PARSONS BRINCKERHOFF

November 2014

ROYAL BOROUGH OF GREENWICH

ENERGY MASTERPLAN

Royal Borough of Greenwich

Revision 2

Royal Borough of Greenwich
Energy Masterplan

287261A

Prepared for
Royal Borough of Greenwich

Prepared by
Parsons Brinckerhoff

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CONTENTS

LIST OF ABBREVIATIONS

CIL	Community Infrastructure Levy
CHP	Combined heat and power (engine)
CCHP	Combined cooling heat and power
DE	Decentralised Energy
DECC	Department of Energy and Climate Change
DH	District heating
DHW	Domestic Hot Water
EfW	Energy from Waste
GIS	Geographic Information System
GPS	Greenwich Power Station
kWh	Kilowatt-hour
MWh	Megawatt-hour
PB	Parsons Brinckerhoff
RBG	Royal Borough of Greenwich
SELCHP	South East London Combined Heat and Power
SH	Space Heating
TfL	Transport for London

SECTION 1

NON-TECHNICAL SUMMARY

1 NON-TECHNICAL SUMMARY

1.1 Opportunity

1.1.1 The Royal Borough of Greenwich is home to some of the most exciting and extensive development in the whole of London. Greenwich Peninsula, Kidbrooke Village and other sites along the Thames waterfront in particular represent large-scale regeneration and opportunity areas for strategic infrastructure to be installed. This strategic infrastructure is key to catalysing a modal shift towards decentralised energy. The aspiration is to unlock low-carbon, cost-effective heat provision that will not only serve new developments, but also help to decarbonise energy supplies to existing properties. This opportunity is most easily realised whilst these areas are in their early development phases, and it is therefore imperative to act in line with the timescales of regeneration, thereby helping district energy (DE) to unlock growth, employment opportunities and poverty reduction.

1.2 Context

1.2.1 At both the national, regional and local levels, there is a clear level of policy support for heat networks. This reflects the proven status of the technology, the strain on national energy infrastructure as energy demands continue to increase, and the critical need to reduce carbon emissions to prevent acceleration of global warming and its consequences. Within the regional context, the Greater London Authority (GLA) is taking a proactive role in supporting and shaping the direction of infrastructure growth – recognising the presence of key physical assets within the city, and the high density of the built environment.

1.2.2 Within the borough of Greenwich itself, there exists a unique opportunity in Greenwich Power Station, which is able to provide significant space for the installation of heat generation

1.3 Benefits

1.3.1 The expansion of district energy in the borough and the provision of cost-competitive heat would deliver the following key benefits:

- Providing low-carbon, cost-competitive heat to developments, public sector organisations and residents within RBG and potentially across its boundaries
- Helping to alleviate fuel poverty[1]
- Attracting new industries and potentially jobs to the borough
- Reducing costs for developers of sites by providing an efficient means of achieving the standards required by the Building Regulations
- Reduce carbon emissions across the borough. Across the 40 year time horizon of this study, implementation of this masterplan would lead to a reduction of more than 600ktonnes CO_2 emissions to atmosphere.

[1] The borough has an anti-poverty campaign including combatting fuel poverty as illustrated by http://www.hays.co.uk/cs/groups/hays_common/@uk/@content/documents/webassets/hays_856251.pdf (section 3), and http://www.royalgreenwich.gov.uk/info/269/keeping_warm_in_winter_service, accessed Oct 2014.

- 9 -

- Provide long-term energy infrastructure that will allow future technological innovation to be integrated to a borough-wide system at low cost.

1.4 Development

1.4.1 The expansion of district energy within RBG will be greatly facilitated if it is closely linked to developments coming forward. The implementation of planning policy provides a means through which the council can directly influence how sites are served with heat and power. In addition, new development is incentivised to link to a district heating network through the avoided costs of installing the required heat generation plant and carbon reduction measures onsite. By contrast, the public sector as a whole has very little influence on the means of energy provision within existing buildings outside its ownership. For existing stock, therefore, a commercial approach to attracting connection to a district energy system must be adopted (i.e. obtaining heat from a DE network should be cheaper than current heat supply arrangements).

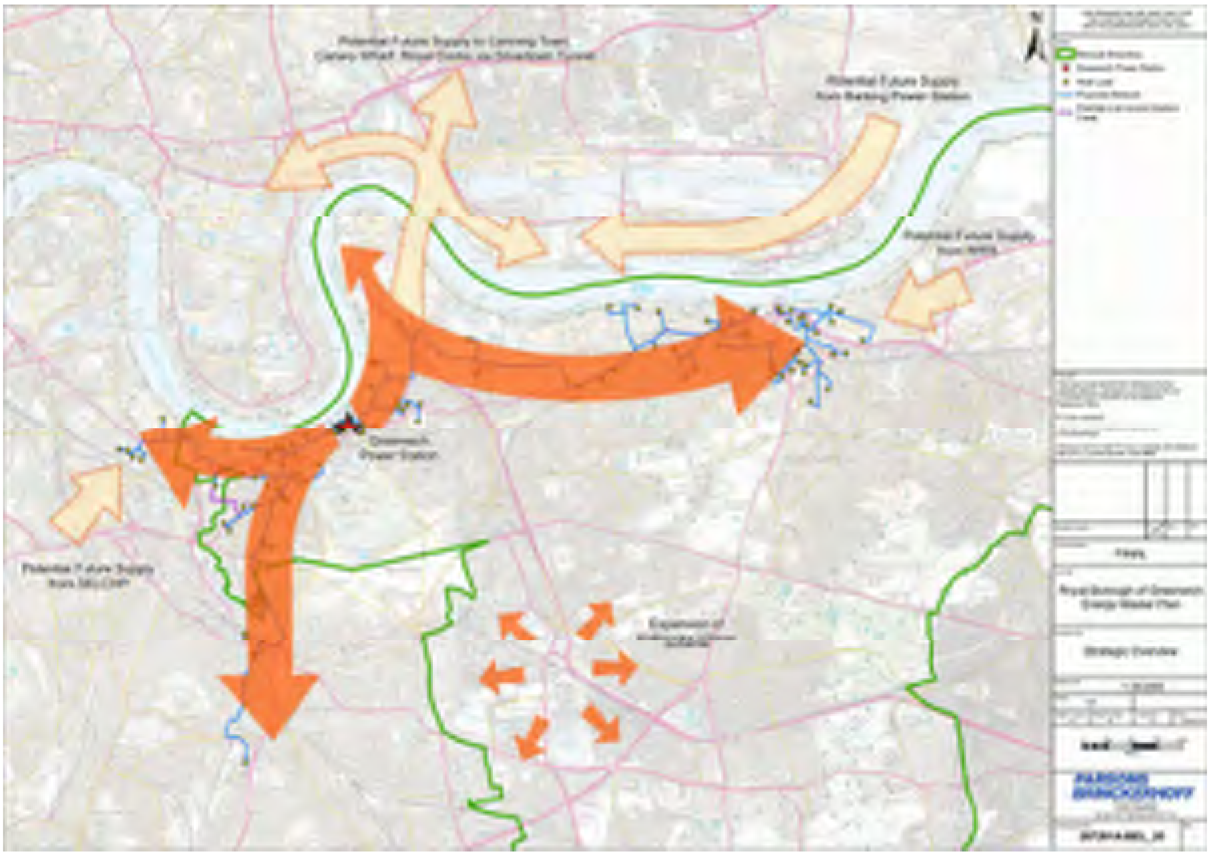
1.4.2 It should be noted that there are some existing district heating schemes within the borough. These are:

- Kidbrooke
- Greenwich Millennium Village
- Greenwich Peninsula
- Royal Arsenal, Woolwich

1.4.3 The long-term vision for the borough, based on development projections, consideration of existing DH systems, and known existing loads is illustrated below.

- 10 -

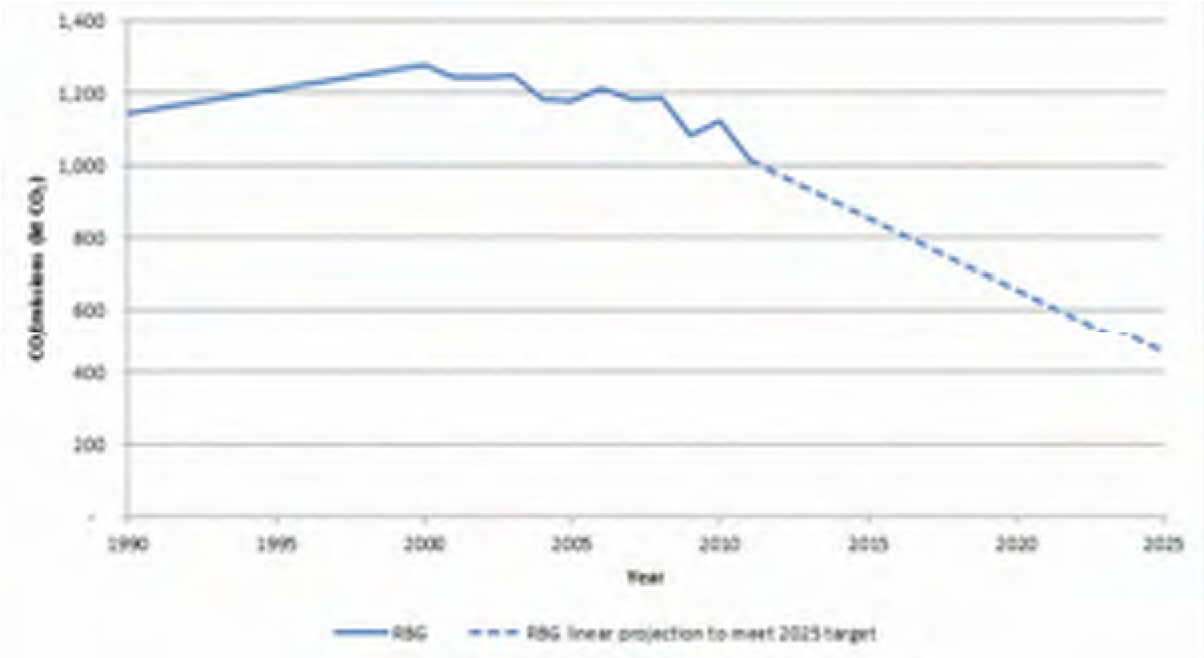
Figure 1-1 Long-term strategic vision for DE within RBG



1.5 Achieving targets

1.5.1 Greater London as a whole, and RBG as a constituent part of the region, has a duty to deliver carbon emissions savings. The London Mayor's target is to achieve a 60% reduction on a 1990 baseline by 2025, and for 25% of energy to be supplied by decentralised energy by the same date. Further emissions reductions will then be required to 2050 in order to contribute towards national targets. The following graph illustrates the Royal Borough of Greenwich's historical emissions and a potential emissions reduction trajectory, based on a straight-line interpolation from recent recorded emissions levels to achieve the 2025 emissions reduction target.

Figure 1-2 RBG emissions reductions required to 2025 (PB, based on published 1990 emissions)



1.5.2 This figure illustrates that a saving of approximately 459,000 tonnes CO_2 p.a. will be required by 2025 to meet the Mayor's target for the borough. The schemes identified in this report are calculated to have the potential to save 15,000tCO_2 p.a., leaving a shortfall of 445,000tCO_2 p.a. to be met through other initiatives, such as improved insulation roll-out programmes, grid decarbonisation, etc. This highlights the depth and extent of emissions reductions required, albeit a significant element of this would be anticipated to be delivered by decarbonisation of the energy supply system.

1.6 How should expansion be pursued?

1.6.1 The recommended phasing of delivery of schemes across the borough is as follows – broadly representing a number of smaller, kick-start networks that can be developed to coalesce into a more extensive strategic scheme:

Table 1-1 Scheme phasing

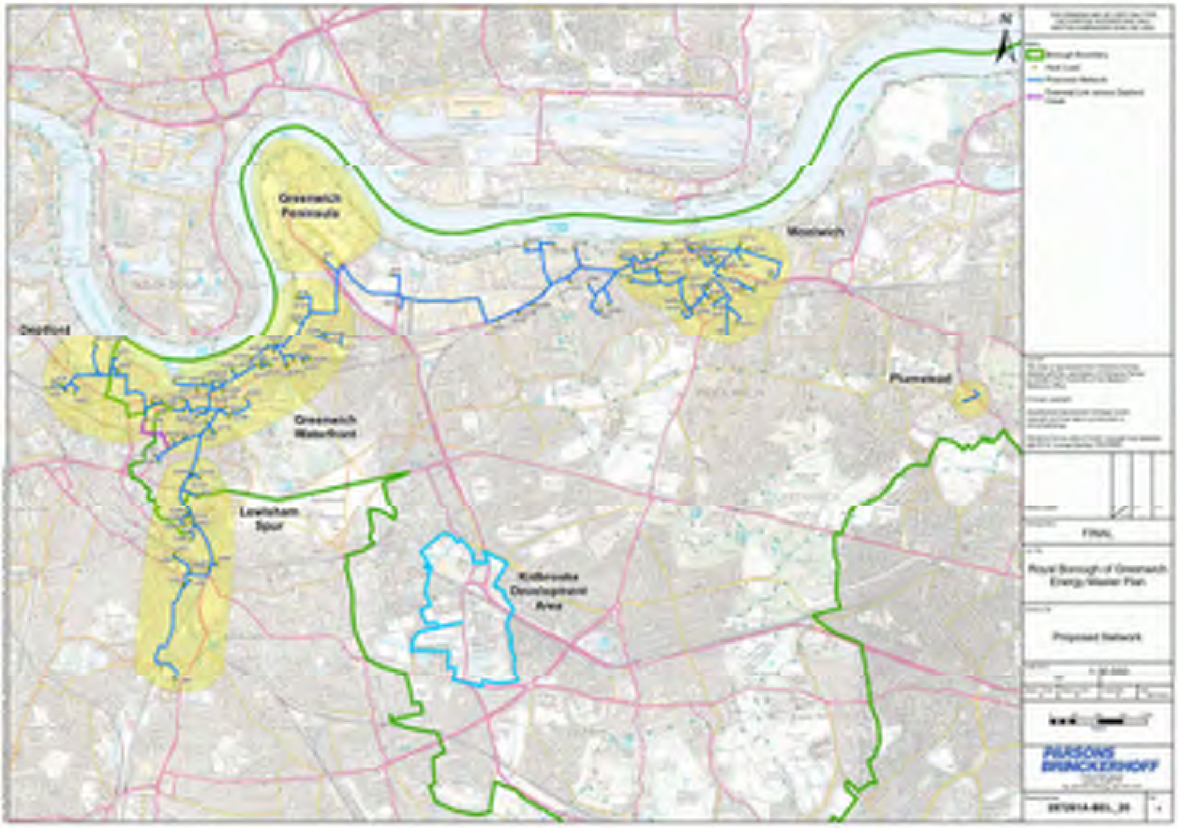
Approximate date of implementation	Scheme
2015	Plumstead scheme (if considered to have sufficient future potential for expansion). - This is a stand-alone network that is not anticipated to link to other schemes under current development projections.
2016	Greenwich Waterfront kick-start scheme - This is envisaged to entail an initial heat pump phase followed by larger gas-fired CHP installation linked to key developments at Lovell's and Enderby's Wharf (this scheme is anticipated to be developed as a future-proofed first phase of the full, strategic network outlined below)
2018-2020	Woolwich – linked to new developments of the Bath Quarter, Connaught

- 12 -

	Estate (kick-start phased based on gas-fired CHP)
2020-2025	Deptford – linked to the Convoy's Wharf development predominantly
2030-2035	Full strategic linking network - to be established based on supply from Greenwich Power Station generation units when the kick-start scheme CHP units installed as part of the networks listed above (and also those within the Greenwich Peninsula) are at the end of their useful life

1.6.2 The location of these schemes is illustrated in the image below.

Figure 1-3: Kick-start networks and wider strategic scheme



1.6.3 Alongside these individual new schemes, RBG should ensure that any significant planning applications coming forward in the areas surrounding existing DH schemes – in particular Kidbrooke Village – are made DH-ready (i.e. operating at appropriate temperatures and with identified points / space provision for connection to a DH network). This will ensure that opportunities emerge for the expansion of DH as a critical mass of 'enabled' properties is delivered.

