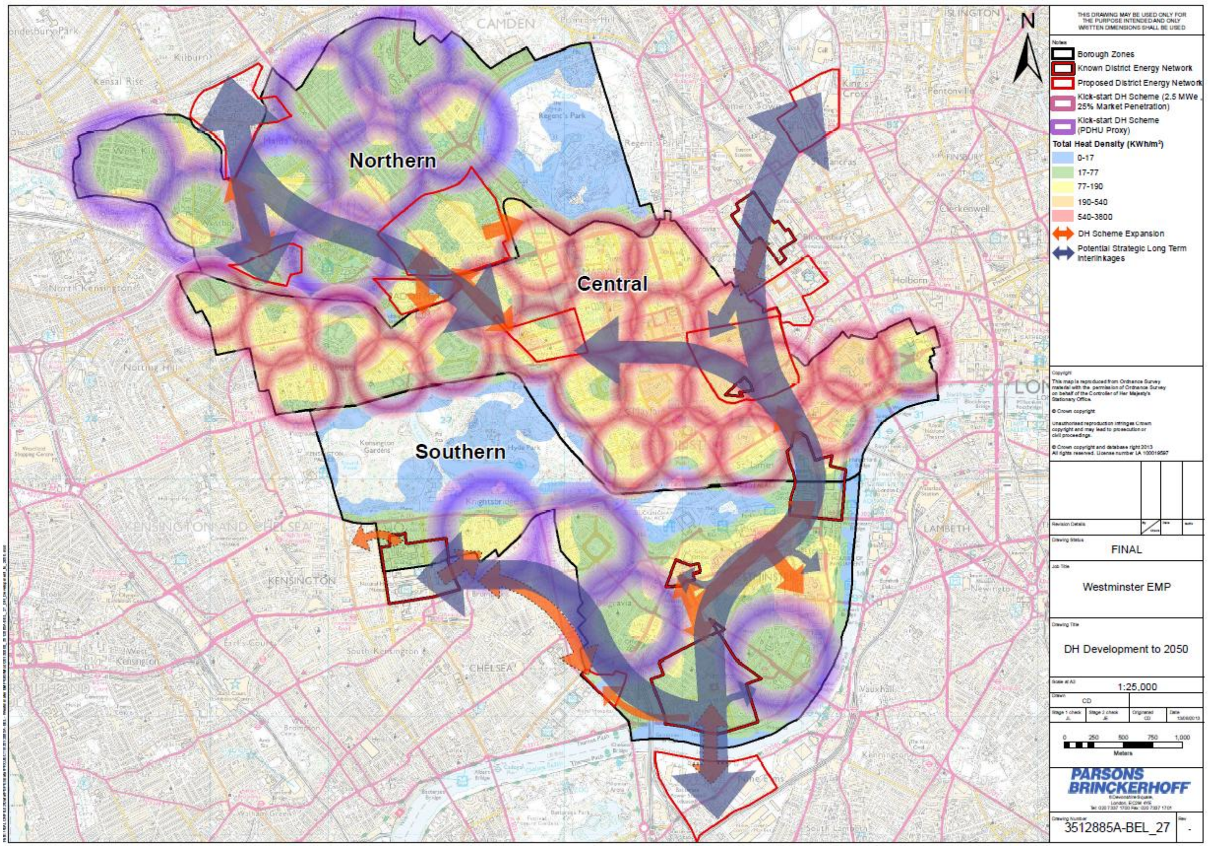


13.10.13 The sum of these elements (e.g. PDHU-type systems within the south and north, kick-start schemes in the central band, and known system expansion) would give a total of DE output of >866GWh p.a. by 2025, thereby meeting the London-wide target for DE within Westminster.

13.10.14 Progression to 2050

13.10.15 The extrapolation of the 2025 target for DE reflects the ambition to increase DE levels in the borough significantly to 2050. This is reflected in the following chart, which illustrates the implementation of further PDHU-scale schemes within the northern and southern bands of the borough, and the intensification of the schemes within the central band.

Figure 13-9 Network growth by 2050



13.10.16 The intensification of schemes within the central band is based around the progressive connection of further properties to each network within the areas previously highlighted – i.e. moving from 1 in 4 properties connecting, to 3 in 4 properties connecting by 2050. This results in a higher heat density of connected load, and greater total demands at each energy centre. The total capacity of CHP required at each energy centre by 2050 is calculated to be approximately 8MWe. Therefore, over the period from 2025 to 2050, it is proposed that the CHP and ancillary plant capacity of each energy centre is increased in line with this increase in CHP capacity from around 2.5MWe to 8MWe[46].

13.10.17 The economic implications of this approach are discussed below.

[46] This would mean at time of life-expiry of the 2.5MWe installation, for this plant to be replaced with a 4MWe unit, and thereafter for a second 4MWe to be added.

14 FORECAST COSTS, VIABILITY AND CIL

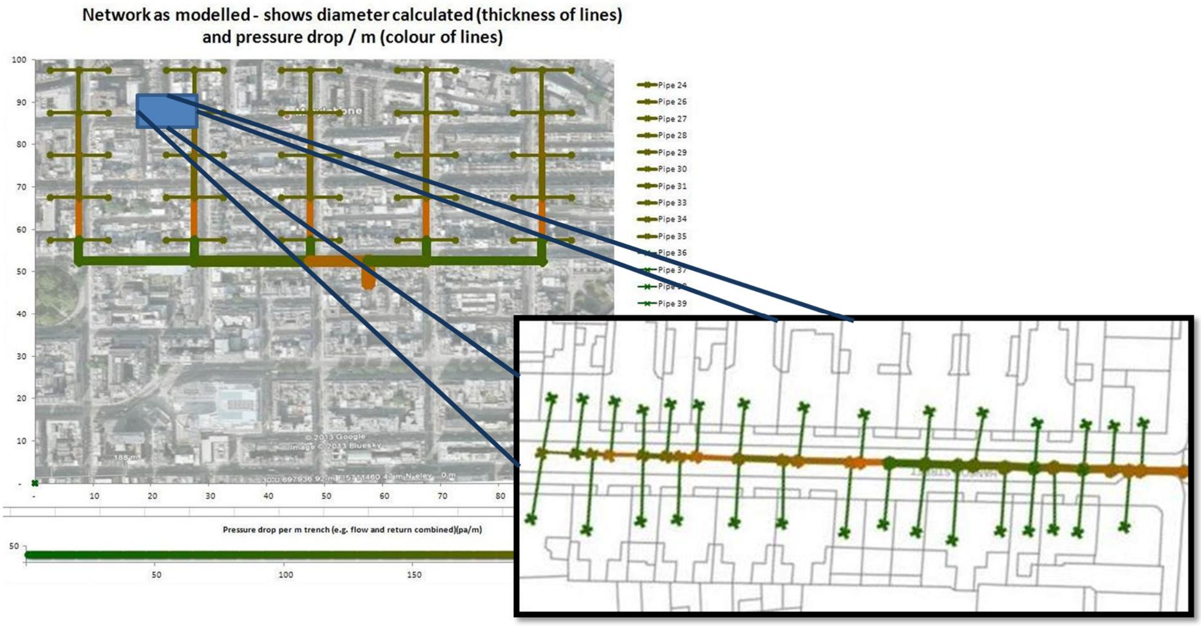
14.1 Central band

14.1.1 The cost of extending DE coverage across the borough has been modelled on the basis of notional heat networks and energy centres. This section specifically considers the central band of the borough as illustrated in Figure 13-6.

14.1.2 The network costs for a 2025 scenario are estimated on the basis of assuming that these would be installed with sufficient capacity to supply an increased level of DE penetration across the borough, i.e. the assumption adopted here is that the networks installed for a 2025 scenario would be strategically over-sized to allow for expansion of supply capacity to the projected levels of DE expansion in 2050.

14.1.3 The network costs have therefore been calculated on the basis of a notional grid system, sized to match a typical Westminster streetscape and the heat and address-point density as evidenced by the National Heat Map. This is illustrated below:

Figure 14-1 Notional network detail



14.1.4 The inset detail street layout is based on a 108m by 54m block. This corresponds to 5,810m^2. There are 50 of these notional street layouts within the overall grid modelled. This gives a total area of 290,500m^2 (i.e. the area identified within 13.10.11). Within each block there are 30 connections shown on the inset diagram above, but in order to give the property density identified by the National Heat Map, each of these connections is assumed to serve 2 properties – i.e. perhaps a retail outlet at ground floor, and residential above.

14.1.5 Therefore, within the overall area illustrated the following figures apply:

Table 14-1 Assumed network heat demands

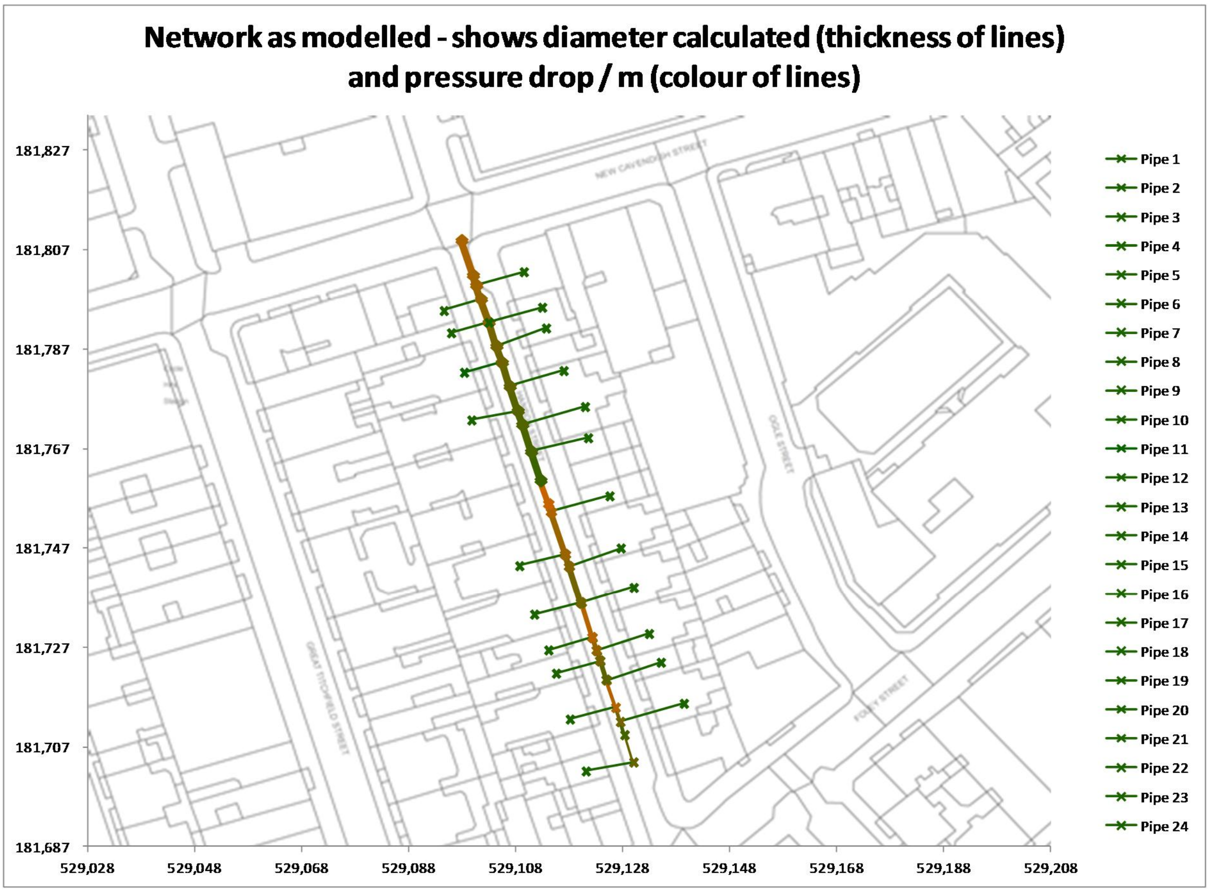
	Single street (inset area in Figure 14-1 above)	Network grid (50x single streets)
Total properties	60	3000
2025 connected properties (25%)	15	750
2050 connected properties (75%)	45	2250
2025 heat demand of properties connected	418MWh	20,880MWh
2050 heat demand of properties connected	1,253MWh	62,640MWh

14.1.6 It can be seen from the table above that the network demand of the 2025 network (20,880MWh) corresponds to the 21GWh that was calculated (see section 13.10.9) as a notional network scale to allow Westminster's contribution to the London DE 2025 target to be achieved.

14.1.7 The cost of district heating network infrastructure for this network is therefore based in 2025 by fixing the main spine infrastructure costs for each network that would allow the full demand of the 2050 build-out to be met, but only including for a reduced number of final connections, corresponding to the 2025 penetration of DE. These two scenarios are illustrated below in Figure 14-2 Street-level network section (75% DE penetration) and Figure 14-3 Street-level network section (25% DE penetration).

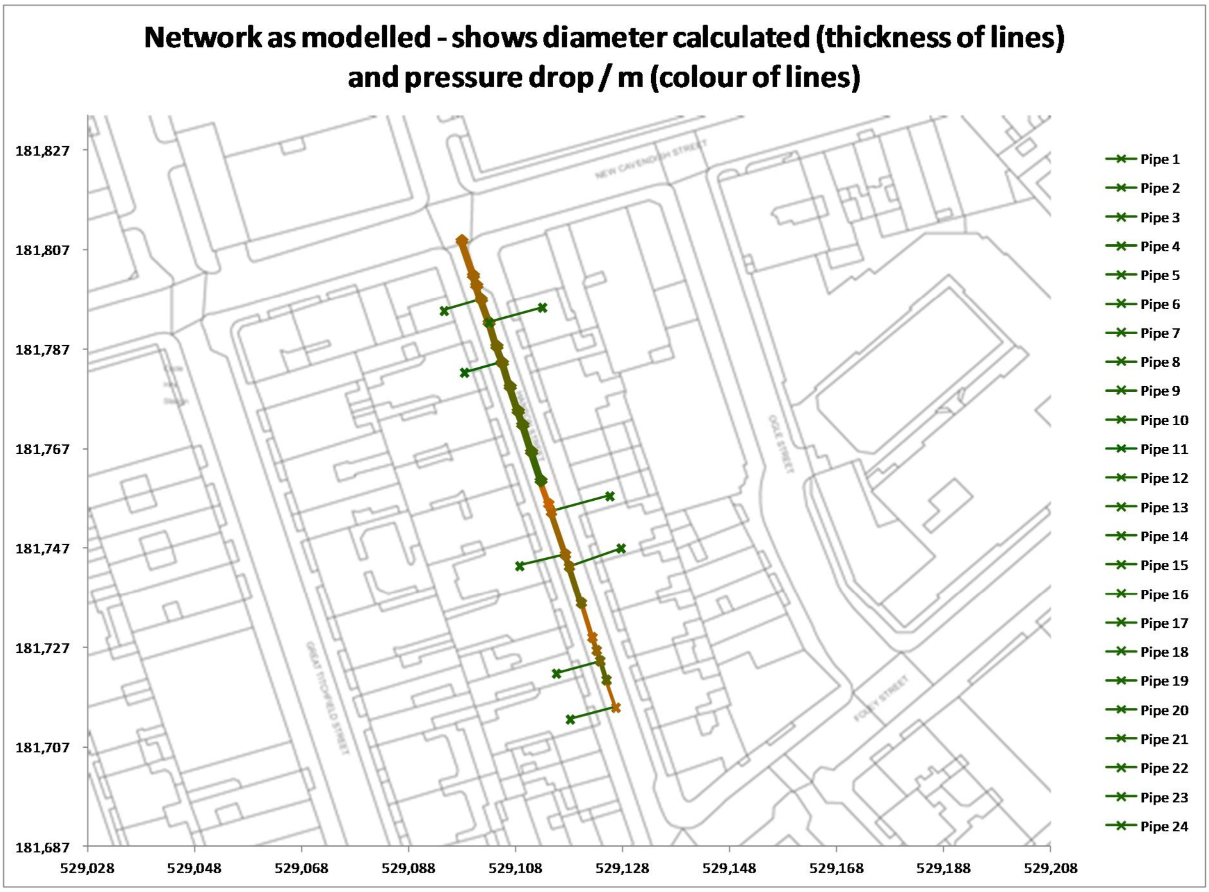
14.1.8 It has further been assumed that in 2050, network return temperatures are (based on on-going secondary system refurbishment) 65 deg C. This figure has been selected on the basis of assuming that approximately half of the total load connected has 'traditional' 82/71 deg C secondary system design (allowing for a 75 deg C return temperature), and that the other systems connected have been installed to the 'District Heating Manual for London' standard of 55 deg C. The average of these two figures gives 65 deg C.