1.7 Delivery

1.7.1 A large-scale, potentially cross-borough network as outlined in this masterplan will require a strategic guiding body to ensure that its constituent kick-start elements are developed appropriately. For this reason it is recommended that RBG take an active lead role in developing this system. This means both investing in the infrastructure and taking on financial risk (i.e. early investment in the scheme where payback is dependent upon future, unsecured heat-sales), and also committing to the project in terms of long-term heat purchase arrangements, to provide the delivery vehicle with a degree of income certainty.

1.7.2 The vision outlined in this report is for the borough to take on a lead role particularly in the early stages of the network development when there is a greater level of risk, but where this risk is largely within the public sector's gift to manage. This approach will protect the strategic scale of the project (i.e. preventing smaller, piecemeal schemes being developed in isolation), and lead to a situation where a de-risked project can then be sold to the market at a later phase of development.

1.7.3 In planning terms, many of the policies required to deliver DH are already in place; the London Plan's energy hierarchy, the Greener Greenwich SPD, the Greenwich Climate Change Strategy and Action Plan, the draft Core Strategy and the Unitary Development Plan all support the installation of district heating. It should therefore be recognised that it is in the *implementation* of these policies that a robust approach must be adopted. This implementation should also adhere strictly to the *District Heating Manual for London's* principles and recommendations.

1.8 Conclusions

1.8.1 The high level of regeneration and development planned within RBG over the coming years represents a significant opportunity for the implementation of district energy.

1.8.2 Greenwich Power Station represents a unique physical asset for the borough and the wider surrounding area, and it would be a missed opportunity if the confluence of TfL's interests and the quantum of neighbouring development cannot lead to a system that generates long-term benefits for all parties.

1.8.3 Centralising supply of heat will enable the use of alternative fuels or secondary heat sources. The GPS has a wharf and access to the Thames, attributes that could help the use of biomass as a fuel source and/or heat pumps taking energy from the river.

1.8.4 Given the largely residential and relatively diffuse spread of buildings within the borough, decentralised energy schemes have been proposed within this masterplan that only address a small portion of the overall built environment. The schemes identified in this study are predominantly in the waterfront areas where the higher accessible heat demand densities allow more viable schemes to emerge. Decentralised energy as a result can only deliver savings in a small portion of the borough, leaving significant carbon savings to be delivered through other means.

1.8.5 Financial analyses were carried out for the schemes outlined in Table 1-1 over 25 and 40 year timeframes. The following items of expenditure were considered:

- Capital expenditure (CAPEX)
- Replacement expenditure
- Maintenance and on-going costs

1.8.6 Income is derived from heat and electrical sales, with the latter considered both on a sale to grid and sale to private wire network basis. Utilities prices are assumed to increase in line with DECC price projections. Heat sales values are priced on the

- 14 -

basis of offering customers a 5% reduction against their ‘business as usual’ costs projected into the future.

1.8.7 A whole life discounted cashflow calculation of the ‘funding gap[2]’ for the identified schemes in the borough is £13m (for a 25 year period).

1.8.8 The following table illustrates some parameters for the schemes identified.

Table 1-2 Key parameters of identified schemes

	Scheme 1	Scheme 2	Scheme 6	Scheme 8	Full Scheme
	Plumstead	Woolwich	Greenwich Waterfront	Deptford	
Technical parameters					
Annual heat demand (excl. losses) (kWh p.a.)	810,252	44,410,095	56,230,337	22,233,892	247,356,799
Peak heat demand (MWth)	1	42	65	6.5	220
Total network length (m trench)	249	7,598	8,739	2,709	30,484
Financial parameters					
Network capital cost	£251,000	£9,440,000	£12,298,000	£3,455,000	£43,887,000
Scheme capital cost	£886,000	£3,834,000	£16,525,000	£5,441,000	£59,066,000
Carbon performance (tCO2 saving to 2034)					
Carbon savings up to 2034	804	59,534	89,976	40,302	
Carbon savings for full scheme 2035-2055 (tCO_2)					499,686
Linear heat density (MWh / m network)	3.25	4.47	6.10	7.59	7.16

1.9 Recommendations/ next steps

- The strategic recommendation of this report is to centralise the generation of heat and power to the Greenwich Power Station in the long term, by means of an extensive DH network linking heat demand nodes. This will allow for significant scale (and concomitant efficiencies and economies) of combined heat and power generation. This location will also allow the central plant operation to benefit from the existing power station infrastructure including its utility connections.

- Protection of a strategic district heating link to Royal Docks and Canary Wharf areas is strongly recommended as part of the Silvertown tunnel works (should this road project be taken forward). Two major energy centres south of the Thames in the form of the GPS and the energy centre on the Greenwich Peninsula are coming forward, and the loads around Canning Town, the Royal Docks and Canary Wharf represent major load centres with high heat densities. The potential to link these demands and heat generation centres should be enabled at the time of the tunnelling works across the river. Given the infrequency of opportunities of this nature to install DH pipework, it would be recommended that this strategic infrastructure is installed with at least 500mmNB DH pipework.

- The Plumstead scheme as identified in this study only delivers marginal operational income. It is recommended that RBG consider the likelihood of

[2] Defined here as the funding required in the first year of the appraisal period to deliver a zero net present value (over 25 years) across the combined cumulative cashflow of all proposed schemes.

further development coming forward within close proximity (and within a reasonable time-scale) of this scheme, as additional heat loads are required to render this opportunity worth pursuing. On the basis of the currently identified heat demands, it is recommended that this scheme is not pursued.

- It is recommended that new decentralised energy schemes are pursued at Greenwich Waterfront, Woolwich and Deptford.

- RBG should hold internal and external facing discussions, including liaison with HNDU / DECC in order to establish what form a suitable delivery vehicle might take for the implementation of both early phase schemes and a wider strategic, longer-term linking network.

- Liaise with the London Borough of Lewisham to evaluate the potential for joint-working both in Deptford (SELCHP), and to assess a long-term link to Lewisham Hospital (which would require conversion to LTHW to be compatible).

- Ensure that in the areas surrounding existing (and planned) DH schemes that developments coming forward are made DH-ready with immediate effect. This should allow a critical mass of DH-compatible development to be tracked, and for RBG to highlight potential opportunities to incumbent scheme operators.

- Should alternative proposals for energy generation plant adjacent to Belmarsh Prison come forward, this plant should be obliged to supply (heat and potentially power) to Belmarsh Prison or demonstrate why this is not feasible.

- RBG should engage with the prospective developers of the Morden's Wharf site, Energy10, and the Environment Agency in order to evaluate whether a waste pyrolysis plant may form part of the supply mix moving forward in Greenwich.

- RBG should engage with English Heritage and Unesco World Heritage in order to establish the processes that will be required to implement a DH system within the boundaries of the Royal Naval College or surroundings.

- 16 -

SECTION 2

INTRODUCTION

2 INTRODUCTION

2.1 Aims and scope

2.1.1 Parsons Brinckerhoff was commissioned by the Royal Borough of Greenwich (RBG) to produce an energy masterplan for the borough, in particular identifying areas where district heating networks could be implemented. The use of decentralised energy networks has the potential both to reduce carbon emissions and also alleviate fuel poverty within the borough.

2.1.2 The masterplan is driven by Transport for London's (TfL) plans to develop Greenwich Power Station. This currently provides back-up electricity to the underground network, but TfL aspires to make greater use of this resource, with the preferred option being a combined heat and power system supplying heat to local dwellings and commercial premises, whilst simultaneously supplying power to the Tube system.

2.1.3 There is a requirement in this study to specifically focus on the regeneration areas within the borough – these are chiefly located in the north of the borough near the Thames, and include Abbey Wood, Thamesmead, Greenwich Peninsula, Charlton Riverside and Woolwich. Consideration is also given to those parts of Deptford in the neighbouring borough of Lewisham. One rationale for this focus in the study is that there is a specific requirement within the RBG Core Strategy for new developments greater than 500 square metres or five dwellings to either connect to a local district heating network, develop a site wide heat network or to be district heating network compatible to allow connection in the future. Thus areas where significant new development is planned are areas where there is greater likelihood for the successful implementation of schemes.

2.1.4 In addition, district heating networks which currently exist within the borough comprise:

- Kidbrooke
- Greenwich Millennium Village
- Greenwich Peninsula
- Royal Arsenal, Woolwich

2.1.5 The required outcomes for the study that addresses a 40-year timeframe are:

- *To provide an overarching strategy which quantifies the potential for one or more district heating solutions for the north of the borough, following the riverfront from Deptford in the west to Thamesmead and Abbey Wood in the east*
- *To identify the most effective/efficient network solution for the utilisation of the GPS as a heat source*
- *To include recommendations as to how this work could be phased*
- *To highlight and comment on EMPs, studies and opportunities in neighbouring boroughs.*

- 19 -

SECTION 3

POLICY BACKGROUND

- 21 -

3 POLICY BACKGROUND

3.1 Introduction

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

3.2 Climate Change Act

3.2.1 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.

3.2.2 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.

3.3 UK Government energy policies and incentives

3.3.1 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 3-1: Polices and incentives in place to support heat networks

Policy	Detail
Energy Company 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.

- 23 -

Table 3-2: 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.

- 24 -

3.3.2 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.

3.3.3 The report suggests that the 2050 carbon emissions reduction target is likely to require a reduction in building emissions to near zero by 2050, together with up to a 70% reduction in emissions from industry – the majority of these are heat related.

The Future of Heating – Meeting the Challenge[3]

3.3.4 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.

3.3.5 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.

3.3.6 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

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

- 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.

3.3.7 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.

3.3.8 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."

3.4 Regional and local energy policies

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

The London Plan[4]

3.4.2 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 Guidance (SPG)[5]

3.4.3 SPGs provide further detail on policies in The London Plan where detailed guidance is required to support implementation. The London Plan SPG that is most relevant to planning for decentralised energy is the Sustainable Design and Construction SPG (adopted by the Mayor in April 2014), which includes emission standards for CHP and biomass installations. In addition to advising of standards this document also directs the reader to additional resources where required.

Climate Change Mitigation and Energy Strategy (CCMES)

3.4.4 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.

[4] http://www.london.gov.uk/priorities/planning/london-plan
[5] http://www.london.gov.uk/priorities/planning/supplementary-planning-guidance

- 26 -

London Heat Map and District Heating Manual[6]

3.4.5 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.

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

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

3.4.8 Also published by the Decentralised Energy Project Delivery Unit (DEPDU) is the London Vision Map – showing identified future opportunities for district heating networks. This is reproduced below.

[6] http://www.londonheatmap.org.uk http://www.londonheatmap.org.uk

- 27 -

Figure 3-1: DE vision map for London

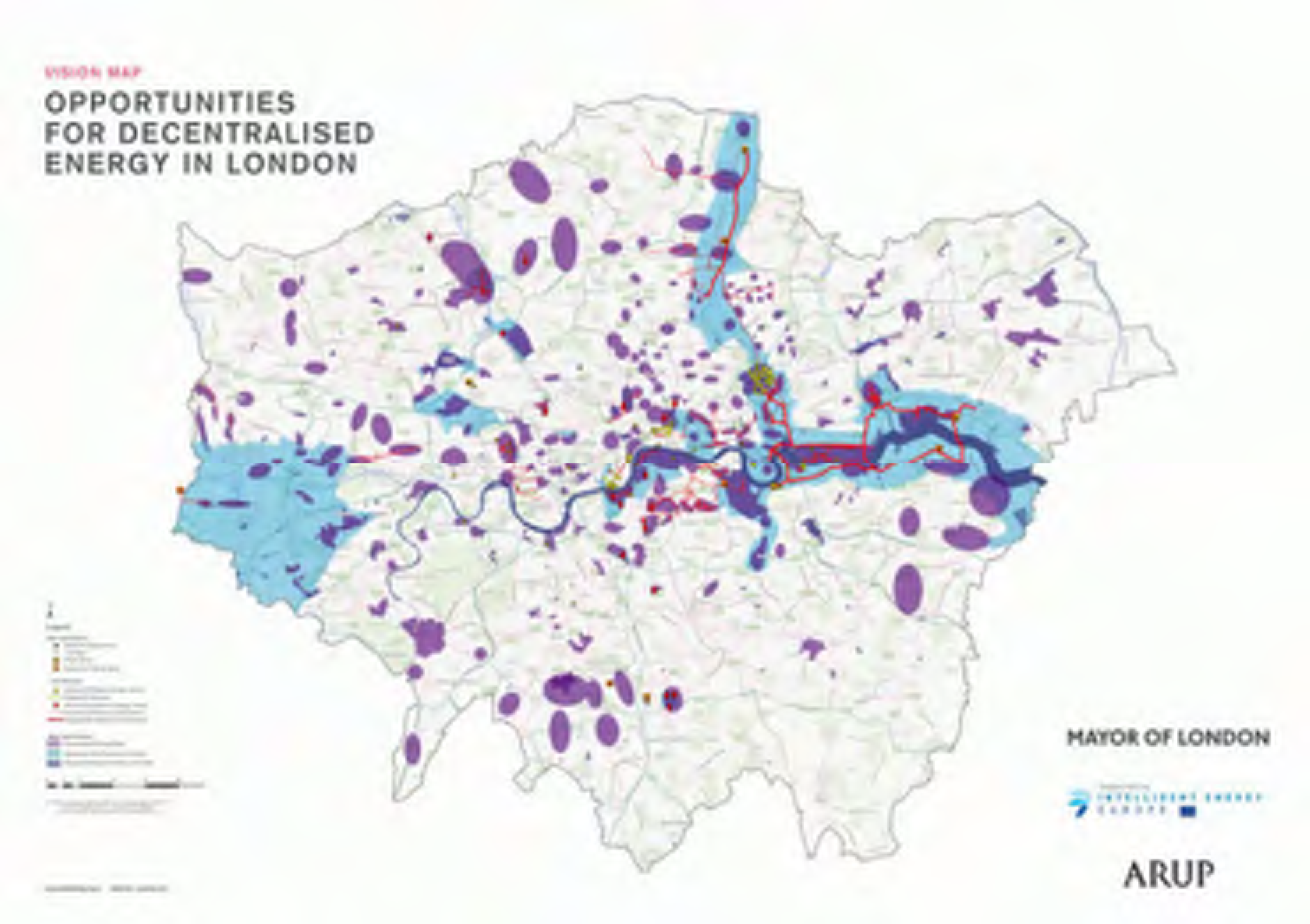
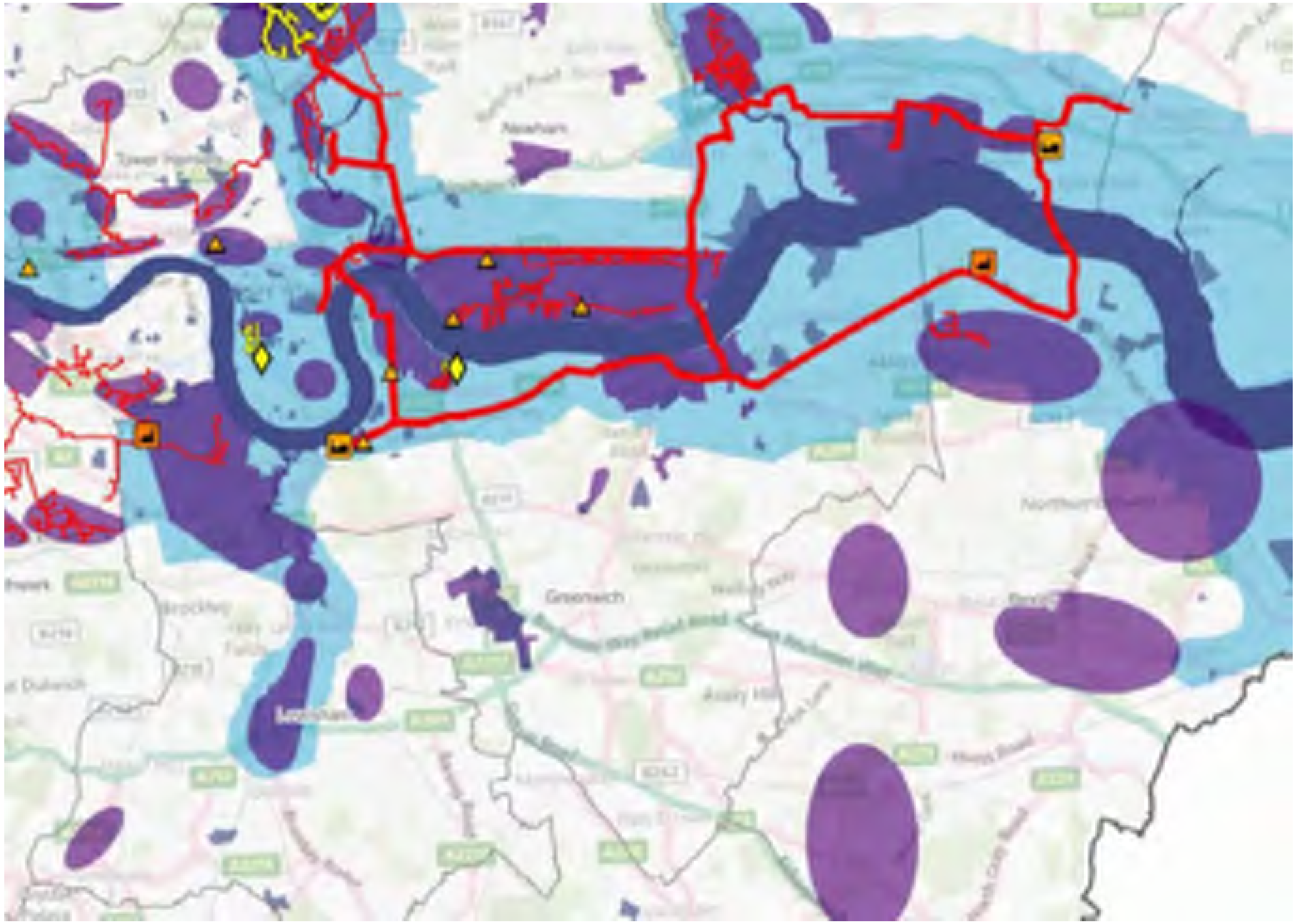