Figure 14-2 Street-level network section (75% DE penetration)



14.1.9 This scenario of DE uptake has been used to fix the DE sizes used in the costing of the 25% DE penetration scenario (to allow for subsequent scheme growth).

Figure 14-3 Street-level network section (25% DE penetration)



14.1.10 The network analysis outlined above, and summarised in terms of assumptions in the appendices, gives rise to the following overall network costs (for a single scheme):

Table 14-2 Single scheme calculated network costs

Date	Total network cost (not including customer substations)	Additional cost (between 2025 and 2050)
2025	£15.2m	n/a
2050	£25.2m	£10m

14.1.11 The capital and operating costs for the other elements of this scheme are based around the trendlines illustrated above in Section 13, and deliver the following overall capital and operating costs as shown below:

Table 14-3: Modelling Assumptions

Category	Composition	Value (if applicable)
Heat sales price composition	Sales price based on equivalent cost of building self supply which is also know as the Business As Usual. This cost is composed of:	
	Small user price for gas (derived from QEP) indexed by DECC central scenario for gas	3.41 p/kWh (base price)
	Boiler efficiency	80%
	Allowance for maintenance and replacement costs	Factor of 1.5 on price above
Heat sales price	Average across domestic and non-domestic customers	7.04 p/ kWh
Capex costs	As outlined above (section 0)	
	Customer connection cost average (customer heat exchanger / substations)	£3.5k per connection
	Network costs (based on schedule of costs by diameters shown in appendices)	
	Contingency	20%
Opex costs	25 year average of DECC central price projection scenario for gas and electricity, adjusted for scale of consumption according to QEP trends of consumption	
	Parasitic electricity demand	10% of CHP electricity generated
	Maintenance cost Plant – boilers, pumps, ancillaries	0.75% of energy centre plant capex
	Metering and billing costs	£150 per customer
	Network annual maintenance costs	1% (of initial capex)
Replacement costs	Main plant items replacement cycle	20 years (15yrs for CHP)

14.1.12 A copy of the spreadsheet illustrating the cashflow used to derive results is contained within the appendices, but some key figures are illustrated here for the notional networks required for the 2025 scenario:

Table 14-4 Scheme capital costs (2025 scenario)

Cost item	£k
EC capital cost	£2,603
Network cost	£15,237
Customer connections	£2,759
Contingency (20%)	£2,060
Total cost	£22,659

14.1.13 An illustration of the first years of the cashflow for this scheme are shown below:

Table 14-5 Cashflow illustration

Year	0	1	2	3	4	5
Capital cost	£22,658,686					
Annual maintenance (plant items)		£142,323	£142,323	£142,323	£142,323	£142,323
nnual maintenance (DH network)		£152,370	£152,370	£152,370	£152,370	£152,370
Repex						
Fuel cost		£1,381,768	£1,387,734	£1,393,716	£1,399,682	£1,405,648
EC rental cost		£76,874	£76,874	£76,874	£76,874	£76,874
Metering and billing		£118,227	£118,227	£118,227	£118,227	£118,227
Heat sales		£1,492,087	£1,498,529	£1,504,989	£1,511,431	£1,517,873
Power export		£877,110	£879,736	£897,588	£919,578	£922,523
Annual opex		**£497,635**	**£500,736**	**£519,067**	**£541,533**	**£544,954**
NPV of options	6.0%	-£15,911,276				

14.1.14 This table illustrates that the scheme generates a positive cashflow (annual opex), but the income is insufficient to offset the significant capital cost of the extensive network required. The overall result is a whole life cost at 6% discount rate (25 years) of negative £15.9m for each scheme of this scale.

14.2 Northern and Southern Areas

14.2.1 The northern and southern areas of the borough have been considered using the PDHU scheme as a proxy. This scheme was developed to link centrally supplied blocks with heat, and hence certain adjustments have been considered to make the use of the scheme as a proxy appropriate to the wider borough situation.

14.2.2 The key figures used as proxy for modelling the potential cost of expansion in these areas are the length of the PDHU network and the total heat supplied. These figures are approximately as follows:

Table 14-6 Key PDHU figures

	Network length (m)	Heat supplied (MWh p.a.)
PDHU	5,390	50,000

14.2.3 Extending this model as a proxy for the northern and southern areas suggests that schemes of this scale would require at least a similar length of network (main spine), and additionally, connections to each of the properties that are to be connected. On this basis, an outline assessment of the capital costs of this type of scheme has been carried out. The key assumptions are as per Table 14-3: Modelling Assumptions above, with the change from the 'central band' that a slightly larger CHP capacity has been selected to match the larger load.

14.2.4 Overall cost and income figures are illustrated below for an individual scheme:

Table 14-7 Cost for northern / southern notional EC

Cost item	£k
EC capital cost	£ 3,278
Network cost	£ 8,915
Customer connections	£ 17,960
Contingency (20%)	£ 3,015
Total cost	**£ 33,168**

14.2.5 An illustration of the first years of the cashflow for this scheme are shown below:

Table 14-8 Northern and southern area notional cashflow

Year	0	1	2	3	4	5
Capital cost	£33,167,702					
Annual maintenance (plant items)		£222,582	£222,582	£222,582	£222,582	£222,582
nnual maintenance (DH network)		£89,151	£89,151	£89,151	£89,151	£89,151
Repex						
Fuel cost		£2,423,962	£2,434,428	£2,444,922	£2,455,387	£2,465,853
EC rental cost		£121,109	£121,109	£121,109	£121,109	£121,109
Metering and billing		£215,731	£215,731	£215,731	£215,731	£215,731
Heat sales		£2,722,650	£2,734,405	£2,746,192	£2,757,947	£2,769,702
Power export		£1,697,767	£1,702,848	£1,737,405	£1,779,968	£1,785,670
Annual opex		**£1,347,882**	**£1,354,253**	**£1,390,102**	**£1,433,956**	**£1,440,946**
NPV of options	6.0%	-£14,854,683				

14.2.6 This table also illustrates a positive operating margin for the scheme, but one that is insufficient to outweigh its significant capital costs.

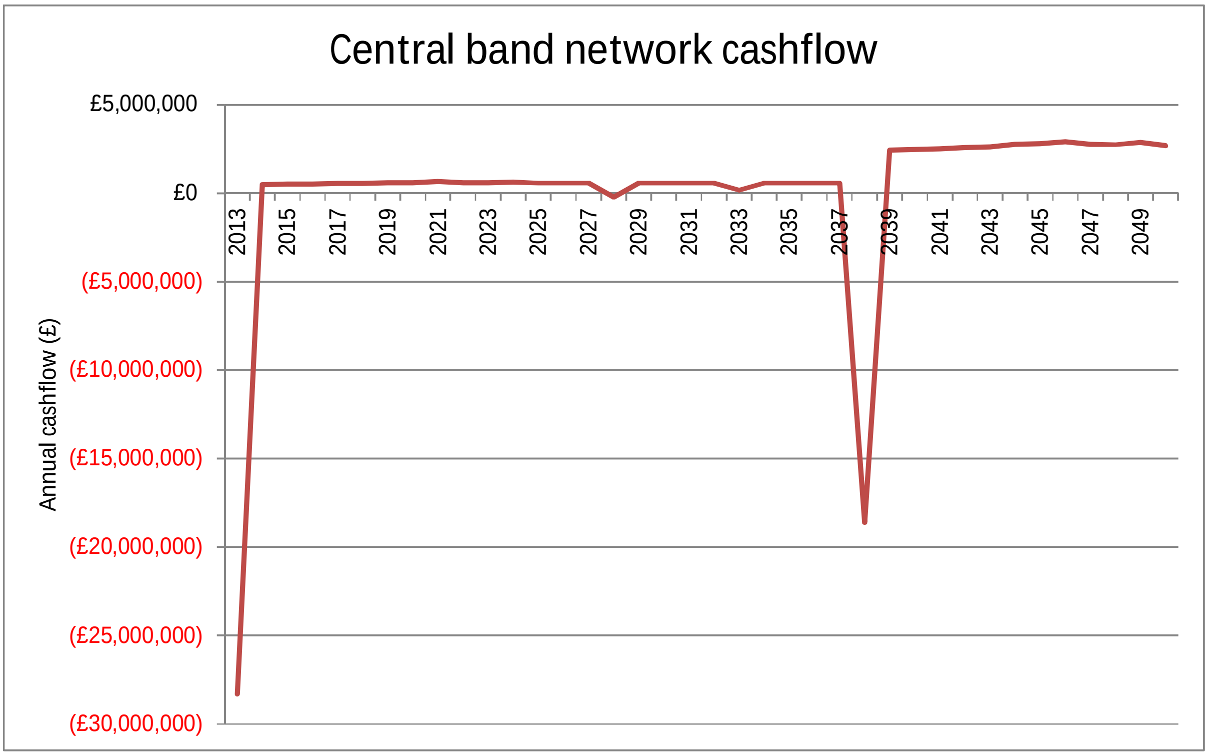
14.3 CIL level setting

14.3.1 The approach adopted to CIL level setting has been to add the cumulative expenditures and operating incomes of the schemes modelled and illustrated in figures Figure 13-8 and Figure 13-9 and to take the overall NPV of the combined cashflow of all these schemes over the period to 2050.

14.3.2 This has been done in a 'block' fashion – i.e. the schemes have not been modelled to grow organically as might be expected in reality. The modelling has assumed that after 25 years of initial operation of the central band schemes (at 25% DE penetration), these schemes then immediately expand to 75% penetration and are supplied by larger CHP units. The cost of linking schemes together via strategic networks (i.e. to Battersea Power Station or similar) has not been taken into account in this model.

14.3.3 An example of the cashflow for a single scheme in the central band is illustrated below:

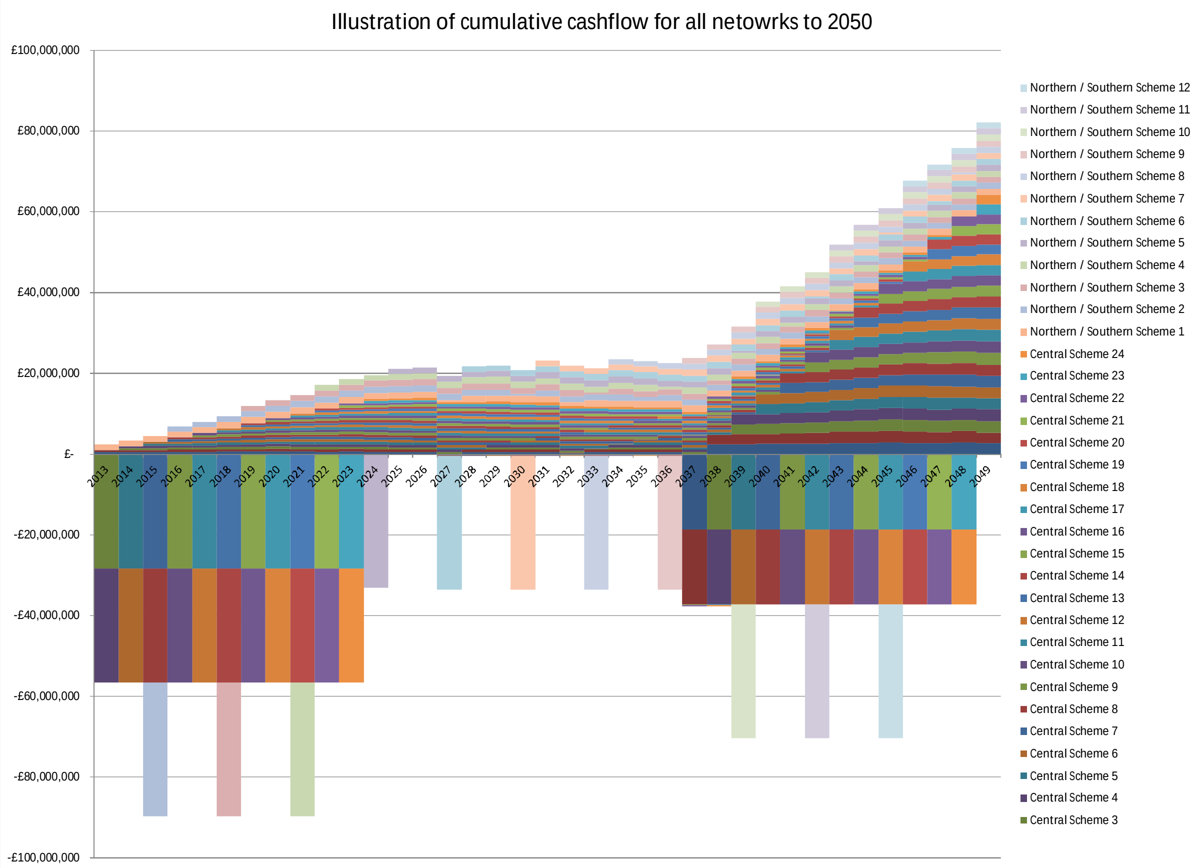
Figure 14-4 Cashflow of central band network illustrating growth



14.3.4 This figure illustrates that the initial phase (25% DE penetration) has a small positive operating margin, but that it is only when the DE penetration reaches 75% that there is a substantial positive operating margin.

14.3.5 The overall cashflow for CIL setting is based on the cumulative cashflow of the addition of all the individual networks modelled, as illustrated below.

Figure 14-5 Summary of cashflow model for CIL setting



14.3.6 The individual colours on this chart illustrate the cashflow (not discounted) for each scheme – i.e. replicating the cashflow chart shown in Figure 14-4 above. Figure 14-5 illustrates the sum of the cashflow positions for all of the schemes modelled as part of this report's proposed means for the City of Westminster to meet decentralised energy policy targets (extrapolated to 2050 – as illustrated in Figure 13-9). This includes the

14.3.7 When this cashflow is discounted at 6% over the period to 2050, the following overall result is obtained:

Table 14-9 CIL level setting

CIL Setting	NPV result (6% discount rate to 2050)
Net present value of DE network installation to 2050	-£459m

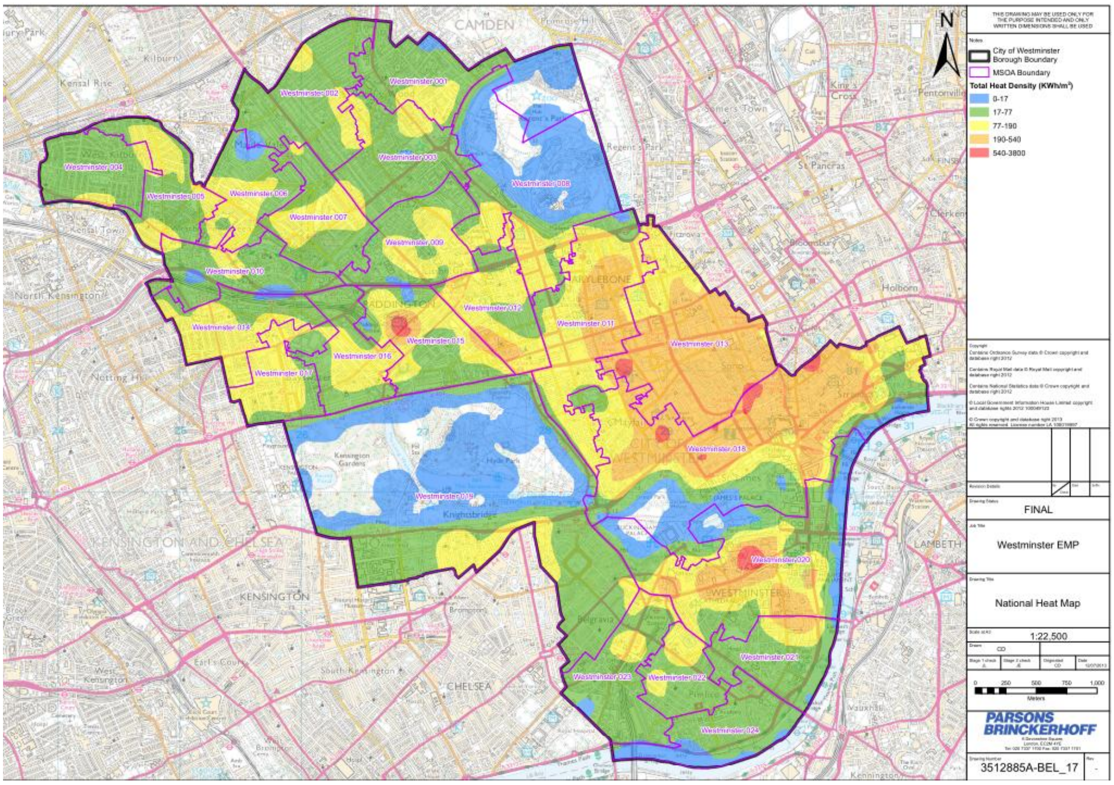
14.3.8 This figure could be used as a basis for CIL setting, on the basis that there is understood to be no explicit methodology that is to be adopted for this levy, and acknowledging the methodology described above that has been adopted to derive this figure.

15 WHERE SHOULD DE BE IMPLEMENTED FIRST?

15.1.1 In practice, the delivery of a specific scheme will depend upon the identification of anchor loads that can help to support the cost of network installation through long-term commitment to a scheme. Key anchor customers could be either new developments, large public sector buildings, or both. However, the following section considers the general areas in which schemes can be expected to emerge, rather than specific locations at street level.

15.1.2 The following map shows the middle layer super output areas (MLSOAs) into which Westminster has been divided in consideration of wider DE roll-out.

Figure 15-1 MLSOA and total heat demand density (as replicated from National Heat Map outputs)



15.1.3 The following table shows the number of planning permissions within each of the MLSOAs shown above.

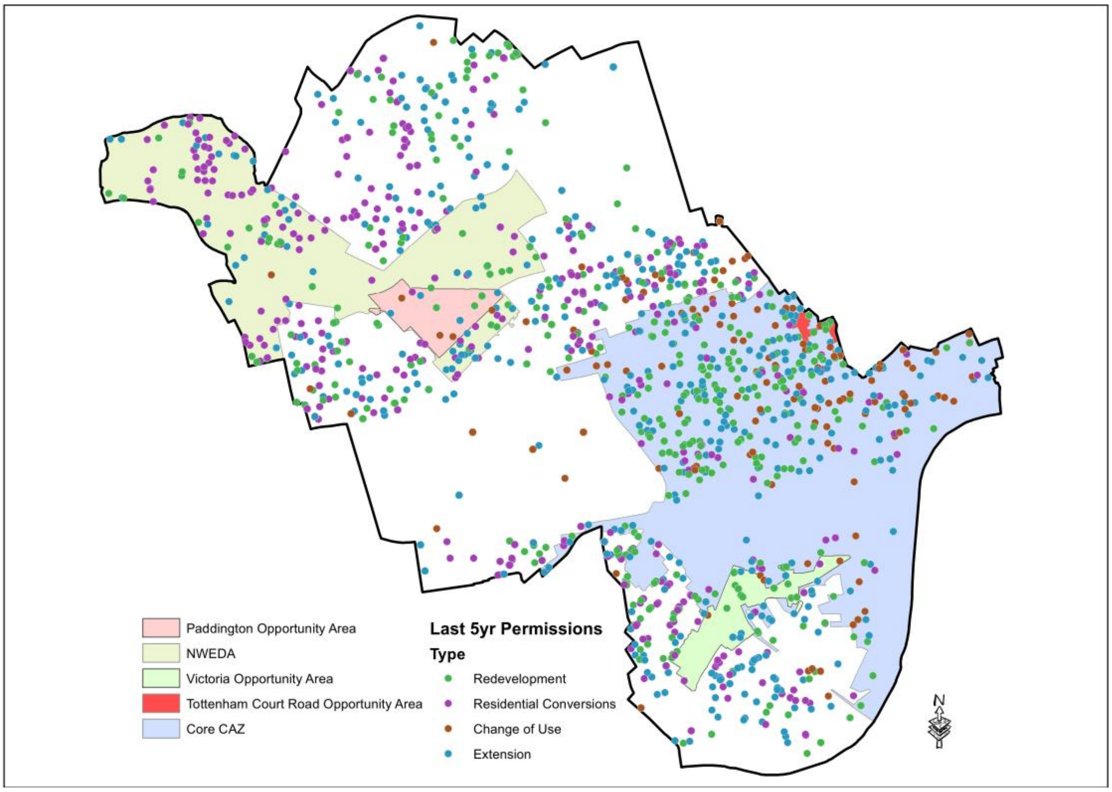
Table 15-1 Number of permissions within each MLSOA (5yr period)

	01 – developments	02 - change of use	03 - extensions	04 - residential conversions	Total
Westminster 001	24	1	22	7	54
Westminster 002	12	0	9	23	44
Westminster 003	11	2	24	8	45
Westminster 004	5	0	4	22	31
Westminster 005	5	0	9	27	41
Westminster 006	5	0	8	13	26
Westminster 007	6	0	16	27	49
Westminster 008	10	4	17	6	37
Westminster 009	11	0	5	7	23
Westminster 010	2	1	3	2	8
Westminster 011	61	16	57	32	166
Westminster 012	17	6	15	24	62
Westminster 013	89	41	80	20	230
Westminster 014	16	0	9	20	45
Westminster 015	22	7	17	10	56
Westminster 016	11	1	17	12	41
Westminster 017	16	4	21	22	63
Westminster 018	85	49	74	24	232
Westminster 019	58	11	47	65	181
Westminster 020	27	10	25	8	70
Westminster 021	6	5	3	2	16
Westminster 022	3	0	35	13	51
Westminster 023	10	3	16	8	37
Westminster 024	6	1	7	6	20
TOTAL	**518**	**162**	**540**	**408**	**1628**

15.1.5 The different MLSOA have greatly varying numbers of applications coming forward. The highest figure is 232 in area 18 (covering the area around the Strand, Covent Garden market, Trafalgar Square, and large parts of Mayfair), and the lowest figure is 8 in area 10 (covering parts of Westbourne Green and the area immediately to the north of the Paddington mainline railway route).

15.1.6 The geographical spread of permissions over the 5 year period analysed is illustrated below:

Figure 15-2 Geographical spread of planning permissions

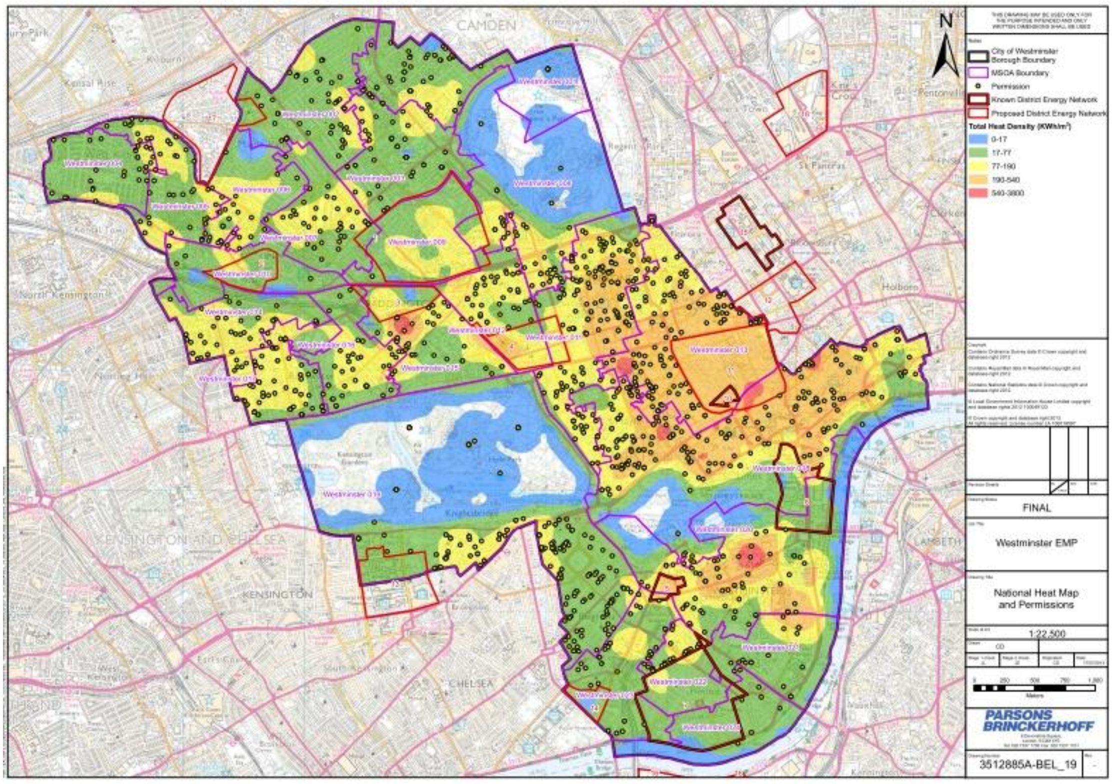


15.1.7 This different level of permissions coming forward in different areas suggest that, given the limits of planning intervention, that there will be different levels of opportunity for district energy systems to be rolled-out according to geography.

15.1.8 In order to refine this analysis in line with the DE potential areas already identified in this report, a secondary table of permissions has been compiled, excluding those that were fall within the DE zones already considered.

15.1.9 This updated spread of permissions is illustrated below:

Figure 15-3 Geographic spread of planning permissions (excluding known DE zones)



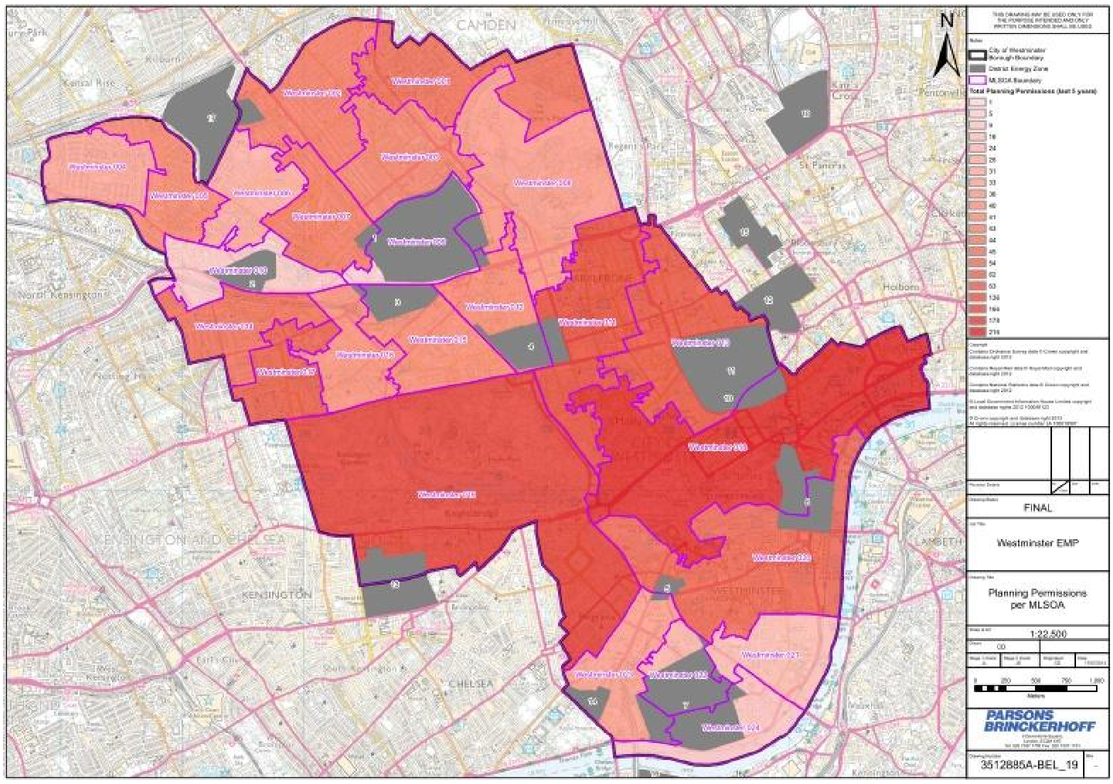
15.1.10 These data are represented by the table below:

Table 15-2 Number of planning permissions by MLSOA excluding DE zones

	01 – re-developments	02 - change of use	03 - extensions	04 - residential conversions	Total
Westminster 001	24	1	22	7	54
Westminster 002	12	0	9	23	44
Westminster 003	11	2	23	7	43
Westminster 004	5	0	4	22	31
Westminster 005	5	0	9	27	41
Westminster 006	5	0	8	13	26
Westminster 007	5	0	15	24	44
Westminster 008	10	4	16	6	36
Westminster 009	0	0	0	1	1
Westminster 010	1	0	2	2	5
Westminster 011	61	16	57	32	166
Westminster 012	12	2	11	16	41
Westminster 013	55	24	44	13	136
Westminster 014	16	0	9	20	45
Westminster 015	9	7	15	10	41
Westminster 016	11	1	16	12	40
Westminster 017	16	4	21	22	63
Westminster 018	84	40	69	23	216
Westminster 019	57	11	45	65	178
Westminster 020	20	10	24	8	62
Westminster 021	6	5	3	2	16
Westminster 022	1	0	17	6	24
Westminster 023	9	2	14	8	33
Westminster 024	5	1	3	0	9
TOTAL	440	130	456	369	**1395**

15.1.11 These comparative figures of planning permissions are illustrated on the map below:

Figure 15-4 Illustrative density of planning permissions by MLSOA



15.1.12 Assuming that planning permissions continue to come forward at approximately the same rates in the same geographies over the coming years, the combination of planning permission densities and heat demand densities illustrates those zones where there is the greatest likelihood of DE success. These areas should then become the focus of policy implementation efforts.