Figure 3-2: Vision map – focus on Greenwich



- 29 -

3.4.9 As can be seen, there are two main identified district heating routes within Royal Greenwich – one towards the north, travelling east to west, the second running the length of the Greenwich peninsula. These routes correspond broadly to the identified areas of significant development within Royal Greenwich. The routes join up to Greenwich Power Station (GPS). A further key element of this aspirational map is to note the key river crossings that link Royal Greenwich with Newham and thence, potentially, Barking.

Royal Greenwich Local Plan: Core Strategy with Detailed Policies (July 2014)

3.4.10 The Royal Greenwich Local Plan (the 'Core Strategy') includes the environmental and energy strategy as related to planning decisions within Royal Greenwich. Policy E1 on carbon emissions states:

Carbon emissions will be reduced in accordance with the Mayor's energy hierarchy by:

i. *First, requiring all development to reduce demand for energy through its design (Be Lean);*

ii. *Second, requiring all developments, with a gross floor area greater than 500sqm, or residential developments of five or more units, to connect to an existing decentralised energy network. Where this is not available a site wide decentralised energy network is required. Where it is demonstrated that a site wide energy network is unfeasible and/or unviable, developments will be required to provide sufficient infrastructure to enable a connection to a decentralised energy network for immediate or future use (Be Clean);*

iii. *Third, supporting the incorporation of renewable energy generation within development proposals (Be Green).*

All major development proposals will require an energy assessment.

3.4.11 The document includes supporting paragraphs to the above policy, and further states: the Royal Borough will assess how it could develop a larger centralised system that could serve the heat and power needs for a large geographical area. There are currently CHP systems at the Glyndon Estate, Royal Arsenal, Greenwich Peninsula and the Eltham Centre.

3.4.12 Policy E(c) sets out requirements for large developments to minimise the impact of air pollutants by reducing CO2, PM10 and NO2 emissions, and to comply with London Plan policy 7.14 on improving air quality.

3.4.13 In addition, Policy H5 Housing Design set out, in part xii, that the achievement on an 'excellent' BREEAM rating is expected for new development, redevelopment, refurbishment or conversions of housing.

3.4.14 Paragraph 4.6.6 of the Core Strategy states:

"The Royal Borough is committed to tackling climate change and reducing carbon dioxide emissions. The Royal Borough's Climate Change Strategy aims to achieve this by reducing demand for energy, increasing energy efficiency and promoting the use of renewable energy technology in line with the energy hierarchy. All development should achieve carbon dioxide reductions in line with policy 5.2 of the London Plan."

- 31 -

Greener Greenwich Supplementary Planning Document[7] (SPD) (September 2014)

3.4.15 This SPD to the Core Strategy, recently adopted by the Royal Borough in September 2014, provides further guidance on sustainable design and construction matters, including energy, which is set out in chapter 3. This chapter includes guidance on each of the stages of the energy hierarchy, demonstrating how development can be designed to be energy efficient and reduce demand for energy. It also covers decentralised energy including combined heat and power, connecting to an existing network and biomass and includes guidance on renewable energy.

Royal Borough of Greenwich Climate Change Strategy

3.4.16 The use of implementation of district heating systems also forms a core part of the *Greenwich Climate Change Strategy and Action Plan.* It includes the following targets as related to CHP:

- Review the potential for thermal stores on council estates.
- Create a Heat Map of the borough
- Review potential for a borough-wide heat/CHP network.
- Review potential for energy delivery vehicle

Developments of 500m^2 floor space or 5 residential units or more are required to incorporate features to enable immediate or future connection to a CH/CHP/CCHP network, or to install a site-wide system.

Greener Greenwich Supplementary Planning Document (SPD)

3.4.17 The Greener Greenwich SPD[8], on which consultation was recently held, provides guidance on how new development within the borough should be designed and built in order to minimise its impact on the environment and achieve high standards of sustainable construction. The document examines energy, water, biodiversity, materials, waste, flood risk and pollution.

3.4.18 In relation to energy, the document looks follows the energy hierarchy of:

- Be lean
- Be clean
- Be green

3.4.19 CHP/ CCHP falls under “Be Clean”. The preferred order to the implementation of CHP is:

- *Connect to an existing C(C)HP network;*
- *Install a site wide C(C)HP network powered by renewable energy source;*
- *Install a site wide C(C)HP network powered by gas/hydrogen fuel cells accompanied by renewable energy;*

[7] http://committees.greenwich.gov.uk/ieDecisionDetails.aspx?ID=2837
[8] http://greenwich.limehouse.co.uk/portal/greener_greenwich_spd?pointId=2804137

- 32 -

- *Install a communal heating and cooling system powered by renewable energy; and*
- *Install a communal heating and cooling system powered by gas*

3.4.20 A feasibility and viability assessment is advised where a new development is within 1km of an existing heat network, or where this is proposed and likely to be implemented within three years.

- 33 -

SECTION 4

PROJECT RATIONALE

4 PROJECT RATIONALE

4.1.1 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

4.1.2 Emissions for 2011 for the 33 London boroughs are set out within the *London Energy and Greenhouse Gas Inventory 2011* (LEGGI 2011)[9]. The document also sets out overall London emissions going back to baseline 1990 levels.

4.1.3 As well as the headline emissions reduction target for London of a 60% reduction in emissions based on 1990 levels by 2025[10] there are also interim targets; these are summarised in the table below:

Table 4-1 GLA emissions reduction targets

Target year	Target CO_2 emissions reduction on 1990 levels
2015 (interim target)	20 per cent
2020 (interim target)	40 per cent
2025	60 per cent
2050	At least 80 per cent

4.1.4 An estimation of the reductions which need to be achieved within the RBG is set out in the following table:

Table 4-2 Estimated required RBG emission reductions as a contribution to the Mayor's targets (sources as above)

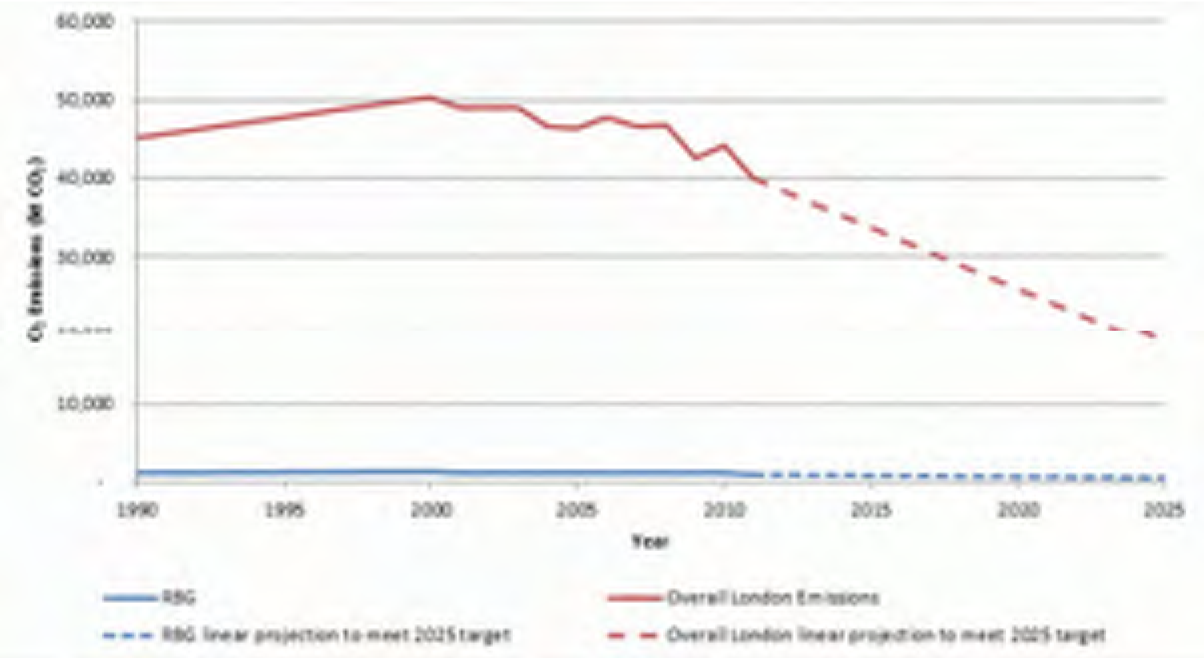
2011 RGB level	1,016	ktonnes CO_2 p.a.
2011 total emission	39,905	ktonnes CO_2 p.a.
% emissions from RBG	3%	
Overall London 1990 level	45,054	ktonnes CO_2 p.a.
RBG estimated 1990 level	1,147	ktonnes CO_2 p.a.
60% reduction by 2025 (RBG)	459	ktonnes CO_2 p.a.

4.1.5 The targets outlined in these tables above are illustrated graphically on the following charts – both for London and extrapolated for RBG as a borough – assuming that its contribution to emissions reductions is in line with its proportion of total emissions.

[9] http://data.london.gov.uk/datastore/package/leggi-2011
[10] https://www.london.gov.uk/sites/default/files/Energy-future-oct11-exec-summ.pdf

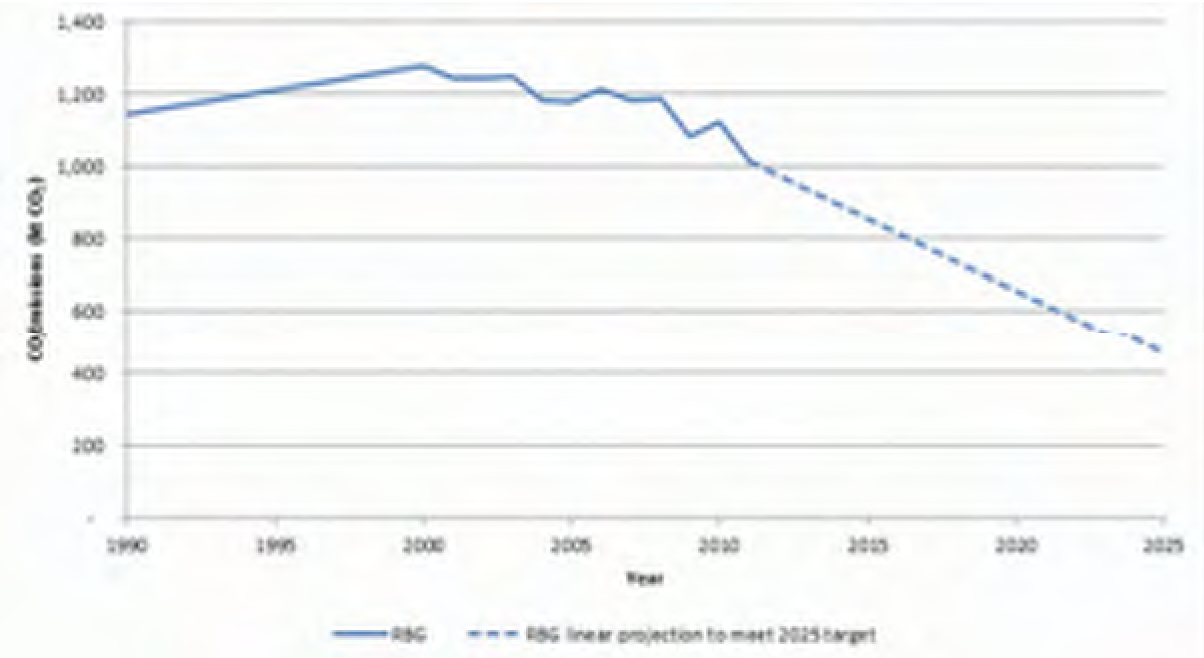
- 35 -

Figure 4-1 London and RBG historic emissions and emissions projections to meet policy targets (PB)



4.1.6 The RBG target in comparison to its baseline emissions is shown in more detail on the chart below:

Figure 4-2 RBG emissions reduction targets (PB)



4.1.7 The table above and this graph illustrate that a significant reduction in emissions is required over the next 10 years. It should be noted that these are not official targets or projections, but have been derived by PB from published figures as part of the work carried out as part of this commission. For example, the overall London emissions reduction target is, to PB's knowledge, not allocated to individual boroughs in any formal documentation.

4.1.8 There are a number of implicit assumptions in this linear projection – i.e. that emissions started to fall in linear fashion from the last recorded figures (2011), and that emissions reductions will be shared out 'equally' between the boroughs (i.e. in line with current emissions levels).

4.1.9 This report considers a 40-year timescale in terms of the roll-out of decentralised energy, albeit the development horizon is such that little is known about schemes that will come forward beyond the next 15 years or so.

4.1.10 The degree to which the implementation of decentralised energy schemes within the borough is able to play a role in the decarbonisation of energy supply is quantified in section 14.

- 37 -

SECTION 5

EXISTING DH NETWORKS AND ENERGY DEMANDS

5 EXISTING DH NETWORKS AND ENERGY DEMANDS

5.1 Existing heat networks in the borough

5.1.1 This section provides a summary of the district heating systems currently in place within the borough. This will allow the potential for these to be extended / connected to a wider customer base to be examined.

5.1.2 There are currently four district heating networks either in existence or being developed within the borough. These comprise:

- Kidbrooke Village (under development)
- Greenwich Millennium Village (operational)
- Greenwich Peninsula (under development)
- Royal Arsenal, Woolwich (operational)

5.1.3 The location of these sites is illustrated in the figure below.

Figure 5-1: Location of existing DH networks within RBG

- 40 -

Kidbrooke Village redevelopment

5.1.4 The Kidbrooke village redevelopment (Berkeley Homes) consists of approximately 4,800 residential units and 34,000m^2 of non-residential space[11]. A district heating system, with CHP, is being implemented.

Greenwich Millennium Village

5.1.5 The Peninsula masterplan includes two main areas: the Greenwich Millennium Village (GMV) to the south, and the Meridian Delta site to the north (around the O2). Both had some initial development in the early 2000s, stalled at the height of the economic crisis, and are once again making steady progress.

5.1.6 The GMV has made the most progress so far, with 1,100 homes completed in the mid-2000s; a further 1,750 homes had stalled but are back on track. GMV is planned to include 32% affordable housing, with one of the key developers being Bellway Homes.[12]

5.1.7 Initial phases of the GMV development have gas-fired CHP units installed.

Greenwich Peninsula development

5.1.8 Knight Dragon is developing the Peninsula area, and has appointed a subsidiary company, Pinnacle Power to provide, amongst other services, energy to the various plots of the site. The proposals are for a residential-led development with 10,000 homes and 2 million sq ft of non-residential usages. These will be constructed over a number of phases. Initial phases will be supplied with boiler-only heat, until a critical mass of heat demand is developed, at which point a centralised energy centre incorporating gas-fired CHP will supply the peninsula area with heat via an extensive DH network. At the time of writing this report (July 2014), a number of packaged boiler solutions were in place on site, and a tendering process is underway for the main centralised energy centre for the site (anticipated to be operational around 2016).

Royal Arsenal, Woolwich

5.1.9 The Royal Arsenal riverside development in Woolwich is supplied via a CHP energy centre owned and operated by Scottish and Southern Energy (SSE). The centre currently contains a 150kW$_e$/200kW$_{th}$ CHP, together with two 2MW boilers and a 70m^3 thermal store[13]. Expansion is planned to meet future phases of development; this would see the installed CHP capacity increased to 2.4MWe[14].

District heating networks in other boroughs

5.1.10 The opportunity could also exist to link with heat networks outside the borough. The main network in reasonable proximity, and which does not require a river crossing, (although still at some distance) is the Southwark low carbon heat network, which

[11] http://www.londonheatmap.org.uk/Content/uploaded/documents/Heat%20Map%20Report%20-%20Greenwich.pdf

[12] http://www.futureoflondon.org.uk/2013/04/26/beyond-the-o2-effect-greenwich-peninsula-site-visit/, accessed June 2014

[13] http://www.sseutilitysolutions.com/Services/Media.ashx?mid=27

[14] http://www.vitalenergi.co.uk/casestudies/royal-arsenal/

- 41 -

emanates from the SELCHP EfW facility in neighbouring Lewisham. A map of the route is illustrated in the figure below.

Figure 5-2: Route of Southwark low carbon heat network

Figure 5-3: Location of SELCHP in relation to Greenwich

5.2 Energy demand mapping principles

5.2.1 In order to identify areas for the potential for decentralised energy networks within the borough (and beyond), both the heat demands of existing buildings and proposed developments/ developments under construction were mapped.

5.2.2 The following data sources were used to determine the demands of existing buildings which could be candidates for connection to a future district heating network:

- Gas consumption data for council-owned, non-residential buildings and communally-heated social housing over the last three years.
- Heat loads from a recent study undertaken by Arup examining buildings which could be connected to a network fed from Greenwich Power Station.
- London Heat Map data

5.2.3 This data was prioritised in the order listed above, in order to allow the most accurate, up-to-date data to take precedence. An assumed boiler efficiency of 85% (as used by Arup in previous work) was used to convert gas demands to heat demands.

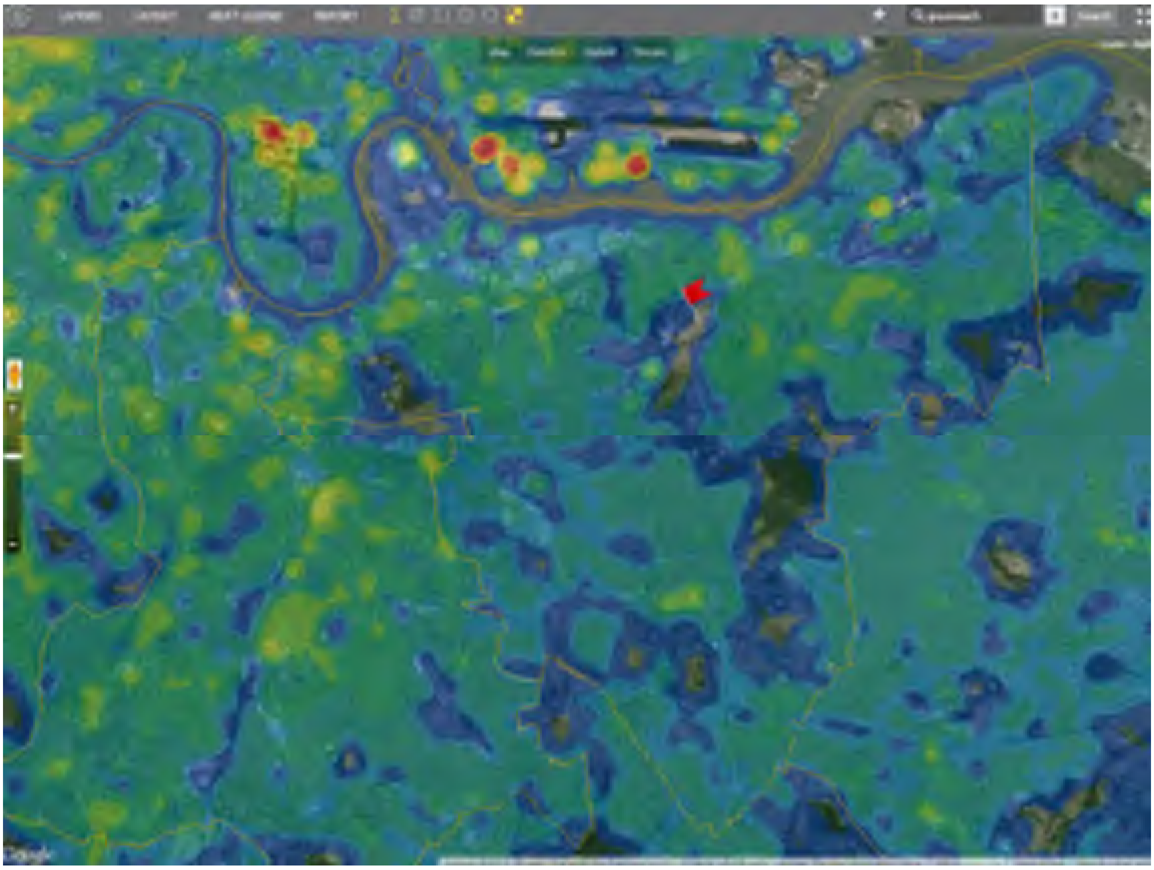
- 43 -

5.2.4 The following graphics illustrate the data on the National Heat Map[15] for the borough. These illustrations were used to cross-reference the demands that were identified through other means:

Figure 5-4 National map data illustration

[15] http://tools.decc.gov.uk/nationalheatmap/, accessed 20th June 2014

Figure 5-5 National Heat Map overall heat demand density



5.2.5 The data illustrated above show existing building information. It can be seen from these two figures that the demands of the borough are predominantly residential (over 95% residential by number of addresses, and over 75% by total heat demand). Figure 5-5 also shows that to the north of the Thames, there are areas of comparatively high heat demand density in the Royal Docks area, and also around Canary Wharf.

5.2.6 The masterplan analysis of this report also takes account of known future developments as described below.

5.2.7 The following sources were used to gather information about future developments and energy demands:

- Key Site Plan of major developments within RBG, as provided by the council
- Schedule of housing trajectory figures, as supplied by the council.

5.2.8 In order to generate heat demands for new developments, energy strategies/statements were retrieved, where available, from the RBG online planning applications system. Heat demand data was calculated in the following manner:

- Where estimated gas demand and boiler efficiency were provided, this was used to calculate building heat demand
- Where boiler efficiency was not provided, an assumed boiler efficiency of 92% was used

- Where Fabric Energy Efficiency was provided (units kWh/m^2/year), this was used in connection with dwelling area to calculate overall gas demand for heating, with benchmarked hot water demands added on to calculate overall heat demand.
- Where no energy demand data was available, the following benchmarks were applied:

Table 5-1 Residential space heating and domestic hot water benchmarks

Building type	Benchmarked floor area (m^2)	Benchmarked space heating demand (kWh/m^2/year)	Benchmarked DHW demand (kWh/year)
Studio flat	42	33	1341
1 bed flat	42	30	1608
2 bed flat	61	33	2140
3 bed flat	89	25	2672
4 bed flat	117	21	3204

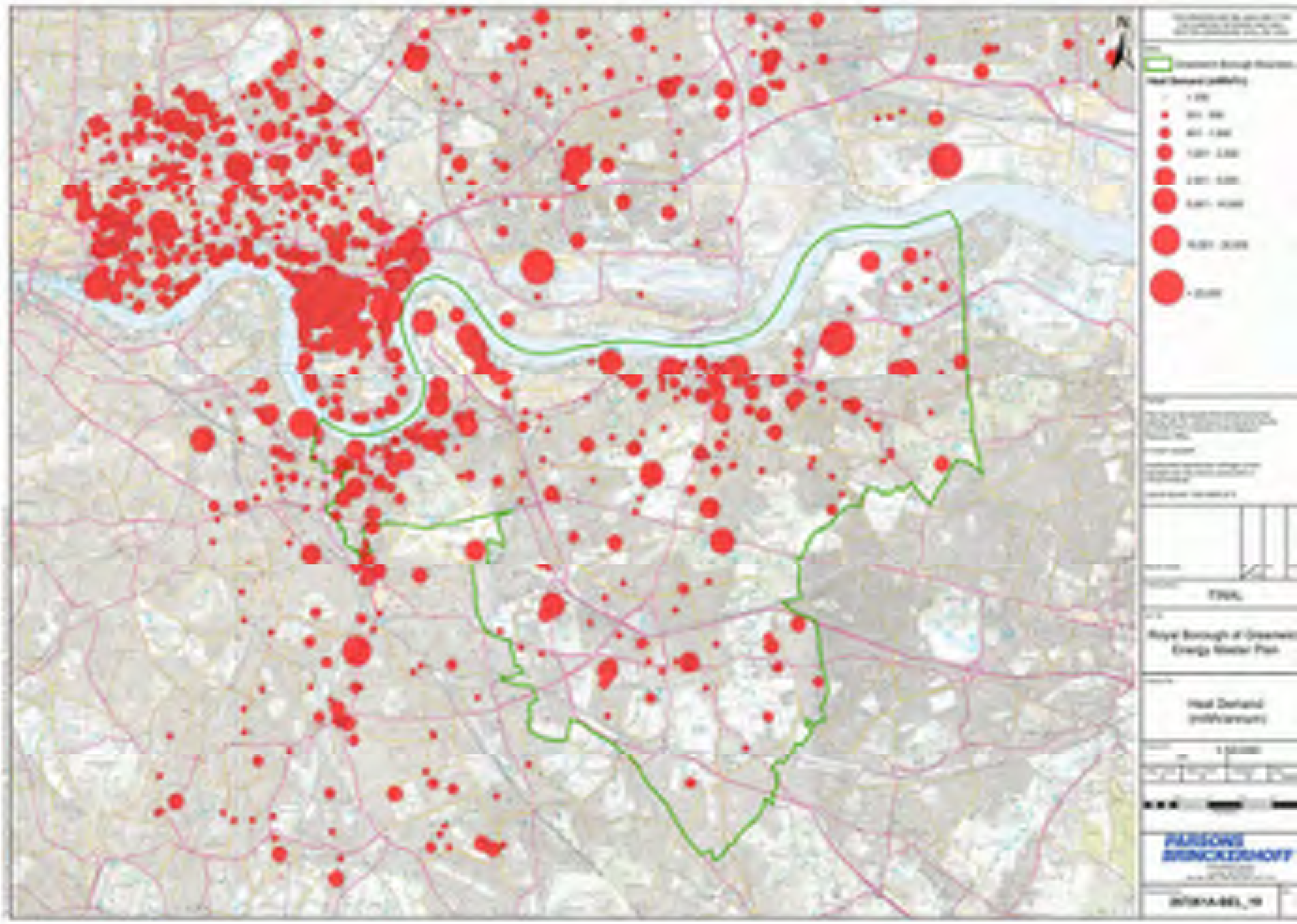
- For non-domestic loads, benchmarks were applied derived from CIBSE Guide TM46:2008.

5.3 Heat mapping

5.3.1 Calculated heat demands were mapped geographically in order to identify clusters of heat demand which could form the basis of a heat network.