15.1.13 The highest density zones of both heat demand and planning permissions are reflected in the recommendations of this report which highlights the central zone where DE implementation should be pursued with most urgency.

16 PLANNING POLICY

16.1.1 High infrastructure costs will be a barrier to viable DE scheme development across the City of Westminster and so it is important that planning policy seeks to reduce these costs wherever possible by requiring developments of an appropriate scale to make suitable provision to enable their connection to a DE scheme, should one come forward at a later date. At a basic level, this means clusters of buildings, for example on housing developments or business parks, should have communal heating served from a energy centre. This reduces the extent of DE network infrastructure requirement in the event of a scheme coming forward that links these developments, as there is a single point of connection from which each development can be served.

16.1.2 In addition to communal systems, the following features would facilitate connection to, and improved performance of, a district heating network:

- Plant rooms that are easily accessible from the nearest public highway, i.e. with a potential pipework connection route direct to the public highway.
- Space provision within plant rooms for installation of the plate heat exchanger and pipework for interfacing the DE network with the secondary systems served from the plant room. This would preferably be in a part of the plant room close to the nearest highway
- In larger developments, oversized plant rooms with enough space for additional prime movers and, possibly, thermal storage that could serve a future DE scheme
- Secondary system designs that compliment the optimisation of DE network design and subsequent reduction of network costs. Specifically:
    - Low loss headers and DE stab-in points downstream of the header to enable hydraulic prioritisation of DE heat over boiler heat in the event of a baseload network in which heat from a DE network could be supplied alongside top-up boiler heat.
    - Variable flow variable temperature secondary system circuits to keep return temperatures low throughout the year.
    - Large surface area heat emitters (e.g. underfloor heating) to improve return temperatures.

16.1.3 If required at the planning stage, there is no reason why ensuring the criteria highlighted above should not? be borne within developers initial costs; attempting to retrofit such systems at a later date is much more difficult. The cumulative impact on a DE network that connects several developments with these features would be significant in terms improving efficiency.

16.1.4 As well as defining the criteria for facilitating connection to a DE network, it is important to define the scale of development above which certain criteria should be required. This enables WCC to have a clear policy when assessing planning applications.

16.1.5 A summary ofexisting and potential policy practice for different scales of development is shown in Table 16-1.

Table 16-1: Assessment of current and potential planning approach to DE

No. of residential units	Equivalent commercial floor area (m^2)	What currently happens (WCC)	What could happen
<10	<1000	Generally less than 10 units struggle to have an on-site centralised energy system. Often 10 small boilers are installed.	Centralised energy centre designed to serve the development. Provision made to enable connection to a future DE network should it become available. Block-based heating systems at this scale are common in continental Europe / Scandinavia.
10 to 49	1,000 to 4,999	Centralised energy centre designed to serve the development. The scheme should be designed to enable space to be provided to connect to a DE network should it become available (this may not be extra space, but with the removal of current boilers / CHP).	As with what currently happens but planning requires details of soft in-fill around the site and 'punch points' at the site boundary to ease connection to DE scheme . A clear route for connection to the public highway should be identified.
50 to 199	5,000 to 19,999	As above but often includes soft in-fill and 'punch points' at the site boundary site to ease connection to DE scheme.	Oversized energy centre, which could be used at a later date for additional plant serving a local DE network. Details should be provided in the form of diagrams and reports to enable planning to deliver the infrastructure at a later date. This should include details of soft in fill around the site and 'punch points' at the site boundary. It should also contain details on how the DE pipes could cross the site and meet the public highway.
200+	20,000+	Centralised energy centre designed to serve the development site. These super major schemes (VC, Chelsea Barracks etc) may also fund connection into DE networks close by (e.g. VC to PDHU).	Oversized energy centre filled either the site owner/occupier operating its own plant and exporting heat to a network, or allowing the space to be used by an external energy centre operator. Under all scenarios, the plant should link, or plan to link with a local DE network. The local network should be part installed by the developer within their red-line area. Details should be provided on how the DE pipes will cross the site under scenarios of expansion to other neighbouring areas.

16.1.6 The table contains four scale-based development categories. A high level assessment of the heating demands associated with these categories can be undertaken based on average per-dwelling heating demands.

16.1.7 A recent Parsons Brinckerhoff study involved the verification of Standard Assessment Procedure (SAP) calculations for a large development consisting of various dwelling types –achieving a mix of Code for Sustainable Homes level four and five energy efficiency compliance levels. The average per dwelling heating demand (space heating and DHW) for that development is c. 7,000kWh/year. Based on this average heating demand, the total heat load for each of the four development categories presented by WCC in Table 16-1 are as follows:

Table 16-2: WCC development category approximate loads

No. of residential units	Annual demand (MWh)
<10	Up to 70
10 to 49	70 - 343
50 to 199	350 - 1,393
200+	1,400 +

16.1.8 From the annual heating demands calculated for the four development scales presented by WCC, we can comment on their suggested planning approach to requiring a development to be DE ready

16.1.9 It is proposed that developments in the category of smallest developments could, in the future, be required to use a communal heating system served from a single energy centre. There is no reason to discourage this proposition, however the size of the heat load of a development of this scale could only contribute marginally to the success of a DE scheme. Indeed, unless there is a DE scheme (i.e network or energy centre) *directly adjacent* to the development, the cost of connecting it to the DE network would not be commercially viable without significant subsidy (e.g. CIL contribution). This is the position of the 'rest of the borough' analysis outlined in this report – the required level of DE penetration means that smaller properties that are not commercially viable must be connected.

16.1.10 WCC has stated that most developments coming forward in the second category – 10 to 49 dwellings – propose the use of a communal heating system. The proposal isthat the future planning approach should be to require all of them to be communal systems and to report the details of soft in-fill around the site and 'punch points' at the site boundary to ease connection to DE scheme. We suggest that for developments at the top end of this scale, this approach is entirely appropriate; however, towards the bottom of the category, heating demands are unlikely to be sufficient to offer a commercially viable connection without significant subsidy. Therefore, depending on the degree to which commercial viability without subsidy is a key requisite of schemes, an option in terms of policy implementation would therefore be that loads of 200MWh or more (c. 30+ dwellings) should be required to be DE ready as a matter of course. Below this point, planners could consider each development on an ad hoc basis – i.e. in the context of existing DE scheme(s) and developments in the area.

16.1.11 It is proposed that the two categories of largest developments should both be required to provide oversized energy centres, with developments of 1.4GWh or more (the top category) required to provide additional plant (or at least space) to supply a local DE network. Within the scope of their development area, developers should fund and install DE infrastructure to meet Planning Policy obligations. Further contribution to wider infrastructure should be made via CIL, in terms of land or 'normal' CIL contributions..

17 CARBON CALCULATION

17.1.1 The value to developers of connection to a district energy system will depend on a number of factors. These include the value of land / space saved through the avoided need for extensive energy centres and the cost of achieving environmental standards by alternative means on a particular site. However, an important element in this is confidence that the district heating supply will provide the appropriate level of decarbonisation of the supply to allow the development to meet its regulatory and planning targets. This section outlines the carbon baseline assumed, and the anticipated level of saving from the kick-start and overall networks proposed.

17.1.2 This report has assumed the simplified baseline / business as usual assumption that buildings that are not connected to a DE system, would be supplied with heat via gas-fired boilers operating at 80% (GCV) efficiency. Equally, the proposed systems are all based around gas-fired CHP in this assessment.

17.1.3 This assessment has adopted the Building Regulation (based on SAP 2009) carbon emissions factors as follows:

Table 17-1 Carbon emission factors

Fuel	Emissions factor ($kgCO_2$ / kWh)
Gas	0.198
Electricity import	0.529
Electricity export	0.517

17.1.4 It is hoped that with increased low-carbon generation, that the grid will decarbonise into the future. This will reduce the benefit in terms of carbon savings that gas-fired CHP provides, and hence there is the longer-term aspiration for the Westminster DE networks that the primary energy sources will shift to lower carbon fuels (i.e. biofuels / waste). It may also be that the gas grid is decarbonised through the more widespread injection of bio-derived methane into to gas grid.

17.1.5 The individual schemes are calculated to generate the following savings in terms of the provision of heat only (i.e. not including the emissions arising from electricity consumption at connected properties).

Table 17-2 Emissions savings from central and northern / sourthern schemes

	Base case emissions from heat (tCO_2 p.a.)	Emissions from DE scheme (tCO_2 p.a.)	Savings (tCO_2 p.a.)	Percentage saving (heat only)
Central scheme (25% DE penetration)	5,431	2,085	3,346	62%
Northern / Southern schemes	9,910	3,547	6,363	64%

17.1.6 In 2025, these savings would correspond to the following total annual carbon savings through the DE network systems:

Table 17-3 2025 emissions savings

	2025	2050
Total emissions savings through new DE systems (tonnes CO_2 p.a.)	105,753	322,587[47]

[47] By this time, it is hoped that 'alternative' fuels would supply many of the schemes modelled. The figure shown here assumes that gas CHP continues to supply all networks modelled.

18 DELIVERY PLAN

18.1.1 This report identifies a technical potential for the expansion of DE within Westminster over the period to 2050, and considers what actions are required to deliver this potential. This section outlines key activities for Westminster to undertake, in order to initiate progress.

18.2 Background to commercial arrangements for district heating in the UK

18.2.1 Historically the development of district heating in the UK has been, with some significant but isolated exceptions (see below), relatively small scale. Networks were developed by local authorities to serve social housing, funded from public finances and were often not maintained or developed in a commercially sustainable way. More recently there has been a move to develop schemes in partnership with the private sector and specifically towards the creation of Energy Service Companies (ESCOs). This move has been primarily due to the lack of public funding for infrastructure projects but has also been driven by the acceptance that systems need to be managed and maintained in a commercially viable manner and that this requires a range of technical and commercial skills which are not always available in the public sector.

18.2.2 Therefore the process of investigating potential business models for district heating based ESCO's and energy services schemes starts with an acknowledgement that, until recently, there were no private sector companies capable of delivering large scale DE projects connecting existing buildings without specific local authority sponsorship. This is now a growth market, and the potential is such that the opportunities to develop such projects are substantial. A decentralised energy approach provides the opportunities for energy cost and carbon emission reduction under which developers responsible for large new-build projects may build flexible energy systems for the future. The development of such schemes can also act as a catalyst for the decarbonisation of existing buildings in the surrounding area.

18.2.3 There are a few examples of city DE schemes that have successfully developed beyond the "estate project" scale and have delivered significant private sector commercial connections, of new and existing development, in Nottingham, Sheffield and Southampton. These are now wholly private sector owned but were originally developed with significant support from the local authority or central government, both in terms of access to funding and in provision of base load, long term connection agreements.

18.2.4 The development of the private sector ESCO market reflects the requirement from planning authorities that energy generation and supply to buildings be considered with the aim of minimising carbon footprint of buildings overall. This has created a market for ESCOs amongst developers seeking to contract out their carbon commitments under planning permissions. The planning process is likely to remain a key driver in the short-term but there are also more strategic approaches being developed towards the use of district heating in London and other major cities such as Leicester, Coventry and Newcastle. Birmingham in particular is partnering with a private sector firm to develop schemes in the city with a view to developing a city-wide district energy network. Two schemes are currently operational, both of which centre around public sector core loads.

18.3 Potential approaches for development of DE

18.3.1 There are a number of potential approaches to the general development of district energy schemes under sponsorship by the public sector; these are summarised in the table on the following page. It should be noted that this is not an exhaustive list of all the potential commercial arrangements possible for public-private partnerships but it does cover the main types of scheme development that have been undertaken to date. It should also be noted that there is no restriction on using different forms of organisation during different phases of the project life. For example the ownership of the Sheffield scheme was originally a mix of public and private but the local authority disposed of its share once the scheme was developed and could be re-financed. This is a good example of a local authority taking some risk early in a project to reduce the costs of finance and then disposing of its interest once these risks have fallen away.