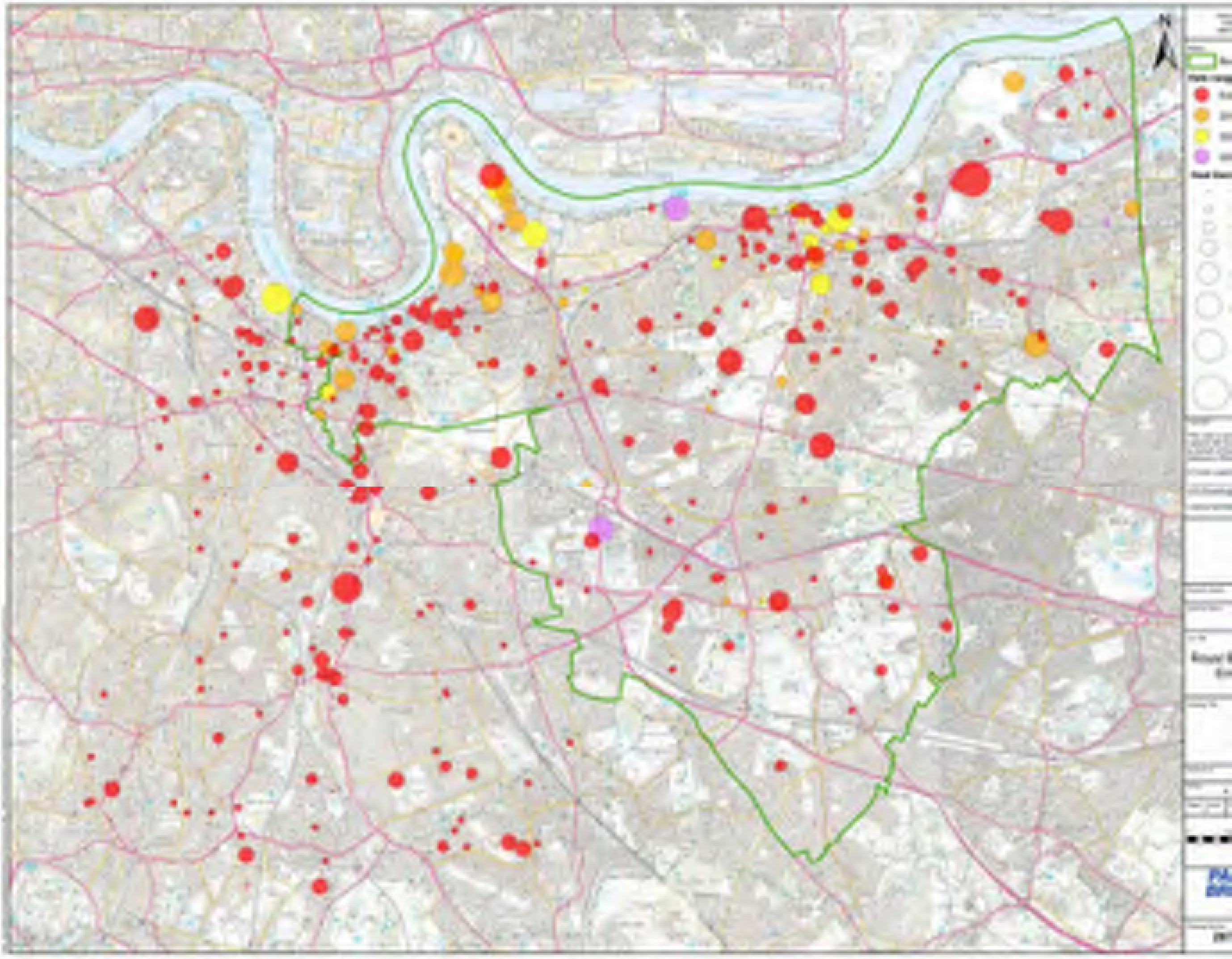
5.3.2 The figure below shows the initial heat mapping., with the size of each bubble representing the magnitude of the heat demand. Heat demands for the neighbouring boroughs are also plotted (neighbouring borough heat demands plotted from London Heat Map data only).

Figure 5-6: Initial heat mapping exercise



5.3.3 A following, more detailed heat map is plotted below. The size of each circle represents the magnitude of the heat demand, whilst the date range at which the load is expected to be available to connect to a potential district heating network is represented by its colour. Heat loads in the adjacent borough of Lewisham (taken from the London Heat Map) are also shown, as there is potential to link up with Greenwich. However, other boroughs have been left out, either owing to the absence of heat demand information (Bexley), or owing to the absence of connection routes (i.e. Tower Hamlets)

Figure 5-7: Initial heat mapping for RBG



5.3.4 In order to better assess the density and magnitude of heat demands, heat density contours (MWh/km^2) were plotted. For each load, an "area of influence" was used to identify nearby loads which could join up in a heat network. Two different radii were used – 750m and 500m. The resultant contours are plotted below.

Figure 5-8: Heat density 500m contours

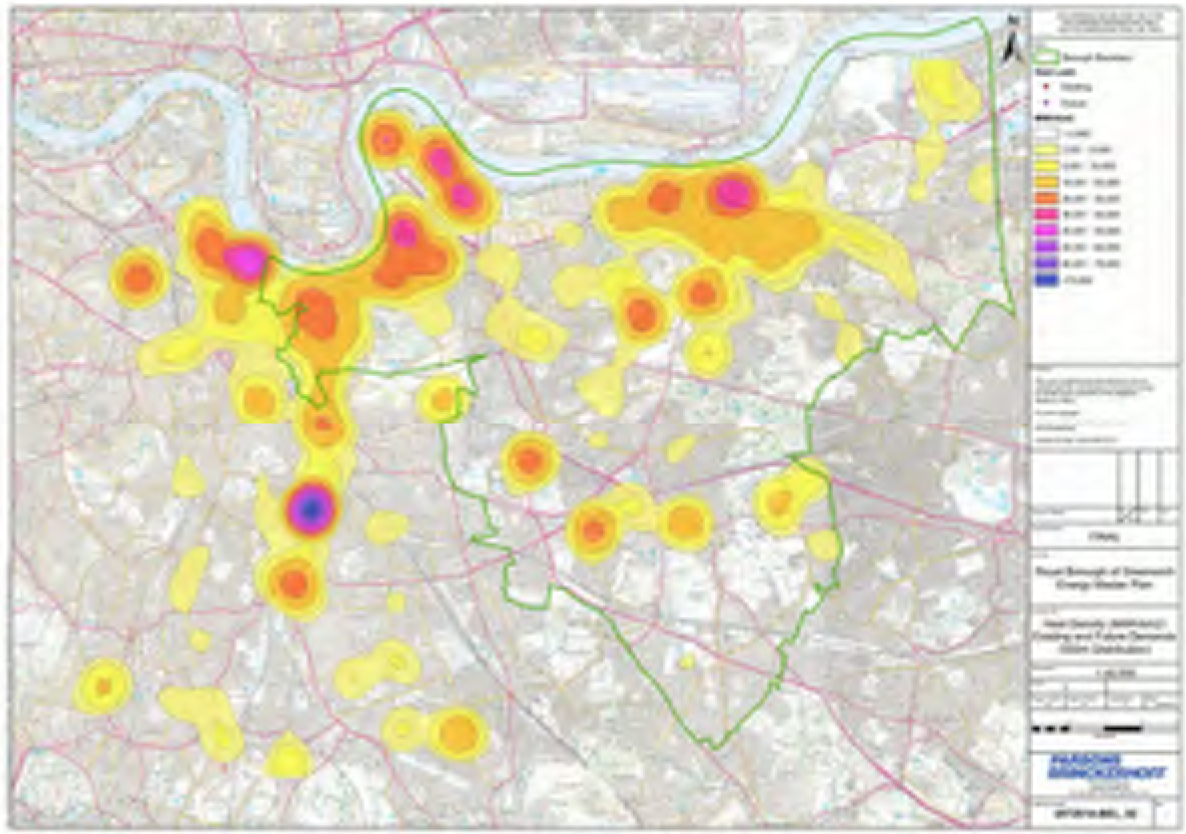
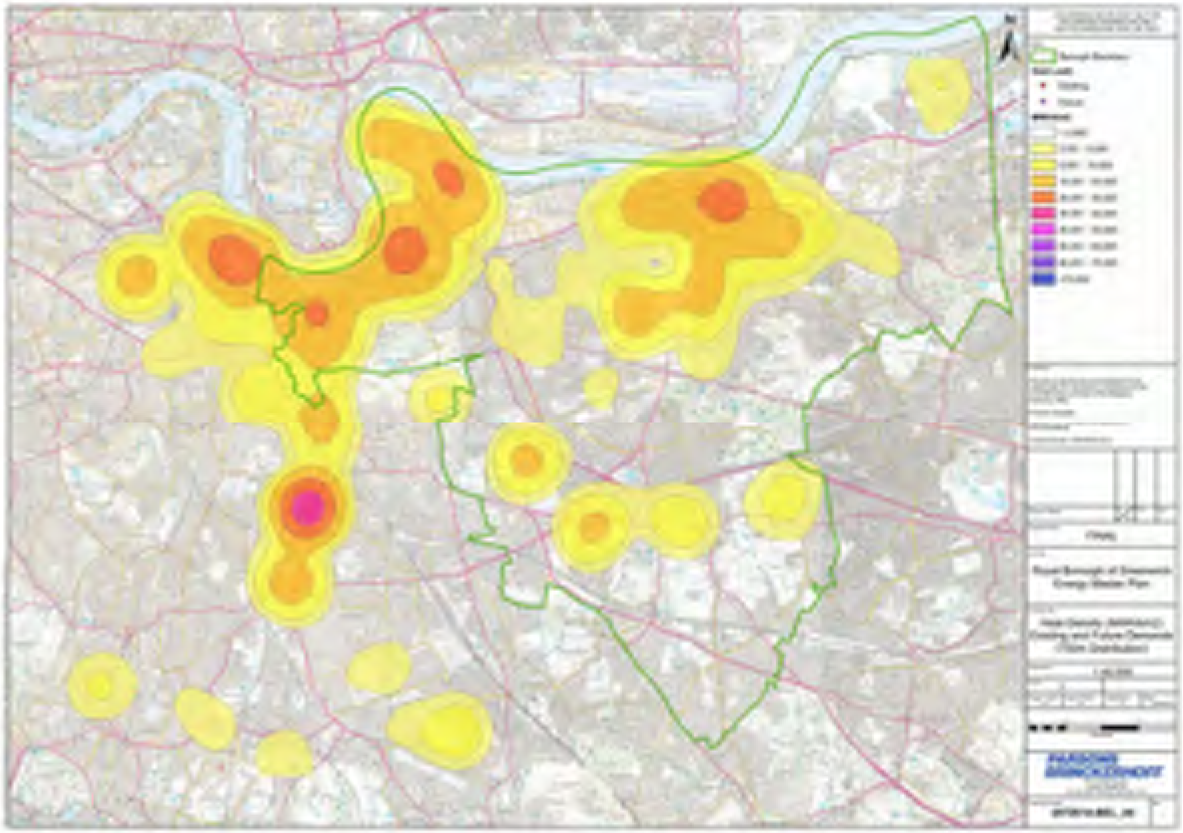


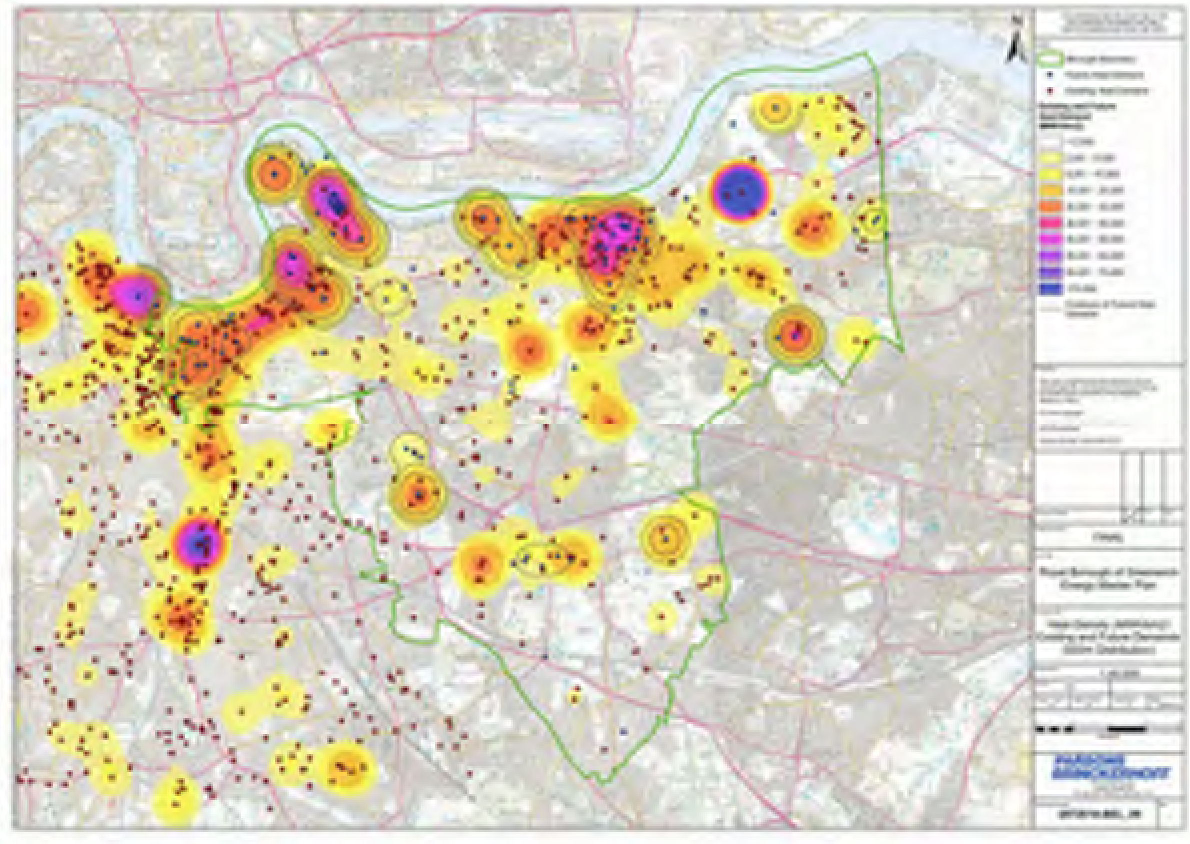
Figure 5-9: Heat density 750m contours



5.3.5 Heat networks within the borough of Greenwich are most likely to be "kick-started" through new developments. Regional and local policies require these to connect to, or have the ability to connect to, a district heating network in precedence over other individual solutions. In addition, new development is better able to install secondary systems– such as underfloor heating - that are more compatible with to heat supply via district heating than traditional radiator systems.

5.3.6 In order to analyse the influence of new development on scheme selection potential, one further set of contour maps was generated – this showing heat densities of future development within the borough. This was overlain on the heat contour map shown above – contours for new developments are shown as thin black lines. Significant areas of new development can be seen in the west of the borough, in the area around the Greenwich Peninsula, and around Woolwich.