Table 18-1: Potential commercial approached to delivering district heating

Description	Funding	Construction	Ownership	O&M	Examples
Public Sector - traditional	Local authority funds Grant funding Other public funds	Public procurement of construction contracts by Local authority	Local authority direct	Local authority internal or public procurement of O&M contract	Lerwick, Shetland
Public sector – arms length organisation	Local authority funds Grant funding Other public funds ALMO Borrowing	Public procurement of construction contracts by ALMO	ALMO	ALMO direct or public procurement of O&M contract	Pimlico District Heating Undertaking, Aberdeen Heat and Power
Public Private Partnership – JV company	Part as Public Sector plus private sector equity plus private sector debt	Public/private sector procurement of construction contracts (depends on JV structure and partner capabilities	JV Co Ltd	JV Co direct or Public/private sector procurement of O&M contracts (depends on JV structure and partner capabilities)	Thameswey Woking, initial Sheffield scheme, Birmingham CC/Utilicom
PPP – split responsibilities (eg energy supply private – infrastructure public sector)	Part as public sector plus private sector equity plus private sector debt	Split public/private procurement with interface management	Split public/private	Split public/private procurement of O&M services. Public O&M potentially packaged with private sector partner	Nottingham
Private sector – direct ES contract	Private sector debt/equity Grant funding – limited availability Supported by contract for services	Public procurement for ES Service – fixed scope Private sector construction contracts	Private sector – possible future reversion to public after defined period	Private sector	SSE Woolwich, EOn Dalston Square
Private sector – concession	Private sector debt/equity Grant funding – limited availability Supported by concession	Public procurement for concession – fixed area/service variable scope (likely base case fixed scope required). Private sector construction contracts	Private sector – possible future reversion to public after defined period	Private sector	Olympic Park/Stratford City
Private sector speculative	Private sector debt/equity Grant funding – limited availability	Private sector	Private sector	Private sector	Southampton

18.4 Ownership of DE assets, operation, ESCOs

18.4.1 There has traditionally been an unwillingness and inability for local authorities to become involved *directly* in the delivery and on-going operation of DE assets (the involvement of WCC in PDHU is an exception to this). This can be attributed to the operation of DE assets not forming the 'core business' of local authorities, and the management of DE plant being a niche area that requires specialist expertise.

18.4.2 However, WCC has a high level of understanding of the issues surrounding DE technologies, and also has a willingness to expand the remit of the PDHU, to develop the role of WCC to that more akin to that of an ESCO operator. Within PDHU reside the skill sets associated with DE operation. Some key benefits associated with the concept of more direct involvement in DE ownership are outlined below:

Table 18-2 Benefits of WCC as utility

Benefits
WCC's ability to access low cost finance (Prudential Borrowing)
Demonstrable experience of the customer interface and plant operation (via PHDU)
WCC as a utility / ESCo would be a clear partner with whom developers could contract for the delivery of energy to specific schemes
Ability to raise funds via CIL (or Allowable Solutions / S106) for decentralised energy projects with strategic importance (rather than just those that are commercially viable)
Enables the de-risking of projects that could then attract private finance after a period of initial growth

18.4.3 The alternative case for the delivery of DE would likely take the form of another public / private partnership, where the emphasis and equity involvement would likely fall more squarely with the private sector. This model has its own merits, but arguably does not leave sufficient room for long-term planning or strategic investment in line with long-term aspirations and policy targets.

18.4.4 The model that is examined and recommended in this study is therefore the 'WCC as utility'. This report does not attempt to flesh-out the detail of the exact form that this SPV might take, but makes the following broad assumptions on its composition and operation:

Table 18-3 WCC as utility model attributes

Attribute	Rationale
Public sector led	Allows for strategic investment in commercially marginal opportunities
Involvement of private sector subcontractors	For specialist services such as CHP maintenance, metering and billing, DE network maintenance
Projects partially funded through ring-fenced monies raised through CIL / planning gain	Enabling funds to be raised and projects implemented to match programme requirements of private sector
Builds on processes and practices established through PDHU's operation	PDHU represents a practice that has evolved since its inception over 60 years ago, and which operates on a not-for-profit basis
Council has capacity to: • Undertake streetworks • Compulsory purchase sites if necessary • Co-ordinate with other local plans	The council's powers could facilitate some aspects of the necessary works / activities
Reputation	The council's reputation and standing could greatly facilitate the 'marketing' angle of establishing the utility model

18.5 Points of planning intervention

18.5.1 Whilst this report attempts to challenge some current practices and accepted norms of the status quo, it also acknowledges that there are limits to planning policy intervention. The assumption made in this report is that planning policy and its requirements related to energy provision and secondary systems can only be applied to new developments or major refurbishments seeking planning consent. This suggests that the only means of implementing change in buildings which do not pass across the planning authority's desk will be through creating sufficient commercial incentive to instigate change, which can be enhanced with public sector-led catalysts..

18.6 Appraisal of potential options

18.6.1 The options for delivery vehicle formation given in Table 18-1: Potential commercial approached to delivering district heating above have varying advantages and disadvantages which generally fall under the following headings:

- Cost of funding
- Risk versus control

- Regulations and licensing
- Availability of resources/skills

18.7 Cost of funding

18.7.1 The cost of funding is critical for DE projects as the cost of infrastructure is generally high and the life of the system long. This has been recognised by central government and also by development agencies that have set up, or are setting up, a number of funding arrangements including grant funding and low cost loans for low carbon infrastructure projects[48]. There has historically been a mismatch between the nature of returns for these projects and the needs of private sector finance. Due to the lack of regulatory structure and high costs of market entry DE projects are treated individually (i.e. project financed) and the costs of private sector funds is driven by competition with other generally faster return projects rather than as a low risk, long term investment.

18.7.2 Generally the public sector has better access to grant funding and funding from other public sector organisations at lower cost than the private sector. The private sector generally has access to more funding from the debt markets albeit that this is now less easy to obtain and available at a higher rate than has previously been the case. The private sector generally has a shorter timeframe for economic analysis and a stronger focus on pure financial returns than the public sector, which are often more able to take account of the value of other potential returns such as environmental and social improvements in their overall appraisal of projects.

18.8 Funding gaps and how to fill them?

18.8.1 The viability analysis conducted as part of this study illustrates that at higher discount rates (equivalent to higher costs of capital), there is a funding gap to be closed to render the recommended schemes viable. One means of closing this gap has recently been clarified by the ‘Zero Carbon Hub’ in a report entitled ‘Allowable Solutions for Tomorrow’s New Homes’ (July 2011).

18.8.2 Allowable Solutions

18.8.3 Allowable Solutions are a concept whereby developers are able make a payment to a 3rd party provider whose responsibility it is to deliver the required emissions reductions for the development to comply with building control. The concept of Allowable Solutions has been developed to facilitate the delivery of zero carbon development; therefore in order to be beneficial, they must represent a lower cost to carbon compliance than alternative means.

18.8.4 The Allowable Solution framework is still in development, however if it is correctly designed Allowable Solutions could help to catalyse both new development and the deployment of a district energy scheme. It is conceivable that a WCC Allowable Solutions fund could, subject to appropriate accreditation, receive capital from any developer wishing to offset their carbon reduction obligation.

18.8.5 Carbon offset funds and CIL

[48] For example, see the following press release related to a £6m fund https://www.gov.uk/government/news/6-million-funding-for-local-authority-heat-networks, accessed 6th November 2013

18.8.6 The government has set carbon reduction targets which will require all new developments to be zero carbon by 2016 for residential properties and 2019 for non-residential properties. In the interim, Part L of the Building Regulations 2010, Conservation of Fuel and Power require a 25% reduction in CO_2 emissions relative to those allowed under Part L 2006, whilst further revisions introduced in July 2013 mandated a further 6% reduction.

18.8.7 There exists a broad range of measures which developers can implement to reduce carbon emissions, but local constraints may mean that it is not possible to implement these to a sufficient extent to achieve the required emissions targets. As an example, a building overshadowed on its southern side would not be able to install solar panels, whilst location within a conservation or flood risk area could also affect the range of measures which could be implemented. In this case, a number of councils have allowed developers to offset emissions through contribution into a carbon offset fund.

18.8.8 Schemes vary by local authority, but generally developers pay into the fund based on the magnitude of the emissions which they are unable to offset. This money is ring-fenced for use on carbon reduction schemes elsewhere in the borough. These can range from the installation of loft and cavity wall insulation to district heating systems.

18.8.9 Planning policy

18.8.10 There exist different planning frameworks under which carbon offset funds can be implemented. Schemes which have already been implemented have used Section 106 and the Community Infrastructure Levy. These are examined in more detail in the sections below.

18.8.11 Planning Obligations

18.8.12 Planning obligations are specific requirements a developer, the council or other parties must agree to undertake to allow a planning application to be granted permission. Secured through a Section 106 legal agreement or a unilateral undertaking, they are used to mitigate the impacts of a development; prescribe the form it may take; or compensate for any loss caused by it. A planning obligation may only lawfully be imposed where it is directly related to the development and is necessary to make the development acceptable in planning terms. An obligation must also be fairly and reasonably related in scale and kind to the development. Used effectively, planning obligations contribute to the achievement of the council's vision for the spatial development of the city, Westminster's City Plan (2013), by ensuring that development accords with relevant planning policy requirements.

18.8.13 Planning obligations have played a key role in helping to manage the impacts of development on the public services and infrastructure that the City of Westminster's residents and workers are reliant on. They have helped to ensure that the additional demands on the city's infrastructure and services arising from new developments can be met. It is however the government's intention that the use of planning obligations, as the principle mechanism for facilitating the delivery of infrastructure associated with the demands of new development, is replaced through the adoption of a local Community Infrastructure Levy (CIL).

18.8.14 Community Infrastructure Levy (CIL)

18.8.15 The Community Infrastructure Levy (CIL) is intended to help pay for new or improved infrastructure that addresses a local authority's wider area needs arising from development growth. This could include new roads and transport, local amenities such as parks, community centres, schools and health facilities. Local authorities that wish to charge a CIL are required to develop and adopt a CIL charging schedule. On adoption of a CIL this schedule would set out the mandatory charges on new development at a rate per square metre of net additional floorspace on most buildings that people normally use. There may be differential rates for different types of land use and within different geographical areas.

18.8.16 In seeking to become a CIL charging authority, authorities are required to demonstrate the potential effects of any proposed levy rate (or rates) on the economic viability of development across their area. By providing additional infrastructure to support development of an area, the levy is expected to have a positive economic effect on development across an area. In deciding the rate(s) of the levy for inclusion in the council's charging schedule, a key consideration is the balance between securing additional investment for infrastructure to support development and the potential economic effect of imposing the levy upon development across their area. The CIL regulations place this balance of considerations at the centre of the charge-setting process. Authorities are not obliged to make a levy, and can set it at zero should they wish. Where a CIL is introduced planning obligations may in some circumstances still be used to secure the provision of infrastructure onsite however the CIL Regulations (2010 and as amended) impose significant restrictions on their use and they must be scaled back to those matters that are directly related to a specific site.

18.8.17 CIL and planning obligations therefore both have a role in contributing to the provision of supporting infrastructure. Authorities are required to ensure that there is clarity about what infrastructure will be funded by CIL and what infrastructure, and non infrastructure, planning policy requirements will be delivered through planning obligations. This is to ensure that there is transparency in the operation of both systems.

18.8.18 Implementation in other London boroughs

18.8.19 This section examines the implementation of carbon offset funds in two London boroughs: Islington and Tower Hamlets.

18.8.20 Implementation in Tower Hamlets

18.8.21 Tower Hamlets' *Supplementary Planning Document (SPD): Planning Obligations*[49] sets out the Council's approach to planning obligations in the borough, and covers the full range of obligations and charges.

18.8.22 In relation to Environmental Sustainability the document sets out the Council's ambition of "ensuring all new homes are built to zero carbon standards (as defined by CLG) by 2016 and all new non-domestic developments are built to zero carbon standards by 2019." [Tower Hamlets SPD: Planning Obligations]

Where officers consider all opportunities to meet the relevant London Plan carbon dioxide reduction targets on-site have been exhausted, contributions to a carbon offset fund will be sought to meet the shortfall.

[49] http://www.towerhamlets.gov.uk/lgsl/451-500/494_th_planning_guidance/supplementary_guidance.aspx

Reflecting relevant Government and London Plan policies and guidance as appropriate, (including any further relevant guidance produced by the LBTH), the remaining carbon emissions will be offset through providing new and additional opportunities to reduce carbon emissions from existing housing in the Borough or community energy saving programmes or other initiatives. [Tower Hamlets SPD: Planning Obligations]

18.8.23 The Council is also currently examining the feasibility of implementing a decentralised energy network in the borough. In areas identified for decentralised energy networks developers will need to pay a levy towards extending and connecting to it. Where developers are not able to connect, alternative CO2 reduction measures must be made and a contribution will also be sought.

18.8.24 Tower Hamlets is seeking to have a CIL adopted by April 2014.

18.8.25 Implementation in Islington

18.8.26 The London Borough of Islington has a carbon offset fund in place, implemented through Section 106 agreements. The Council's Environmental Design SPD[50] sets out the environmental standards which new developments in the borough must meet. Any remaining emissions which cannot be reduced onsite can be offset through payments into the carbon offset fund. The current price per annual tonne of CO_2 is £920 [Environmental Design SPD], based on a cost analysis for retrofitting CO_2 reduction measures in Islington properties. For minor developments a fixed rate of £1500 per house and £1000 per flat is set. The fixed fee is in recognition of the fact that minor schemes are not required to report on emissions to the same level of detail as larger schemes.

18.8.27 The Council is also in the process of implementing a CIL[51] which, inter alia, will raise money for district heating networks in the borough. Islington Council has identified 14 heat networks which it plans to implement between 2013 and 2018 at an estimated cost of £42m. Of this, £20m of funding has been identified, leaving a funding gap of £22m which will be filled through CIL contributions.

18.8.28 Further details of the magnitude of the Levy are provided in the Council's Environmental Design SPD[52]. For minor new-build residential developments a simple flat fee has been set at £1500 per house and £1000 per flat.

18.8.29 For major developments:

"...the financial contribution shall be calculated based on an established price per tonne of CO_2 for Islington. The price per annual tonne of carbon is currently set at £920, based on analysis of the costs and carbon savings of retrofit measures suitable for properties in Islington

The calculation of the amount of CO_2 to be offset, and the resulting financial contribution, shall be specified in the submitted Energy Statement. The spending of carbon offset payments and monitoring of CO_2 savings delivered will be managed by the council."

[50] http://www.islington.gov.uk/publicrecords/library/Planning-and-building-control/Publicity/Public-consultation/2012-2013/(2012-10-22)-Environmental-Design-SPD-FINAL.pdf
[51] http://www.islington.gov.uk/publicrecords/library/Planning-and-building-control/Publicity/Public-consultation/2013-2014/(2013-06-28)-CIL-Draft-Charging-Schedule-and-Supporting-Information-June-2013.pdf
[52] http://www.islington.gov.uk/publicrecords/library/Planning-and-building-control/Publicity/Public-consultation/2012-2013/(2012-10-22)-Environmental-Design-SPD-FINAL.pdf

18.8.30 Application to Westminster

18.8.31 It can be seen in the sections above that funding a district heating scheme through a carbon offset fund is a realistic undertaking and one which is already being implemented by Islington and Tower Hamlets councils. Westminster City Council has not yet set a CIL (although a mayoral CIL of £50/sqm has been implemented), nor has it any specific planning obligations within an SPD which aim to raise money for emissions reduction schemes. It is likely that the Council will set a CIL before 2014 and should take advantage of this opportunity to incorporate a carbon levy to fund schemes including district heating systems.

18.9 Risk versus Control

18.9.1 Public sector organisations are generally risk averse and there has historically been a tension between the desire from local authorities, and others, to move all risk to the private sector and the desire to retain control over the development of potentially high profile and high impact projects. If there is a full transfer of risk to one party then that party will, naturally, require full control over management of the risks and will be unwilling to allow outside influence on the operation and development of a project.

18.9.2 The transfer of risk also has implications for the costs of funding and a realistic approach to risk needs to be adopted to give a project a chance of proceeding. The principle by which an ESCo should operate in terms of dealing with risk is the same as any other business operation. This is to allocate the risks to the party most familiar with the specific risk and by implication most able to deal with it as a result of their normal operational practices and structures. The means by which risk is dealt with (transfer, distribution, mitigation and tolerance) aims to reduce the possibility of occurrence and impact as far as is practically possible, thereby minimising obstacles to the long-term financial stability of the organisation ultimately responsible for the projects.

18.9.3 Responsibility for risk has important implications financially for the partners engaged in the development of the ESCo; where risk is allocated within a partnership also broadly determines where the financial benefits are distributed. Capital and operational risks will have a proportion of finance or a share of profits associated with them; this is where the objectives of the cluster development ESCo and the strategic aims of WCC need to be considered. It may be, for example, that key element of control that WCC would want to maintain would be in minimising costs to customers to ensure social objectives are met.

18.10 Regulations and Licensing

18.10.1 The heat market in the UK is unregulated at present. There are proposals being developed for various types of regulation both at a national and at a local level. This lack of specific regulation may act as both a help and a hindrance to the development of DE. Whilst the lack of regulation provides commercial freedom to develop schemes as required by local circumstances, schemes are generally caught by a range of different regulations related issues (such as town planning, carrying out streetworks and environmental compliance) without a national framework for how these will be applied. This can mean a significant amount of work being required to mutually agree the way in which regulations will be applied to this type of scheme and restrictions on ability to access equipment which can create difficulties throughout the project life.

18.11 Availability of Resources and Skills

18.11.1 No matter which approach is taken, the delivery of schemes must be achieved safely, to programme and to a quality specification. Achievement of this requires the use of high quality resources, with sufficient experience of delivery of this type of schemes. What must be noted is that, even where an organisation has an excellent track record in project delivery, the specific personnel who will be in key positions will have a significant impact on actual project outcomes. Whichever approach is taken it is important to have the ability to monitor progress and quality – the self-interest of a concessionaire will not necessarily make up for lack of experience of key people and there will be some reputation risk whatever the structure adopted for delivery.

18.12 Operation of Schemes

18.12.1 The requirement for skilled and experienced resources is not restricted to scheme development. There has been a history of scheme performance deteriorating over time in the UK due to inadequate training and supervision of operations and maintenance. There has also been a tendency towards short-term thinking in relation to maintenance, particularly of CHP units but also of DE assets. Finally whilst short-term contracting for maintenance is undesirable there are also pitfalls in long term arrangements particularly in ensuring performance is incentivised appropriately over the life of the contract, and in dealing with indexation for cost increases over time.

18.12.2 Arrangements will ideally be:

- long term - preferably matched to the expected life of the asset and with provisions for handback of plant at the end of the term in a suitable condition for ongoing operation for at least 12-24 months
- simple - avoiding trying to address all possibilities for the future now but with straightforward management procedures which allow each party appropriate control over changes requested by the other
- flexible - able to adapt straightforwardly to changing market conditions preferably via defined negotiation and modelling processes
- with sufficient provision for oversight and reporting that the asset owners and end-users of the system can be assured they are getting good value over time.

18.12.3 PDHU has already been through the process of setting-up and implementing this type of arrangement – a legacy that offers a significant advantage in the prospect of WCC establishing an expansion of the gift of this operation.

18.13 Westminster as distribution asset owners

18.13.1 One means through which WCC could significant alleviate some of the current key risks and barriers to DE implementation, would be to take on the role of distribution asset owner. This could operate in the same way as other utilities, and would see WCC recoup its investment costs through charging for the transportation of heat. This is identical in principle to the role of the asset owner at the King's Cross District Heating Network, and has close similarities to the role of the distribution network operators in the electricity market.

18.14 Westminster as whole system owner

18.14.1 A further step towards full operation as an ESCo would be for WCC to own not only the heat distribution assets, but also the energy centre assets. This would transfer the majority of risk onto WCC in terms of commercial exposure, but would allow WCC to take close to full responsibility for delivery and expansion.

18.15 Customer charters

18.15.1 An important aspect of developing public trust in the value / reliability and safety of DE systems is the provision of a standard customer care charter for schemes, which could potentially be included in DE-related planning conditions.

18.15.2 The Combined Heat and Power Association (CHPA) is working to set up a Domestic Heat Customer Protection Scheme which will include approving ESCO customer care charters and the provision of a dispute arbitration service. Progress is being made on a voluntary scheme lead by a number of CHPA members. They produced a draft document (July 2013) which they put out to consultation in the autumn (2013). This consultation period has now closed (as at December 2013). In addition, to prominent market-leading ESCOs such as EON and SSE participating, the working group includes representatives from consumer protection organisations such as ‘Which?’.

19 POTENTIAL SOURCES OF FUNDING / ASSISTANCE

19.1 Heat Network Delivery Unit

19.1.1 In March 2013 DECC produced a policy paper called 'The Future of Heating - Meeting the Challenge'. The paper sets out specific actions to help deliver low carbon heating over the next several decades and provides an assessment of the current situation, the barriers and challenges. The paper addresses industry, heat networks, buildings and the grid infrastructure.

19.1.2 For heat networks the following actions were identified:

- DECC will support local authorities in developing heat networks by establishing a Heat Networks Delivery Unit (HNDU) within the Department that will work closely with project teams in individual authorities.

19.1.3 The nature of the assistance that the HNDU will provide has not yet been made fully explicit. However, it is expected that this unit will be made up of around 10 full-time equivalent employees, and that expertise will be provided in technical, commercial and financial areas, to supplement Local Authority in-house skills.

19.1.4 The HNDU will manage a fund of £6m over two years, to invest in the development phase of heat network schemes. The HNDU will be formally launched in autumn 2013, at which point it will start to take applications from LAs for funding and support. HNDU support will contribute to the cost of procuring technical reports and advice on the phases of a heat network's development. HNDU will be able to provide support alongside the City Deals programme.

19.1.5 One action on Westminster is therefore to engage with the HNDU when it is established, in order to benefit from the support that the HNDU can offer.

19.2 London Enterprise Panel - London Infrastructure Group

19.2.1 The London Infrastructure Group, which forms a subgroup of the London Enterprise Panel has terms of reference that include '*strategic infrastructure that will create jobs and growth for London, including […] energy (including infrastructure that will create sustainable energy),[...]*'[53].

19.2.2 In recent Mayoral questions (22nd May 2013), The Mayor of London stated[54] that '*The LIG priorities include […] enabling the efficient and sustainable management of energy production and use. The LIG welcomes proposals from decentralised energy (DE) projects that contribute towards these priorities and my 2025 targest for DE.'*

19.3 BRE and SDCL green refurbishment program

19.3.1 Sustainable Development Capital and BRE have launched a new program[55] to provide capital investment for non-domestic energy efficiency retrofit projects in the UK. The £100 million fund, which has backing from the Green Investment Bank, is

[53] http://www.london.gov.uk/moderngov/mgCommitteeDetails.aspx?ID=282, accessed 30th July 2013
[54] http://mqt.london.gov.uk/mqt/public/question.do?id=46497, accessed 30th July 2013
[55] http://www.2degreesnetwork.com/groups/built-environment/resources/bre-and-sdcl-team-up-deliver-100-million-green-refurbishment-program/, accessed 30th July 2013

open to businesses looking to invest in building retrofit and energy infrastructure projects where clear energy and carbon emissions savings will result.

19.3.2 Financing will be available for up to 100% of the project cost, typically up to £2 million for an energy efficiency upgrade, and the fund will focus on projects where savings cover capital costs within a reasonable period of time – usually in the region of three to five years - and use commercially proven technologies.

19.3.3 The fund will focus on four key areas:

- Building retrofit including technologies such as LED lighting, HVAC improvements and voltage optimization in commercial buildings and light industrial facilities.
- Renewable heating including the installation of technologies such as biomass boilers in hospitals, leisure centres and manufacturing facilities.
- Combined heat and power installations in hospitals, universities and on a district scale.
- Urban infrastructure such as heat networks and street lighting retrofits.

19.3.4 The. BRE's role will be to provide strategic and technical support to projects, which will include post completion reviews to verify the energy savings and make recommendations for further improvements.

20 CONCLUSIONS AND RECOMMENDATIONS

20.1 Conclusions

20.1.1 Westminster has a high density of heat demand that would suggest that there is excellent potential to install DE networks. However, the data of heat demands also suggests that the total demand is made up of a large number of small properties. The high levels of penetration of DE required to meet London's targets mean that connection of these smaller properties is inevitable as part of the overall route to a low-carbon DE scenario. This means that the installation of long lengths of DE pipework are inevitable across the borough to achieve high levels of DE penetration, with concomitant high costs.

20.1.2 The analysis carried out as part of this study is based around average property sizes and average density, in order to be able to draw conclusions on the overall costs and scale of change required to implement significant change to 2025 and 2050.

20.1.3 Only a small portion of the demand that needs to be accessed to meet targets will be subject to planning applications in the period to 2050, and hence there is a need to find an alternative route to accelerate DE take-up.

20.1.4 The findings of this report corroborate the widely-held view on deliverability – i.e. that large, anchor loads will be critical in the development of infrastructure that can then be strategically expanded to enable far higher levels of DE penetration.

20.1.5 Analysis of major applications coming forward suggest that there are sufficient numbers of larger applications on average to imply that it may be possible to secure (with suitable application of policy) space for energy plant around which schemes could be centred.

20.2 Recommendations

20.2.1 Parsons Brinckerhoff strongly recommends that planning approval for development within the WCC is subject to secondary system designs that are compatible with delivering low return temperatures to a district heating network. Guidance is contained within the London District Heating Manual. At detailed planning stage, careful assessment of major applications must take place to ensure that the proposed designs at a detailed technical level are suitable to deliver low return temperatures to a primary network under the full range of anticipated operating conditions.

20.2.2 It is recommended that where possible allowance should be made in design to accommodate the use of 'waste heat'. This should include centralisation of chilled water heat rejection plant within developments, co-locating heat delivery stations close to sources of waste heat, and ensuring that systems operate on variable-flow, variable temperature principles as outlined in the London District Heating Manual.

20.2.3 Consideration could be given to the adoption of a tax / charge related to annual heat rejection to atmosphere, although this would require considerable conceptual development in terms of monitoring, reporting, and enforcement.

20.2.4 The use of distributed absorption chilling driven by heat derived from a district heating network is not recommended.

20.2.5 Chilled water

20.2.6 Tottenham Court Road / East of Oxford Street and Paddington Basin - it is suggested that policy should encourage new developments to consider the supply / purchase of chilled water to/ from immediately adjacent sites.

20.2.7 Victoria Area - it is recommended that development in this area is future proofed for district cooling connection, and that as strategic new development comes forward, an assessment of the potential to supply / purchase chilled water from a cooling network is required.

20.2.8 In order to facilitate identification of potentially beneficial chilled water links between sites, it is recommended that WCC set-up and maintain a database of chilled water plant capacities, locations, and likely replacement cycles.

20.2.9 Heat sources for DE networks

20.2.10 It is suggested that the use of gas-CHP and possibly waste heat and gasification CHP are currently the most suitable technologies for the early phase network development. This reflects primarily the proven nature of gas-fired CHP, and its ability to generate carbon savings at relatively low cost.

20.2.11 The front-runner technologies for the later phases of the network expansion appear to include the use of waste-heat resources (with heat pumps) and biofuel CHP technology.

20.2.12 In later phases of DE expansion, when larger-scale plant will be required, it is recommended that WCC liaise with the electricity and gas network operators in order to establish zones in which existing capacities / fault-levels can accommodate new generation capacities. This could lead to increased cost-efficiency in installation.

20.2.13 Specific areas

20.2.14 PB strongly recommends that any energy centre system developed on the Battersea Power Station site should link to PDHU via the existing network under the Thames.

20.2.15 Battersea's heritage as a power station, its location and link to PDHU suggest strongly that there should be a strategic push to make use of this location as a site for significant generation capacity that allows economies of scale to be maximised and a wide area of Nine Elms on the South Bank and Westminster to be supplied with heat.

20.2.16 Chelsea Barracks - It would be a great shame to 'miss' this expansion opportunity for the PDHU system, given that developments of the scale of the Chelsea Barracks do not occur very frequently, and even more rarely in such a beneficial location for system expansion.

20.2.17 It is recommended that the potential of a WDHS to PDHU link should not be seen as a factor influencing the NOVA Victoria to PDHU connection. Further it is also recommended that the link between Victoria Circle and PDHU is implemented.

20.2.18 Anaerobic digestion in Soho – it is recommended development of this concept technology is supported, given its potential benefits, but it remains technically and commercially unproven at this stage for the scale of installation and urban environment. The recommendation is therefore to maintain a watching brief, and to assist concept development where easily possible.

20.2.19 Kilburn south - the approach recommended for WCC in this area is to engage with Brent Council to try to facilitate the examination of the potential for the South Kilburn masterplan DE system to link to loads immediately across the borough boundary (St Augustine's Church of England Secondary and Primary schools, and Tollgate House). The energy centre for the Kilburn development area is understood to be very close to these loads.

20.2.20 Natural History Museum / South Kensington area - The Natural history museum currently employs an ESCo is in a 15-year agreement for the supply of understood to have started around 2006, and hence a potential 'break-point' for the introduction of an alternative supply for the NHM will occur around 2021. In advance of this point in time, it would be recommended that Westminster engage with the NHM and its partners to explore the potential for this system to expand into neighbouring zones. This concept would require support from across the borough boundary to Kensington and Chelsea, and hence engagement with this neighbouring borough would be essential to maximise the potential of this expansion.

20.2.21 Portman Estate – this area represents an excellent prospect for DE success. The anticipated phasing of development of building development in this area leads to the recommendation to establish a DE delivery vehicle as early as possible for the entire area. This will then allow a coherent strategy to be developed.

20.2.22 Church Street / Paddington – It is recommended that the Church Street and Paddington Basin areas are linked in terms of heat provision. In addition, the St Mary's hospital is a significant heat user, and this institution should be incorporated in all strategic planning of energy assets for the area.

20.2.23 Westbourne Green – It is recommended that in the strategic long-term, that connection between Westbourne Green and the Kilburn South system should be pursued. The alternative connection towards Church Street is geographically more distant, and goes through areas of lower heat density.

20.2.24 <u>Extending DE to properties that are not applying for planning permission</u>

20.2.25 In order to impose a planning obligation on properties to connect to a DE system when they are simply due to replace their boiler plant would require legislative change. It is also difficult to envisage how this could be effectively implemented. The approach suggested at this stage to convince property owners to connect to emerging DE system at time of boiler replacement is simply one of awareness raising and information provision.