Figure 5-10: Areas with high densities of new development overlain on total heat densities

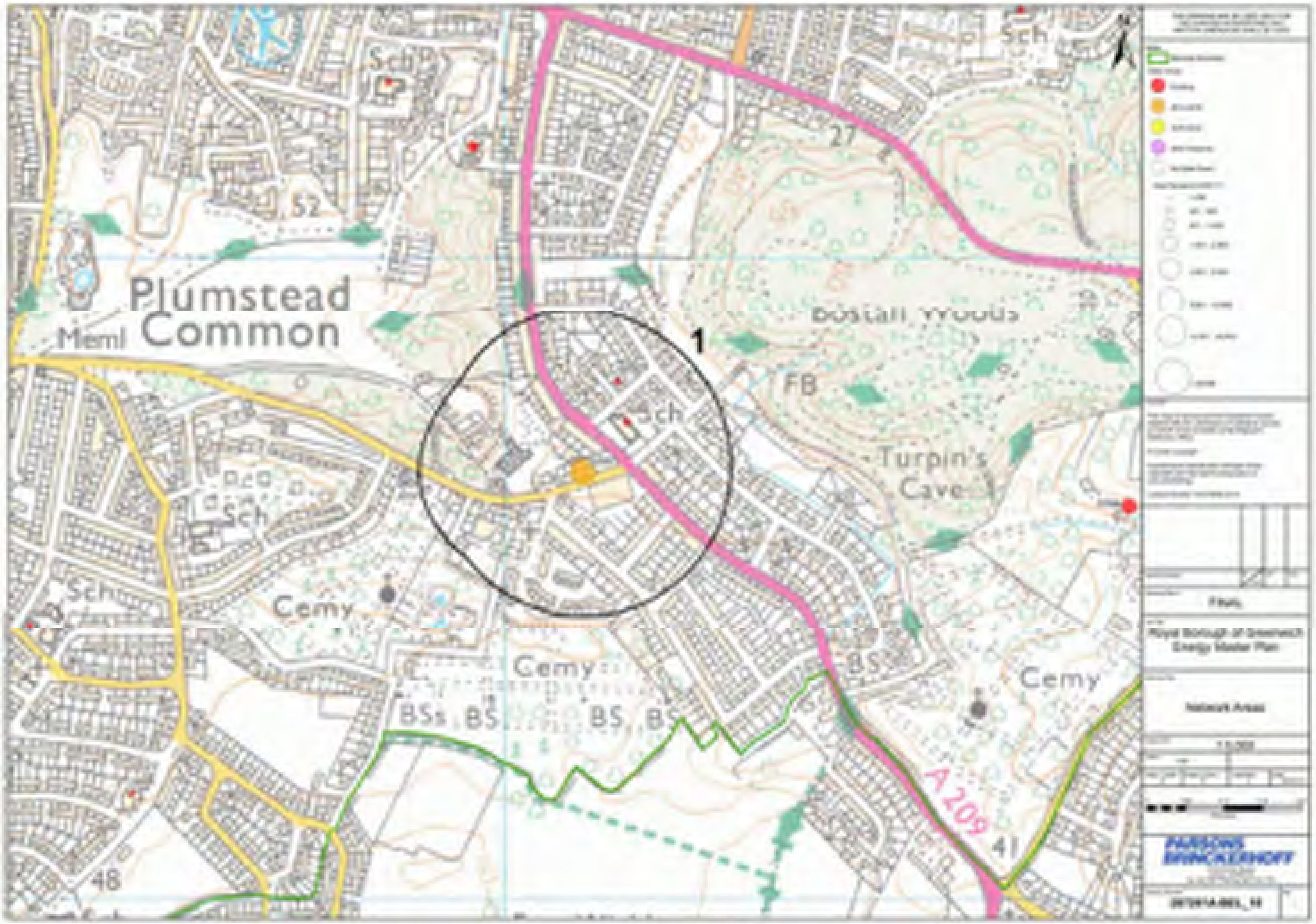


Following production of the maps, high heat density areas were identified as an initial selection criterion for clusters of loads to investigate the viability of district heating networks. A total of seven focus areas were identified, located in the following areas:

Scheme number	Scheme Name
1	Plumstead Common
2	Woolwich
3	Charlton
4	Kidbrooke
5	Greenwich Peninsula
6	Greenwich waterfront
8	West Deptford

5.3.7 These areas were subsequently analysed on a more detailed basis, looking at the individual loads making up each one:

Figure 5-11: Scheme 1: Plumstead Common



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- 52 -

Figure 5-12: Scheme 2: Woolwich

- 53 -

Figure 5-13: Scheme 3: Charlton

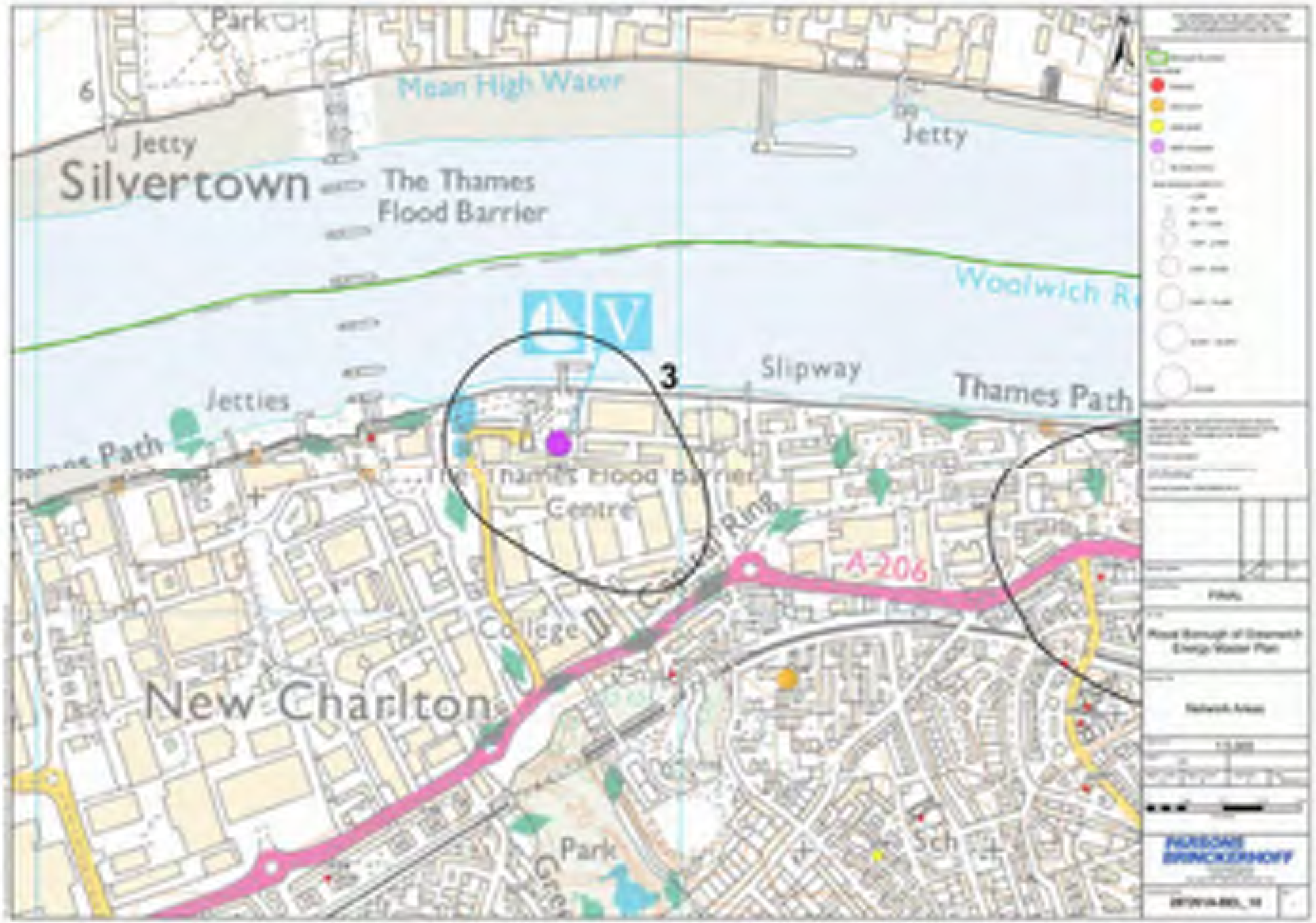
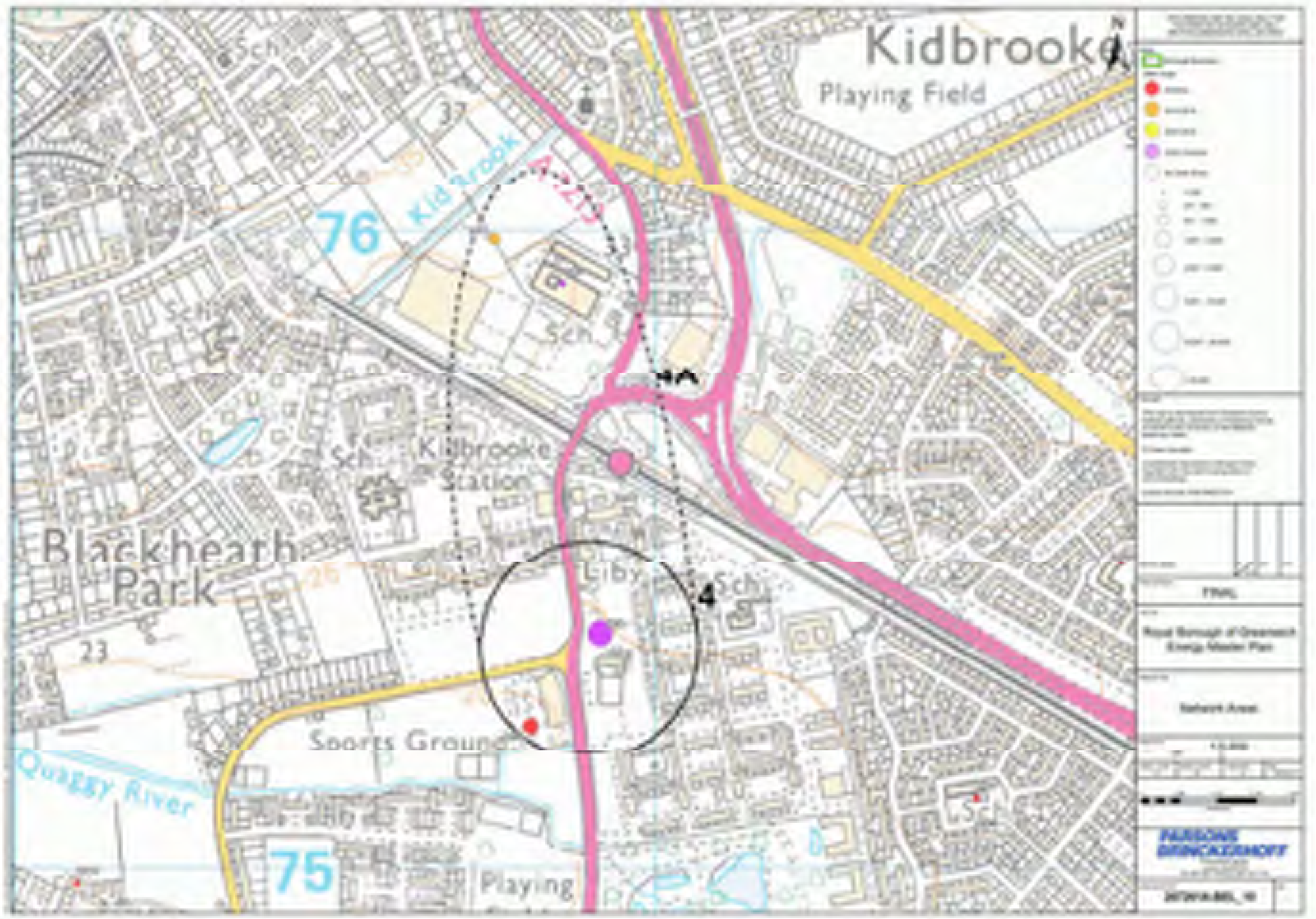
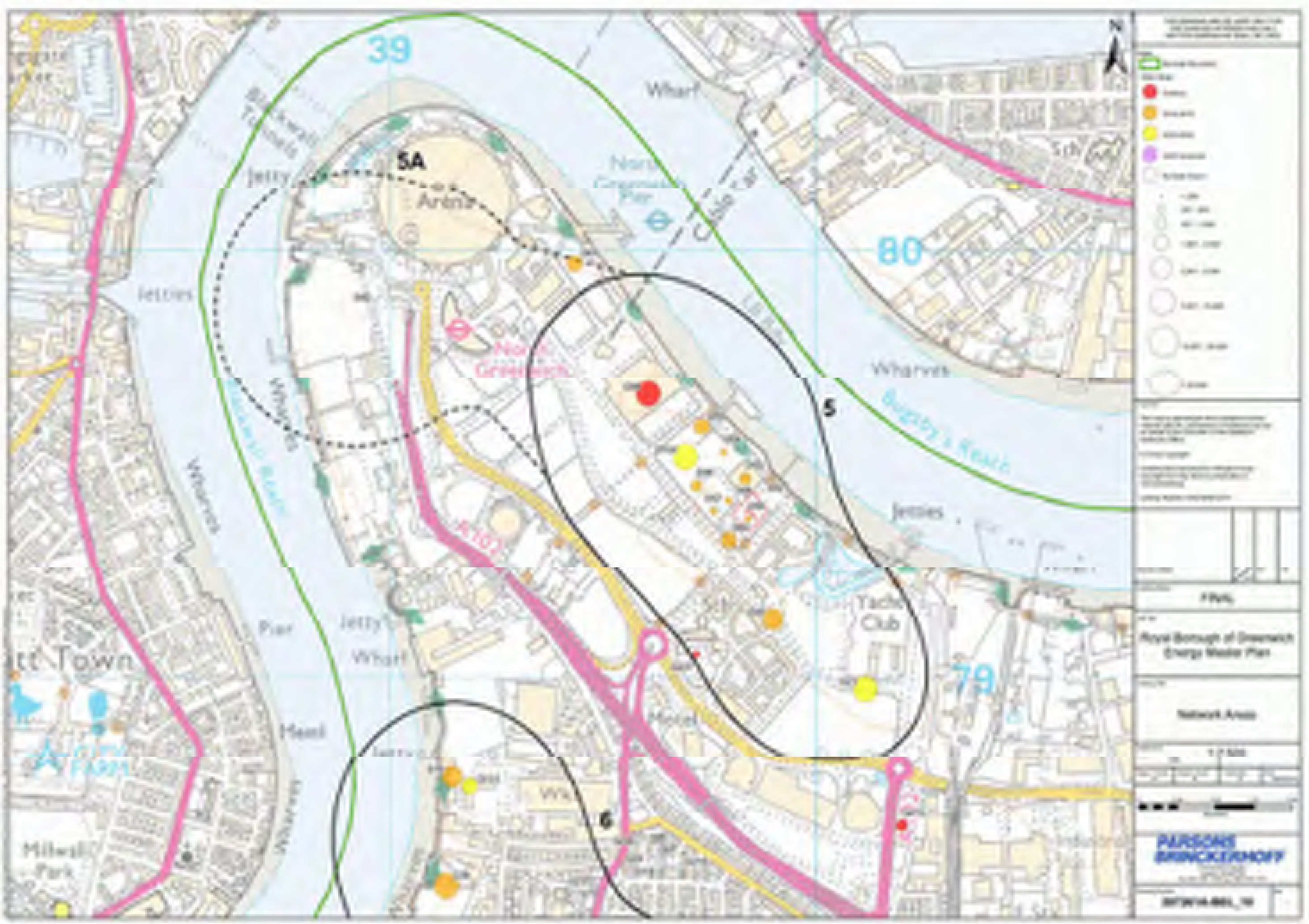