20.2.26 <u>Delivery mechanism</u>

20.2.27 In order to help overcome the problem of raising capital for both feasibility work and physical installations, it is recommended that Westminster use the Community Infrastructure Levy to help deliver DE schemes within the borough.

20.2.28 It is likely that the Council will set a CIL before 2014 and should take advantage of this opportunity to incorporate a charge to fund schemes including district heating systems.

20.2.29 The level of CIL required to support the schemes outlined in this report has been based upon achieving the extrapolated 2050 target for DE penetration. The level of CIL required is based around the cumulative NPVs of all the proposed networks, calculated at 6% over the period to 2050.

Table 20-1 CIL level setting

CIL Setting	NPV result (6% discount rate to 2050)
Net present value of DE network installation to 2050	-£459m

20.2.30 It must be noted that these estimates are based on central estimates and have been developed from multiple assumptions, and further that these figures are very sensitive to assumptions – particularly around utility prices, cost of individual connections to premises, and network installation costs.

20.2.31 It is recommended that WCC expands its role in the arena of DE development within its Borough to take a more active lead in investing in infrastructure. The recommendation is for activity in three areas:

- Maintaining a ‘live’ database of compatible properties, and where possible boiler replacement cycles
- Funding DE infrastructure and recouping investment via a ‘distribution charge’ for heat delivered through networks that WCC has funded
- Leasing energy centre space from major development sites for the installation of ‘oversized’ energy plant
- Expanding the operation of PDHU to other schemes

20.2.32 A key next stage element of further work must be to develop the structure and form of WCC’s involvement in this area, setting out its roles and responsibilities, and considering how this dovetails with policy and other implementation strategies.

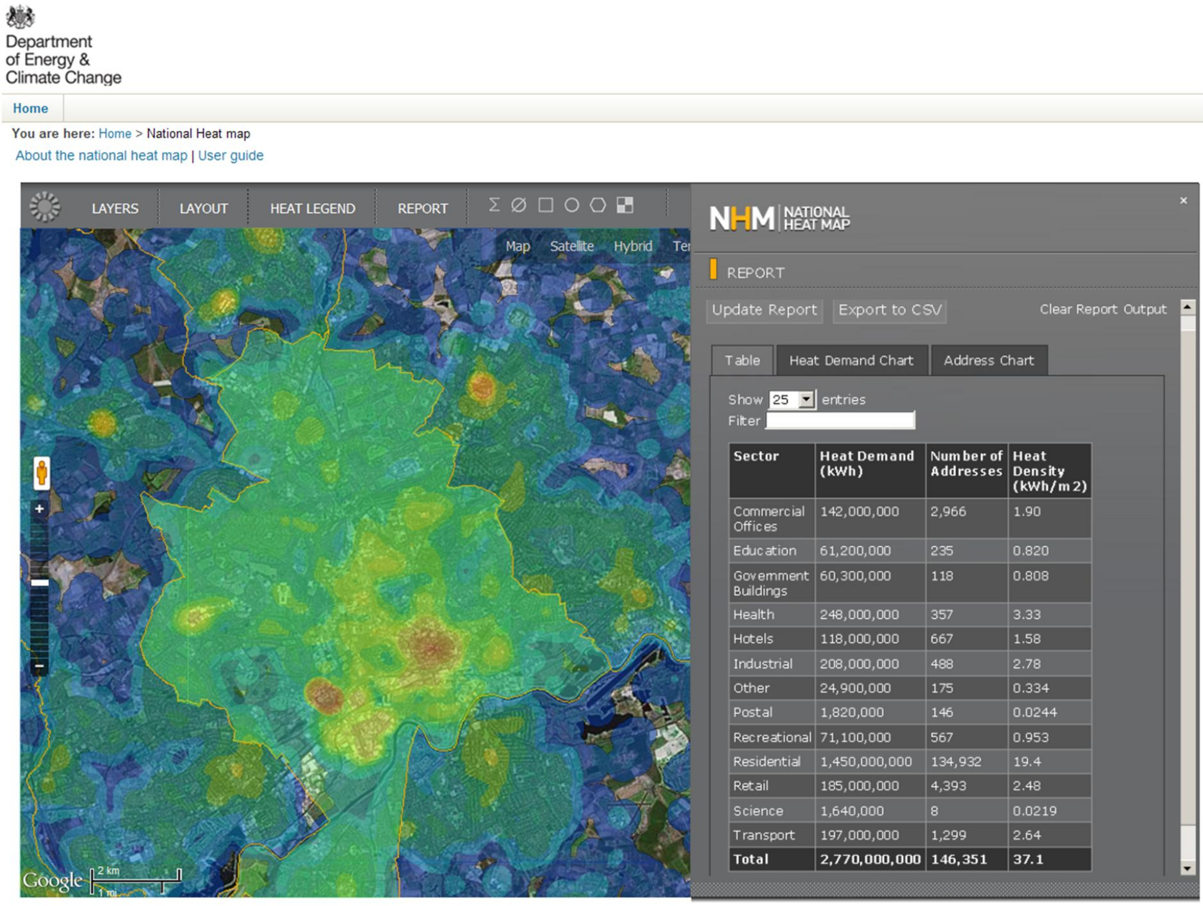
20.2.33 WCC should engage fully with the HNDU when it is established in order to benefit from the support that this organisation can provide both in terms of advise and funding.

20.2.34 Appendices

20.3 Appendix A – National Heat Map results for other DE cities

20.3.1 The following maps illustrate the results from the National Heat Map database for Nottingham, Sheffield and Southampton.

Figure 20-1 Nottingham - National Heat Map illustration



Sector	Heat Demand (kWh)	Number of Addresses	Heat Density (kWh/m2)
Commercial Offices	142,000,000	2,966	1.90
Education	61,200,000	235	0.820
Government Buildings	60,300,000	118	0.808
Health	248,000,000	357	3.33
Hotels	118,000,000	667	1.58
Industrial	208,000,000	488	2.78
Other	24,900,000	175	0.334
Postal	1,820,000	146	0.0244
Recreational	71,100,000	567	0.953
Residential	1,450,000,000	134,932	19.4
Retail	185,000,000	4,393	2.48
Science	1,640,000	8	0.0219
Transport	197,000,000	1,299	2.64
Total	**2,770,000,000**	**146,351**	**37.1**

Figure 20-2 Southampton - National Heat Map illustration

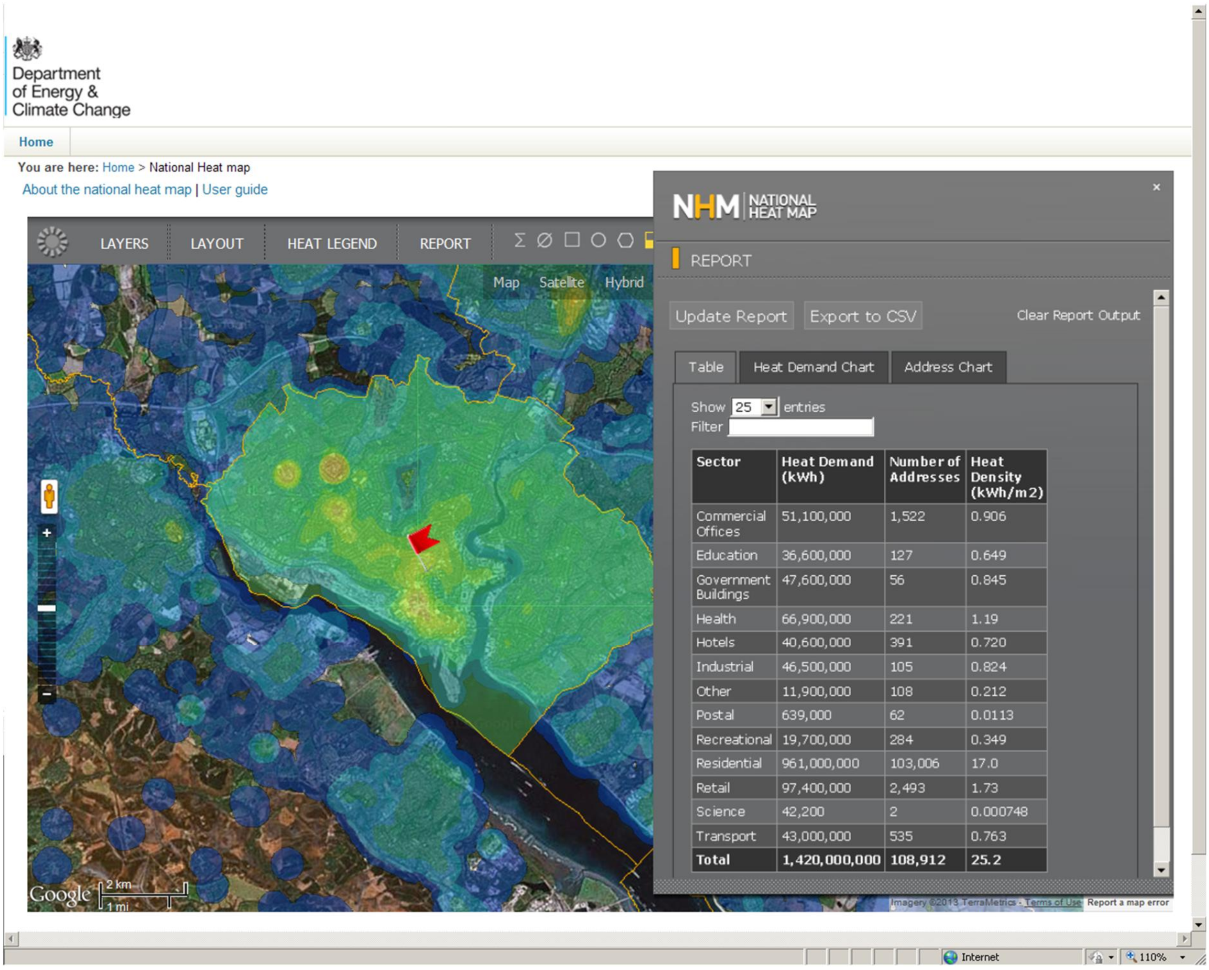
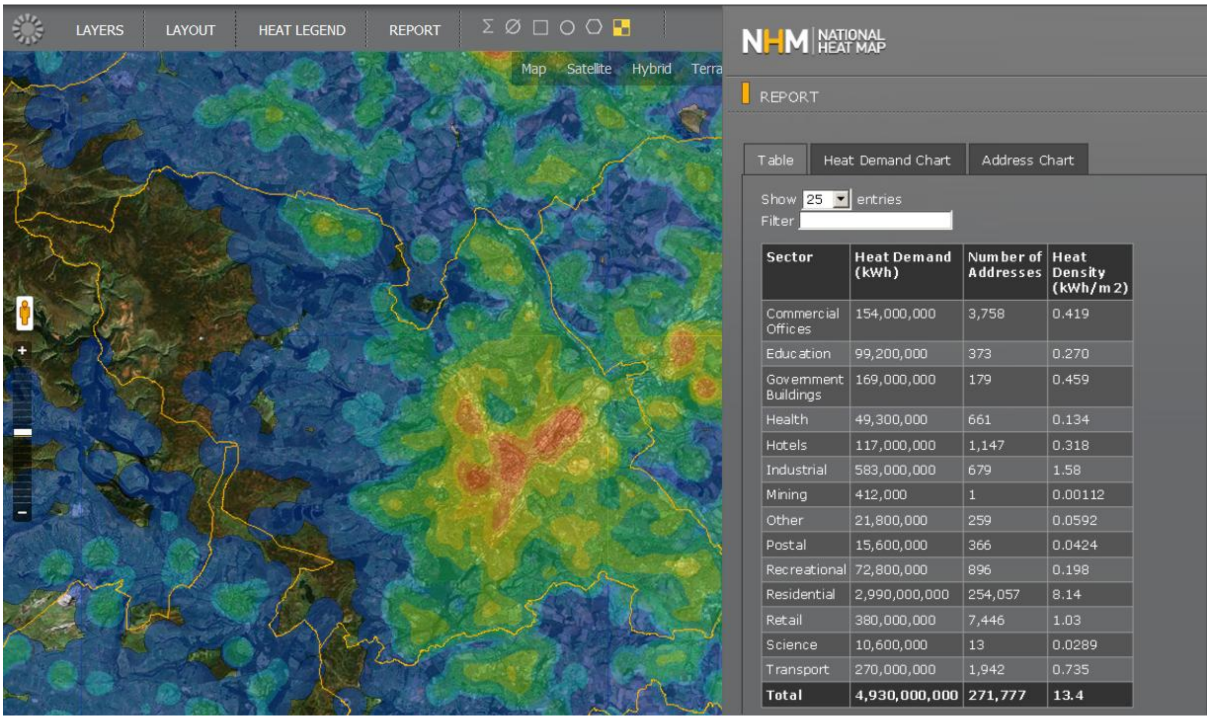
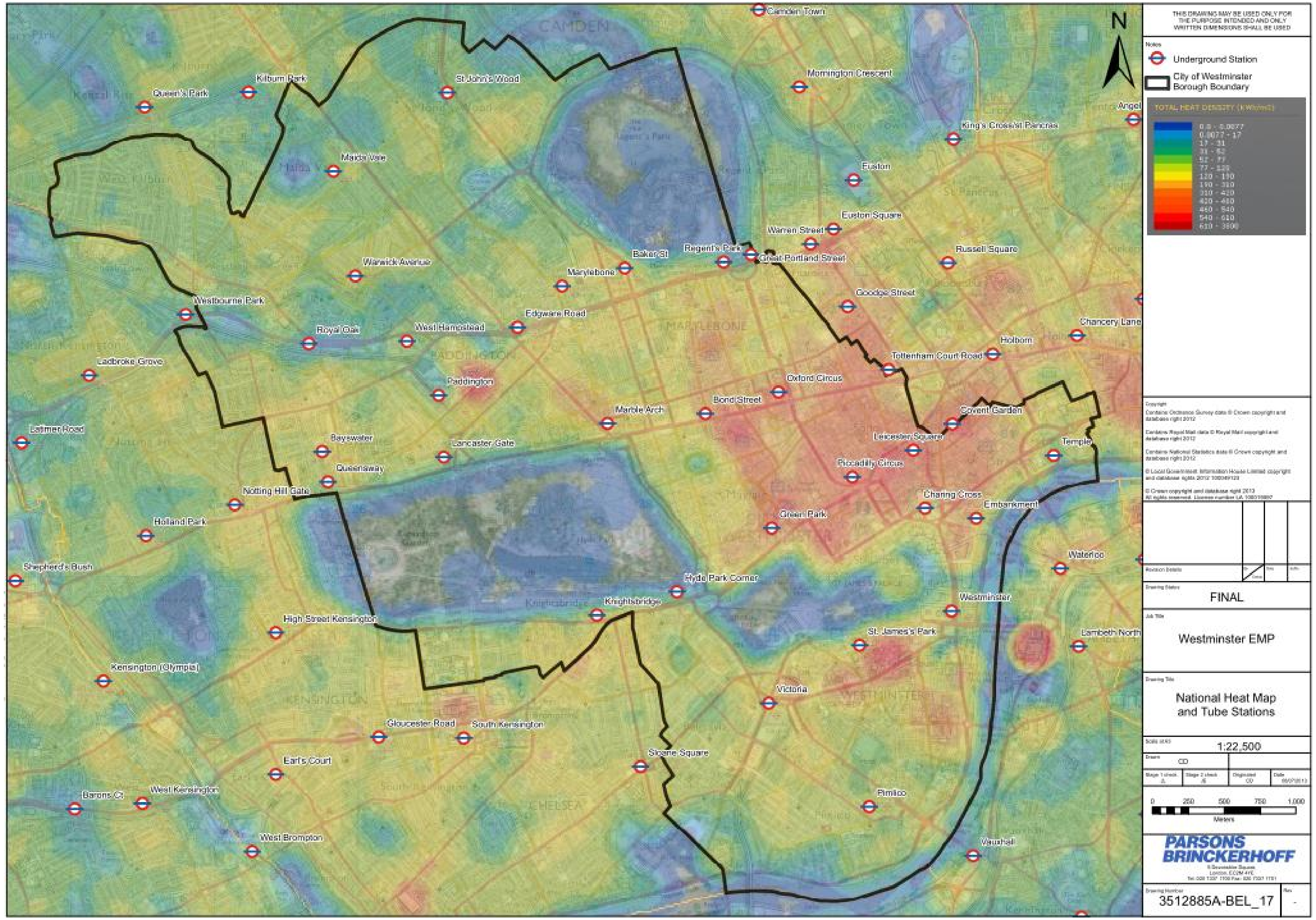