Figure 5-14: Scheme 4: Kidbrook



- 55 -

Figure 5-15: Scheme 5: Greenwich Peninsula



- 56 -

Figure 5-16: Greenwich Waterfront (including extension to west Deptford

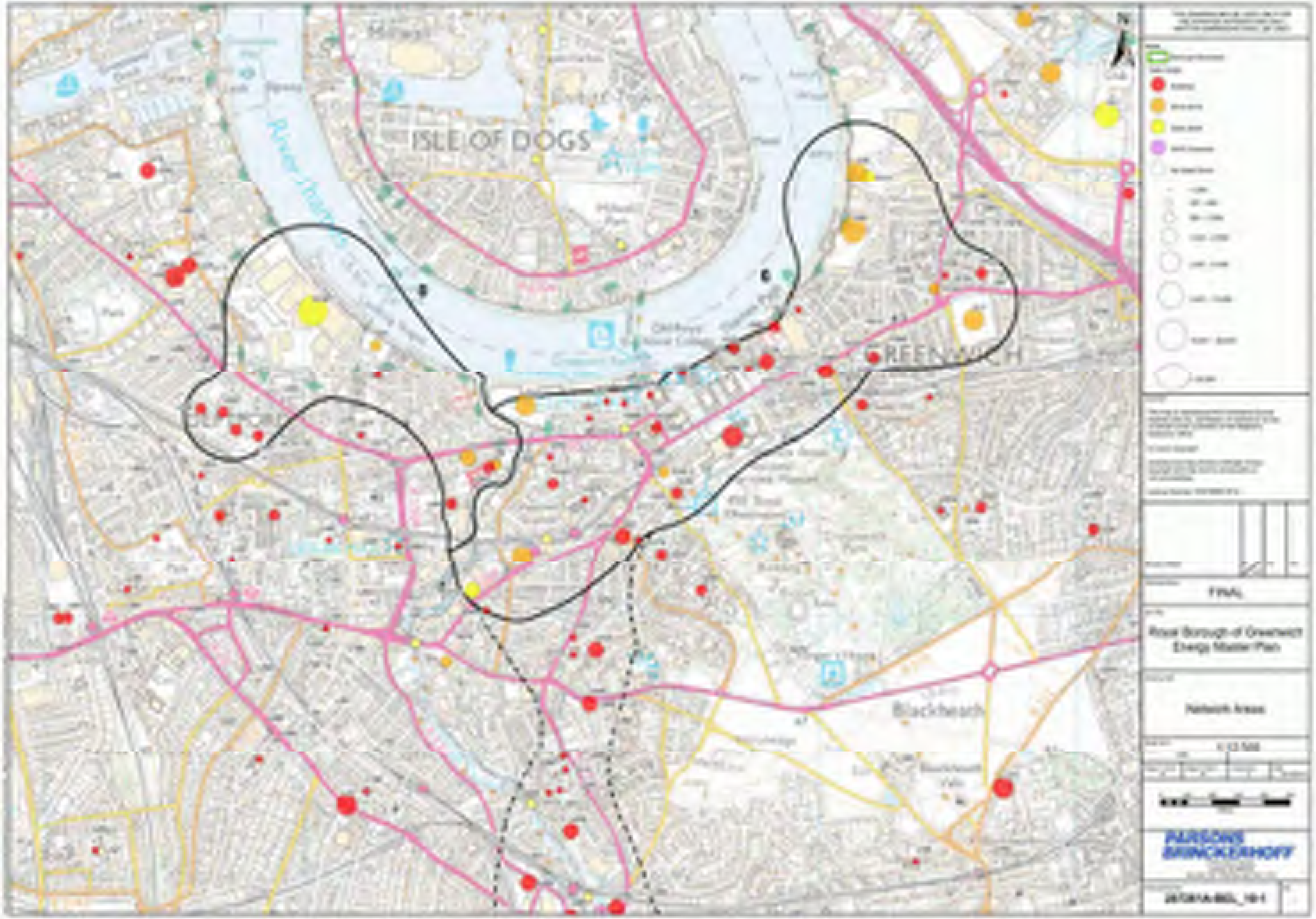
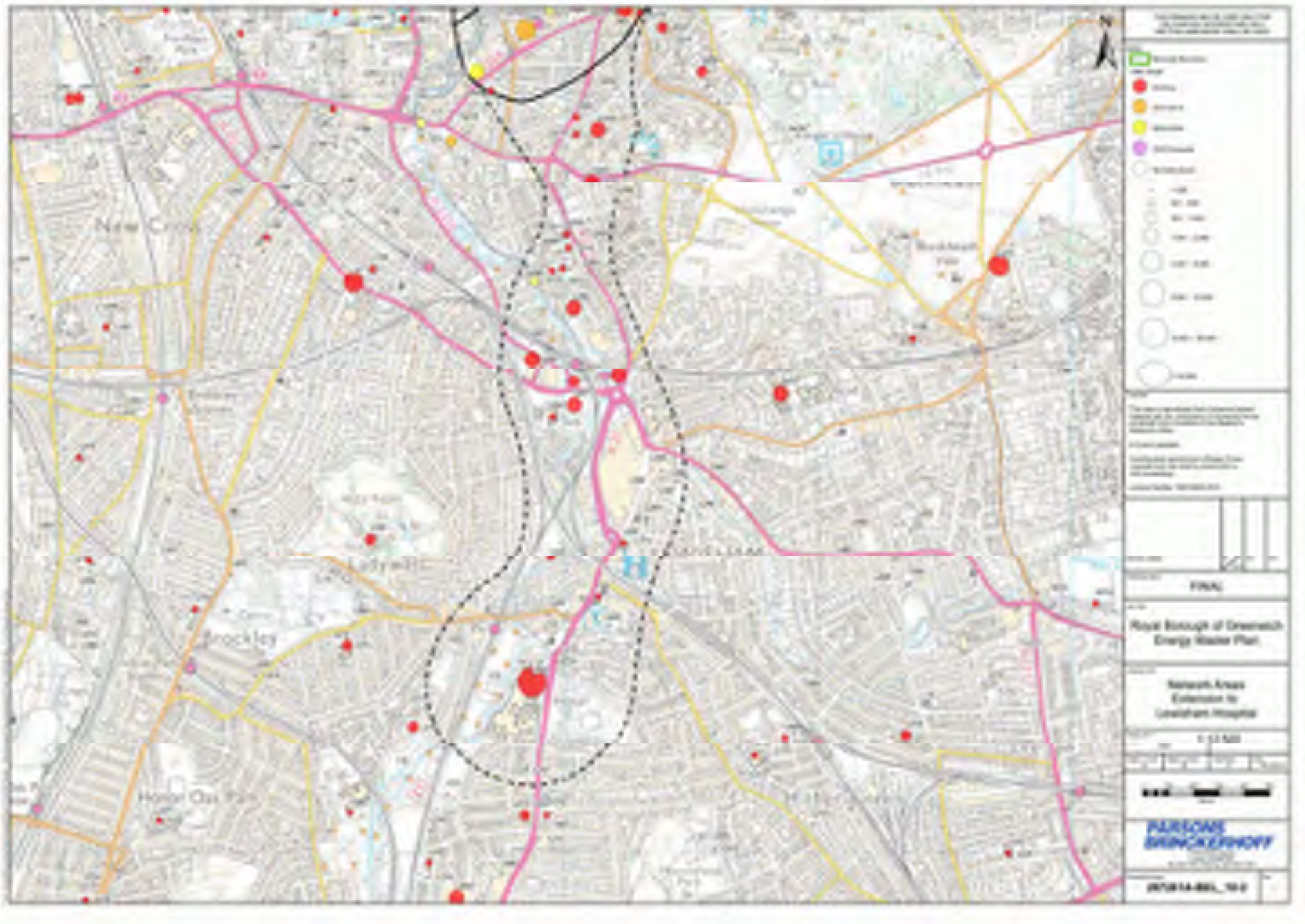


Figure 5-17: Extension to Lewisham Hospital



- 58 -

5.4.1 The initially identified network study areas were refined to incorporate adjacent loads which were felt to be worth consideration. For example, in the Deptford area, the four social housing loads to the south-west of Convoy's Wharf were included in further analysis.

5.4.2 A further selection criterion was applied - with loads with a total annual demand of below 100MWh per year being excluded. This is an approximate value below which, PB has found from experience, it is generally not economically viable to include within a DH network. As designs for each of the schemes progress, however, the inclusion of additional loads including those below this threshold should be reviewed.

5.4.3 Examination of the scheme areas also lead to the conclusion that that some were unviable in terms of kick-start networks. . For example, whilst Area 3 (Charlton) is an area of significant development in its own right, and where it would be expected that an on-site district heating scheme will be implemented, there are few other demands in the vicinity, and therefore there it would not be anticipated that a 'cluster' would emerge as a separate scheme that requires explicit attention as part of this study. The Charlton Riverside Development itself has a heat demand of 20.6GWh annually. A district heating scheme onsite is mandatory as per London Plan policy, and furthermore the location of this scheme forms a key 'stepping stone' in the wider, cross – borough scheme proposed (see later in report). Similarly, a district heating system is currently being implemented within the Kidbrooke Development Area and, as this report does not seek to redesign what is already being implemented, its detail is not examined further, although it is still considered for potential connection to a wider scheme, and also as a 'kick-start' network from which further loads could be added.

5.4.4 The area labelled 8 in Figure 5-16 (i.e. the area towards Convoy's Wharf) is located on the other side of the River Ravensbourne to the bulk of the rest of the loads in the area. Initial network design suggested accessing this via the A200. However, this incorporates a lifting bridge, meaning that laying pipework on this infrastructure is not possible. For this reason, this part of the network was split off from the main Greenwich Waterfront scheme as a stand-alone network in its own right. There is an existing bridge crossing Deptford Creek (Ha'penny Hatch), but this is some distance from the 'direct' route linking GPS to Convoy's Wharf. On balance, the presence of SELCHP considerably closer to Convoy's Wharf than the GPS, and the impediment of Deptford Creek has led to the recommendation that in the short-to-medium term a crossing of this waterway is not pursued for DH connection.

5.4.5 The following clusters (as illustrated in the figures above) were taken forward for further analysis:

- Cluster 1: Plumstead
- Cluster 2: Woolwich
- Cluster 5: Greenwich Peninsula
- Cluster 6: Central Greenwich waterfront
- Cluster 8: Deptford.

5.4.6 Cluster 5 – on the Greenwich Peninsula requires some additional discussion. A significant amount of development is currently underway on the Greenwich Peninsula, with the bulk being undertaken by developer Knight Dragon. A district heating network is currently being developed by Pinnacle Power. This will comprise both the loads identified above, as well as additional elements of the development which are as yet

- 59 -

unspecified. Discussions with Pinnacle Power, which is working on behalf of Knight Dragon to implement a district heating network for the development, have confirmed that full build-out is likely to comprise 10,000 dwellings and 3.5 million square feet of non-domestic space. PB has adopted the details of planning applications and this overall total figure for development to generate an estimate of heat demand for the Peninsula (see also section 6.1.9).

- 60 -

Section 6

HEAT LOAD PROFILING

- 61 -

6 HEAT LOAD PROFILING

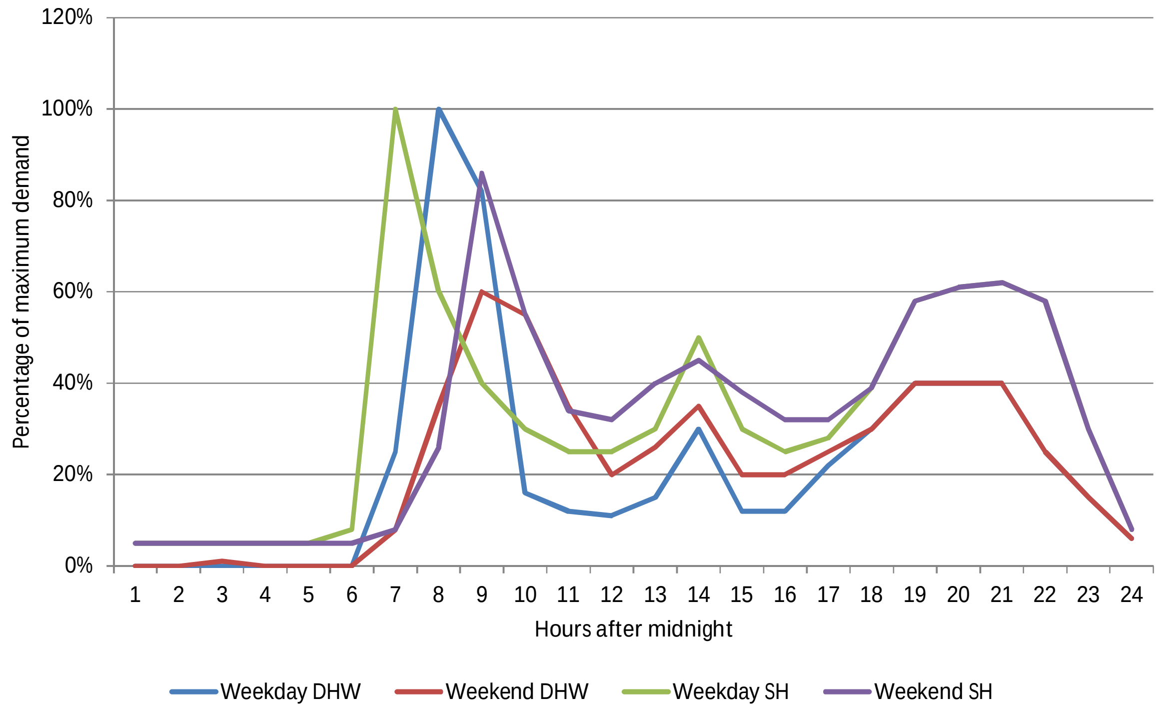
6.1 Load profiling

6.1.1 The benchmark-calculated or actual heat demands for each potential load were received in the form of a single annual figure (kWh/year). However, for the purposes of choosing a heat supply source to serve these loads, and also for district heating infrastructure sizing, an hourly profile is required, whereby the variation in heat demand from each load can be examined over the course of the year and peak demands estimated.

6.1.2 Annual profiles were produced for each load using Parsons Brinckerhoff's bespoke load profiling tool. For each building use type, this splits annual demand between space heating and hot water requirements, allocating a diurnal demand profile to each. The hot water profile is assumed to be constant throughout the year. However, space heating demands are dependent upon external temperature, and thus heating is considered to be required once the external temperature drops below 15.5°C. This is modelled using a degree day series for London.

6.1.3 The figure below shows example heat demand profiles for an existing residential property.

Figure 6-1: Heat demand profile – residential property



6.1.4 For developments with multiple use types (e.g. Enderby's Wharf), an overall combined profile was generated. This was generated through weighting demand profiles for each constituent use type by heat demand.

6.1.5 The end output is an overall demand profile for each heat network reflecting the heat demand throughout the year.

- 62 -

6.1.6 The resultant annual profiles for the schemes taken forward are shown below – these are shown at full build-out. The modelling of schemes has taken phasing of loads into account.

6.1.7 The graphs below illustrate demands on an hourly basis across a single year. Details of individual demand sites included within the figures illustrated here can be found in the appendices to this document.