Figure 20-3 Sheffield - National Heat Map illustration



20.4 Appendix B – Underground station locations in Westminster



20.5 Appendix C – Network modelling detail sheets

Parsons Brinckerhoff - Energy Solutions
Westminster City Council Notional Networks
Version 3.98i - July 2013

Key metrics for sense checking / outputs

Pipework inputs				Allowable velocities / pressure drop for sizing				
				Main SPINE		Branches (final connections)		
Diameters (nominal) (mm ID)	Cost per m (trench) (£ capex)	Insulation thickness	Heat loss W/m (TRENCH)	Max allowable pressure drop (pa/m)	Max velocity (m/s)	Max allowable pressure drop (pa/m)	Max velocity (m/s)	Length of this diameter in this option
mm (ID)	£ / m Trench	mm	W/m trench	pa/m	m/s	pa/m	m/s	m
25	£1,222	38.15	18	200	0.75	200	0.75	-
32	£1,257	41.3	20	200	0.75	200	0.75	-
40	£1,317	38.35	22	200	1	200	1	82
50	£1,344	39.85	25	200	1.15	200	1.15	20
65	£1,435	41.95	29	200	1.5	200	1.5	43
80	£1,509	45.55	30	200	1.75	200	1.75	26
100	£1,654	55.35	31	200	2	200	2	-
125	£1,794	55.15	36	200	2.5	200	2.5	-
150	£1,916	55.85	42	200	3	200	3	-
200	£2,078	67.95	44	200	3	200	3	-
250	£2,427	88.5	42	200	3.5	200	3.5	-
300	£2,588	88.05	49	300	3.5	300	3.5	-
350	£2,917	102.2	47	300	3.5	300	3.5	-
400	£3,159	111.8	48	300	3.5	300	3.5	-
450	£3,334	86.5	66	300	3.5	300	3.5	-
500	£4,312	101	63	300	3.5	300	3.5	-
600	£5,096	95	78	300	3.5	300	3.5	-
700	£6,519	94.5	90	300	3.5	300	3.5	-
800	£7,445	93.5	102	300	3.5	300	3.5	-

Network Geometry

Network Length		171	m (trench)
Total cost	£	235,680	Capital cost
Cost / m	£	1,378	£ / m average

Hydraulic Analysis

At	103%	senstivity on flow rates (this accounts for temp drop in flow to index run)			
Factor on pressure drop for fixtures / fittings	115%				
Total load at EC	262	kWth	System volume	0.829	cubic metres
Static head	35	m head			
Allowance for pressure drop across heat exchangers	5	m head			
Pressure drop from frictional losses (excl heat x'gers)	0	m head			
Pump power (kWe)	0	kWe	Annual pumping	0.337	MWhe
Total flow rate at EC	2	kg/s	based on	20%	minimum flow rate
Assumed ground temperature	8	deg C	Pump efficiency	65%	
Continuous heat loss (whole network)	4	kWth	and a typical mixed use load duration curve		
Estimated annual heat losses (whole network)	38	MWh p.a.	Based on series	2	type insulation
Network flow temperature	95	deg C			
Temperature of flow at index run	94.1	deg C			
Return water temperature	65	deg C			
Time of flow from EC to index (mins)	9.1	minutes			

Network Geometry (shows pressure drop per m gradient)

Loads	No. of dwellings	HIU (SH, kW)	HIU (DHW, kW)	CIU load (kW)	Average return temp (deg C)	Total load (diversified to base of block) (kW)
L1	-	3	30	32	-	-
L2	-	3	30	32	-	-
L3	-	3	30	32	65	32
L4	-	3	30	32	65	32
L5	-	3	30	32	-	-
L6	-	3	30	32	-	-
L7	-	3	30	32	65	32
L8	-	3	30	32	-	-
L9	-	3	30	32	-	-
L10	-	3	30	32	-	-
L11	-	3	30	32	65	32
L12	-	3	30	32	-	-
L13	-	3	30	32	65	32
L14	-	3	30	32	-	-
L15	-	3	30	32	-	-
L16	-	3	30	32	-	-
L17	-	3	30	32	-	-
L18	-	3	30	32	-	-
L19	-	3	30	32	-	-
L20	-	3	30	32	-	-
L21	-	3	30	32	65	32
L22	-	3	30	32	65	32
L23	-	3	30	32	-	-
L24	-	3	30	32	-	-
L25	-	3	30	32	-	-
L26	-	3	30	32	-	-
L27	-	3	30	32	-	-
L28	-	3	30	32	-	-
L54	-	3	30	32	65	32
L55	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-
-	-	3	30	32	-	-

Parsons Brinckerhoff - Energy Solutions
Westminster City Council Notional Network
Version 3.98i - July 2013
Key metrics for sense checking / outputs

Pipework inputs

Diameters (nominal) (mm ID)	Cost per m (trench) (£ capex)	Insulation thickness	Heat loss W/m (TRENCH)	Allowable velocities / pressure drop for sizing – Main SPINE: Max allowable pressure drop (pa/m)	Main SPINE: Max velocity (m/s)	Branches (final connections): Max allowable pressure drop (pa/m)	Branches (final connections): Max velocity (m/s)	Length of this diameter in this option
mm (ID)	£ / m Trench	mm	W/m trench	pa/m	m/s	pa/m	m/s	m
25	£1,222	38.15	18	200	0.75	200	0.75	-
32	£1,257	41.3	20	200	0.75	200	0.75	-
40	£1,317	38.35	22	200	1	200	1	-
50	£1,344	39.85	25	200	1.15	200	1.15	-
65	£1,435	41.95	29	200	1.5	200	1.5	-
80	£1,509	45.55	30	200	1.75	200	1.75	50
100	£1,654	55.35	31	200	2	200	2	270
125	£1,794	55.15	36	200	2.5	200	2.5	-
150	£1,916	55.85	42	200	3	200	3	539
200	£2,078	67.95	44	200	3	200	3	620
250	£2,427	88.5	42	200	3.5	200	3.5	162
300	£2,588	88.05	49	300	3.5	300	3.5	54
350	£2,917	102.2	47	300	3.5	300	3.5	27
400	£3,159	111.8	48	300	3.5	300	3.5	-
450	£3,334	86.5	66	300	3.5	300	3.5	-
500	£4,312	101	63	300	3.5	300	3.5	-
600	£5,096	95	78	300	3.5	300	3.5	-
700	£6,519	94.5	90	300	3.5	300	3.5	-
800	£7,445	93.5	102	300	3.5	300	3.5	-

Network Geometry

Network Length	1721	m (trench)
Total cost £	3,453,498	Capital cost
Cost / m £	2,006	£ / m average

Hydraulic Analysis

At	100%	senstivity on flow rates (this accounts for temp drop in flow to index run)		
Factor on pressure drop for fixtures / fittings	115%			
Total load at EC	35,824	kWth	System volume	91.44 cubic metres
Static head	35	m head		
Allowance for pressure drop across heat exchangers	5	m head		
Pressure drop from frictional losses (excl heat x'gers)	11	m head		
Pump power (kWe)	70	kWe	Annual pumping	58.74 MWhe
Total flow rate at EC	285	kg/s	based on	20% minimum flow rate
Assumed ground temperature	8	deg C	Pump efficiency	65%
Continuous heat loss (whole network)	70	kWth	and a typical mixed use load duration curve	
Estimated annual heat losses (whole network)	616	MWh p.a.	Based on series	2 type insulation
Network flow temperature	95	deg C		
Temperature of flow at index run	94.9	deg C		
Return water temperature	65	deg C		
Time of flow from EC to index (mins)	9.1	minutes		

Network Geometry (shows pressure drop per m gradient)

Loads	No. of dwellings	HIU (SH, kW)	HIU (DHW, kW)	CIU load (kW)	Average return temp (deg C)	Total load (diversified to base of block) (kW)
L24	-	3	30	715	65	715
L26	-	3	30	715	65	715
L27	-	3	30	715	65	715
L28	-	3	30	715	65	715
L29	-	3	30	715	65	715
L30	-	3	30	715	65	715
L31	-	3	30	715	65	715
L33	-	3	30	715	65	715
L34	-	3	30	715	65	715
L35	-	3	30	715	65	715
L36	-	3	30	715	-	-
L37	-	3	30	715	-	-
L38	-	3	30	715	-	-
L39	-	3	30	715	-	-
L40	-	3	30	715	-	-
L41	-	3	30	715	-	-
L42	-	3	30	715	-	-
L43	-	3	30	715	-	-
L44	-	3	30	715	-	-
L45	-	3	30	715	-	-
L64	-	3	30	715	65	715
L65	-	3	30	715	65	715
L66	-	3	30	715	65	715
L67	-	3	30	715	65	715
L68	-	3	30	715	65	715
L69	-	3	30	715	65	715
L70	-	3	30	715	65	715
L71	-	3	30	715	65	715
L72	-	3	30	715	65	715
L73	-	3	30	715	65	715
L74	-	3	30	715	-	-
L75	-	3	30	715	-	-
-	-	3	30	715	-	-
-	-	3	30	715	-	-
-	-	3	30	715	-	-
-	-	3	30	715	-	-
-	-	3	30	715	-	-
-	-	3	30	715	-	-
-	-	3	30	715	-	-
-	-	3	30	715	-	-
L76	-	3	30	715	-	-
L77	-	3	30	715	-	-
L78	-	3	30	715	-	-
L79	-	3	30	715	-	-
L80	-	3	30	715	-	-

20.6 Appendix D – Comparison of distributed absorption chilling vs local electric chillers

Parsons Brinckerhoff - Energy Solutions

Comparison of distributed absorption chilling and local electric chilled water provision

INPUTS

Boiler efficiency
80% GCV

CHP elec efficiency 37% GCV
CH heat efficiency 40% GCV

pump power
2% % of heat delivered

losses
10%

heat rjection powwer
2% % of heat rejected

COP
0.7

Emissions factors

gas	0.198	kgCO2/kWh
elec expo	0.529	kgCO2/kWh
elec impo	0.517	kgCO2/kWh

Cost factors

gas	2.8	p/kWh
elec export	7	p/kWh
elec import	10	p/kWh

DISTRIBUTED ABS CHILLER SYSTEM

ENERGY CENTRE

fuel 2,946,429 kWh gas; 583,393 kgCO2; 82,500 £

CHP 75%

heat output 1,178,571 kWh heat

1,090,179 kWhe power output; 576,704 kgCO2; 76,313 £

pump power 31,429 kWhe; 16,249 kgCO2; 3,143 £

heat required 1,571,429 kWh heat

fuel 491,071 kWh gas; 97,232 kgCO2; 13,750 £

Boilers 25%

392,857 kWh heat

Total CO2	145,281	kgCO2
Total cost	27,938	£

DISTRICT HEATING NETWORK

losses 142,857 kWh heat

CONNECTED BUILDING

heat input requiRed to 1,428,571 kWh heat

Abs chiller

chilled water 1,000,000 kWh

pump / fan power required 48,571 kWhe; 25,111.43 kgCO2; 4,857 £

heat rejection 2,428,571 kWh heat

LOCAL ELECTRIC CHILLER SYSTEM

Total CO2	186,120	kgCO2
Total cost	36,000	£

BUILDING SYSTEM

Elec chiller COP
3

pump / fan power required 26,667 kWhe; 13,786.67 kgCO2; 2,666.67 £

heat rejection 1,333,333 kWh heat

power input required 333,333 kWhe; 172,333 kgCO2; 33,333.33 £

Elec chiller

chilled water 1,000,000 kWh

SAVINGS GENERATED THROUGH USE OF ABSORPTION CHILLING SYSTEM

Total CO2	40,839	kgCO2
Total savir	8,063	£

20.7 Appendix E – Westbourne Green scheme capital cost breakdown

Capex items	Cost
New building	£540,000
Driveway and site preparation works	£150,000
Architect design fees @ 12%	£82,800
CHP 1	£1,800,000
CHP 2	£1,800,000
Thermal store (LTHW)	£270,000
Gas boilers	£1,225,000
Flues ductwork and stack	£250,000
Emission monitoring	£40,000
Ventilation	£100,000
Heat meters	£162,000
Energy Centre Plant Control (inc interfaces with EcoPark site)	£200,000
CW system (break tank and booster pumps)	£25,000
Oil tanks	£100,000
Gas pipework to energy centre building	£250,000
Internal gas works	£25,000
Internal LTHW and DHW pipework (inc valves)	£650,000
Insulation	£250,000
Pumps	£100,000
Pressurisation set	£50,000
Chemicals dosing	£20,000
Sidestream filtration package	£20,000
Degasser package	£25,000
EC DESIGN FEES	£813,480
HV switch gear	£35,000
Transformers integrated breaker	£50,000
LV switchboard	£50,000
BMS interface	£5,000
Import / export metering	£8,000
LV switch breaker	£30,000
415V cabling inside energy centre	£20,000
Terminations at energy centre substation	£10,000
Lights & small power - supply and install	£40,000
Fire and security	£30,000
Network costs	£10,739,427
Network design @ 2.5%	£268,486
Westbourne Green conversion costs	Not included
Contingency	**£3,593,129**
Total	**£23,827,321**