Figure 6-2: Heat demand profile – Scheme 1 - Plumstead

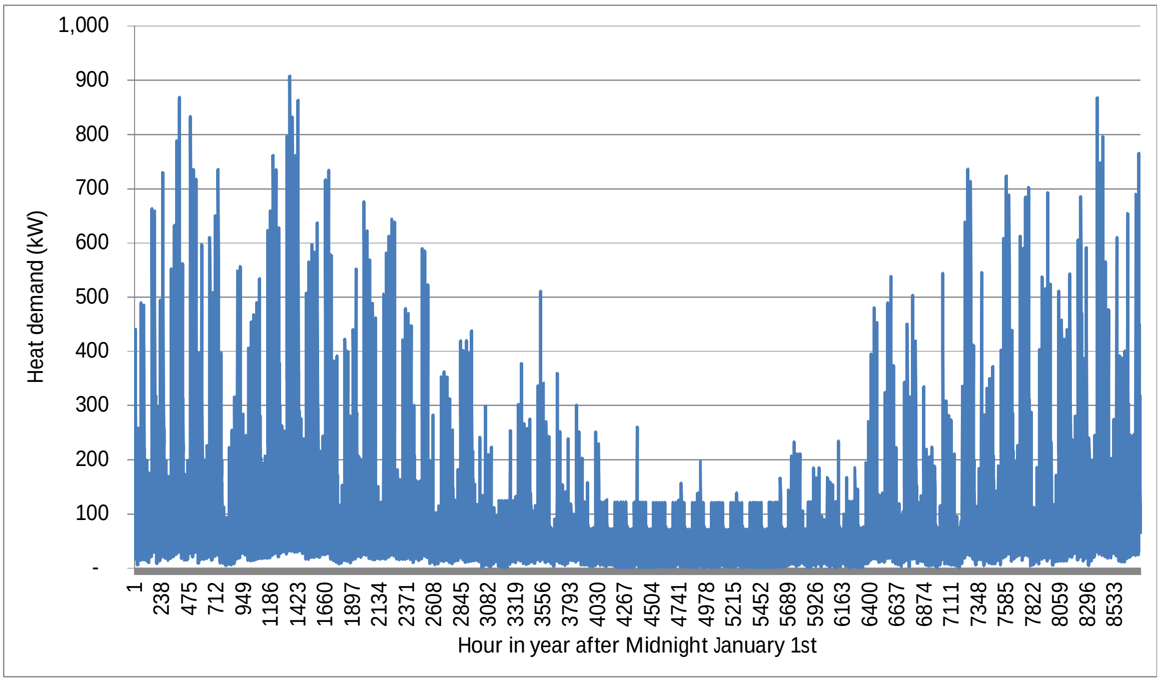
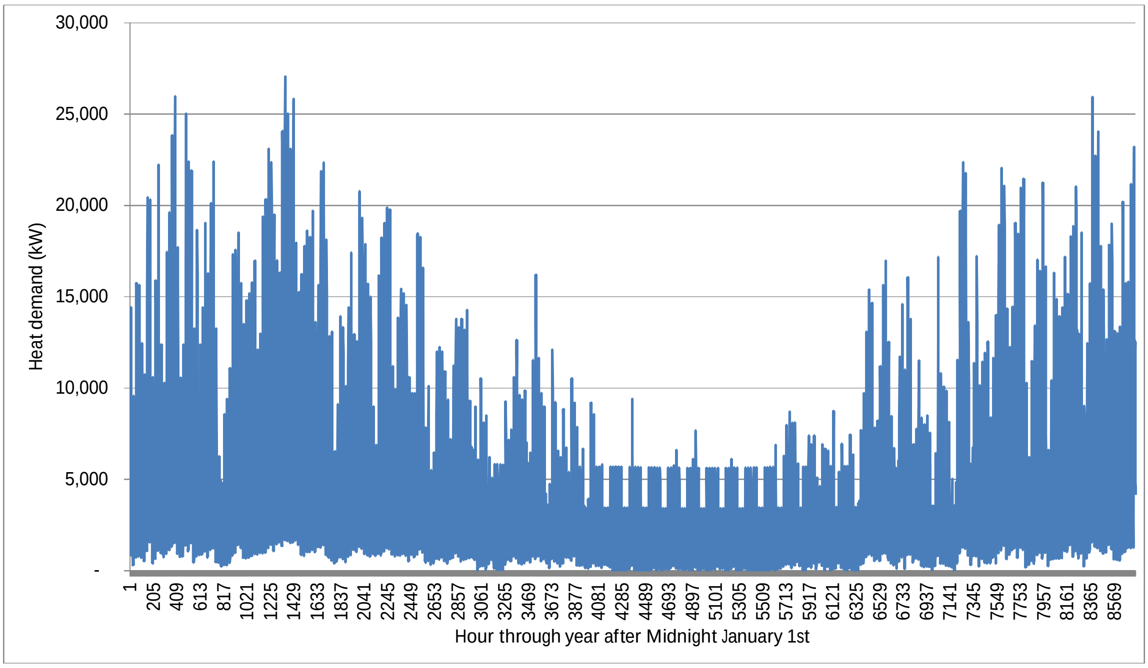


Figure 6-3: Heat demand profile – Scheme 2 - Woolwich



- 63 -

Figure 6-4: Heat demand profile – Scheme 6 – Greenwich Waterfront

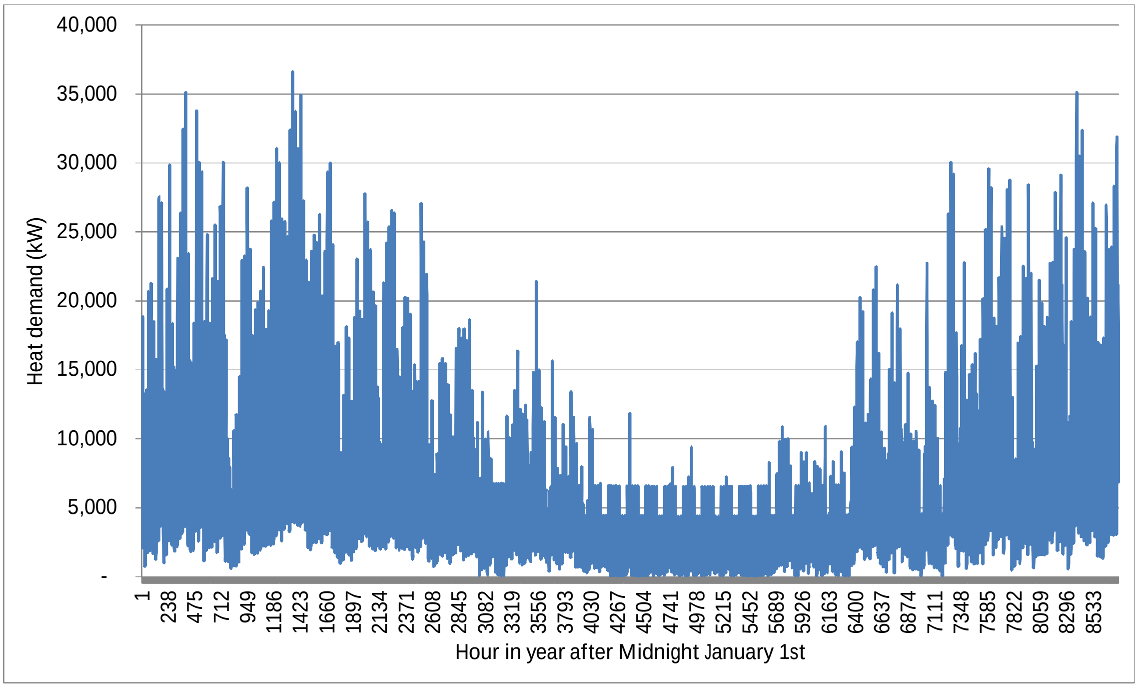


Figure 6-5: Heat demand profile – Scheme 6 with extension to Lewisham

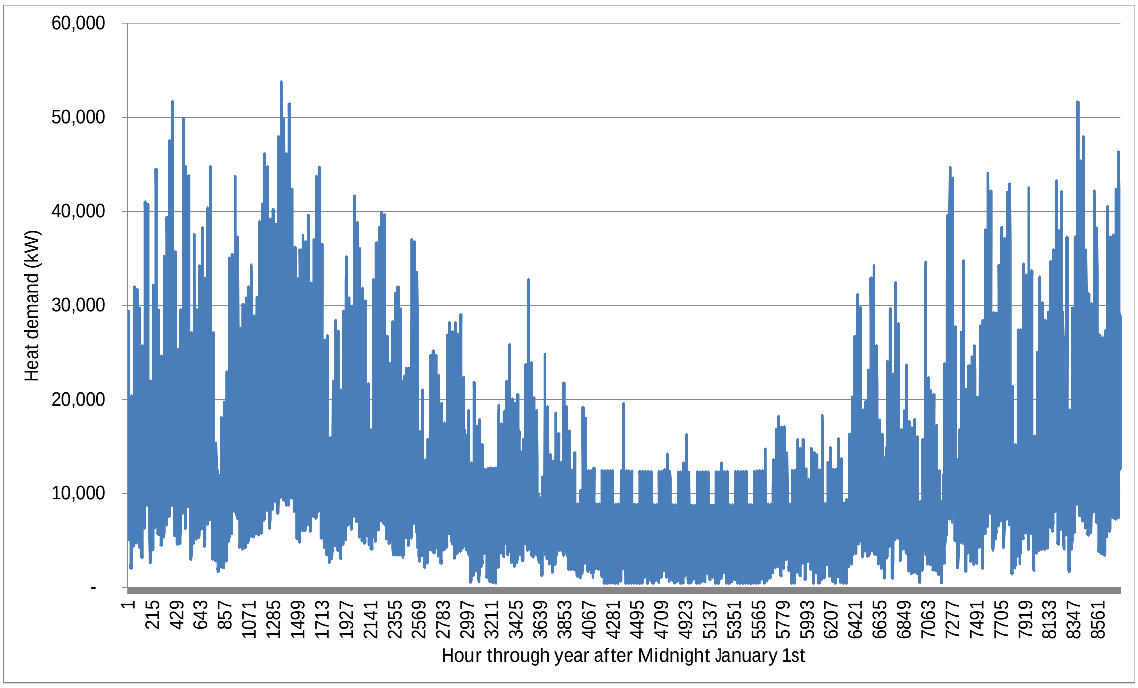
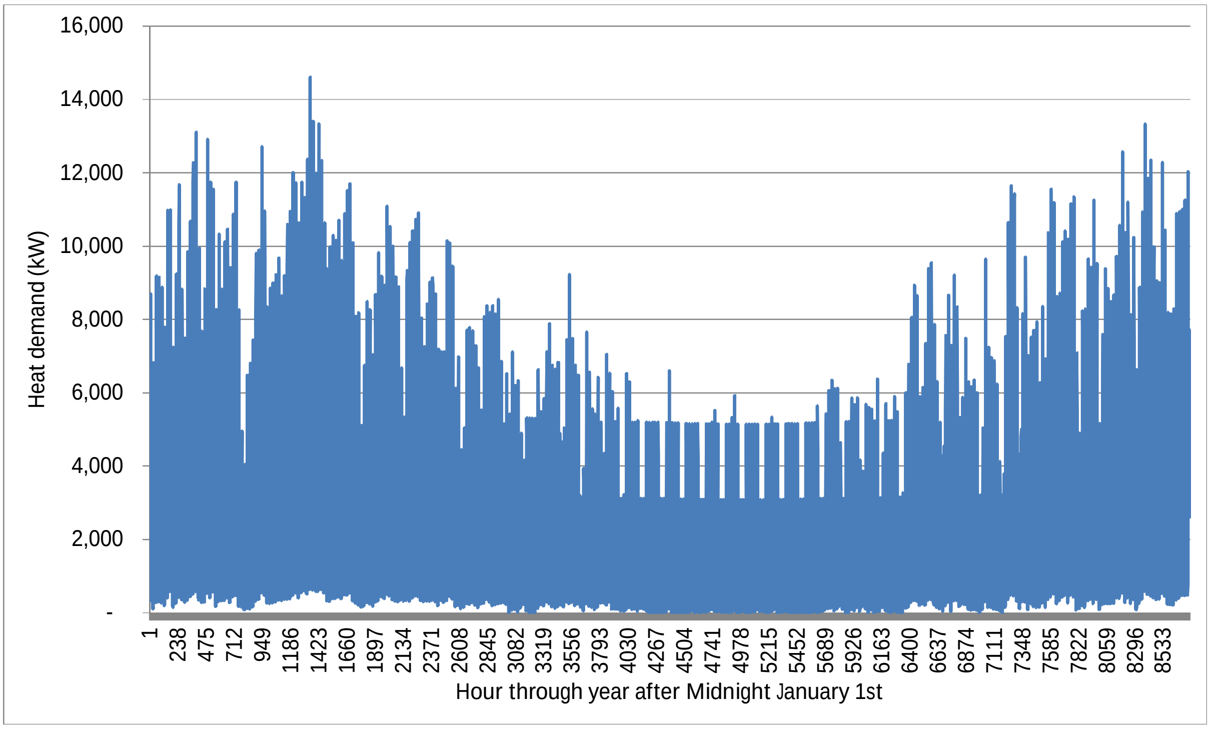


Figure 6-6: Heat demand profile – Scheme 8 – Deptford



6.1.8 It will be noted that the shape of all the profiles is broadly similar. This is owing to the predominance of residential development within the schemes, whose demand profile dominates.

6.1.9 Cluster 5 – Greenwich Peninsula

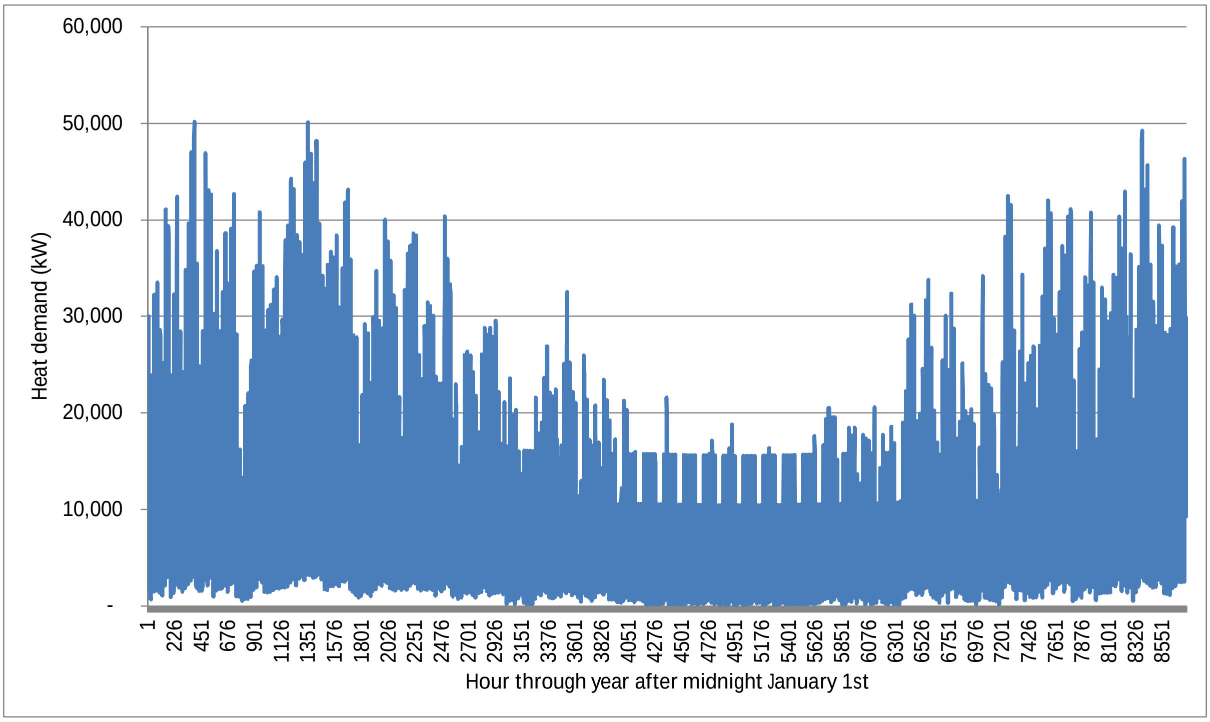
6.1.10 In order to estimate the total heat demand at the Greenwich Peninsula at full build-out, the following strategy has been followed:

- Heat demand of loads on Greenwich Peninsula not a part of the Knight Dragon development noted. These are largely existing demands (Millennium Village, Millennium Dome, Millennium Primary School).
- Heat demand of known Knight Dragon loads noted or calculated, along with the number of residential properties and the floor area of non-residential development
- Unaccounted for Knight Dragon development calculated (no. of residential properties/ floor area of commercial development). Known Knight Dragon loads scaled up by no. properties/ floor area to reach total
- A mixed-use commercial profile was applied to the commercial loads.

6.1.11 The resultant load profile is illustrated in the figure below

- 65 -

Figure 6-7: Heat demand profile – Scheme 5 – Greenwich Peninsula



6.1.12 It should be noted that analysis of Cluster 5 (Greenwich Peninsula) is not taken forward as part of this masterplan as networks are already being developed in this area by Pinnacle Power.

SECTION 7

NETWORK ROUTE DESIGN

- 67 -

7 NETWORK ROUTE DESIGN

7.1 Network design

7.1.1 An initial network design linking the heat loads in the cluster schemes selected for further analysis to an energy centre was carried out using GIS software. The following main criteria were used:

- Network to run along roads, avoiding as far as possible major (A and B) roads
- Network length to be minimised
- Network route constraints (major roads, railway lines and rivers) to be avoided where possible. The map below illustrates the main constraints to district heating implementation within the borough.

- 68 -

Figure 7-1: Key constraints to DH network implementation within RBG

- 69 -

7.1.2 This illustration above shows the large Unesco World Heritage Site and its surrounding buffer zone that protects the historic and geographic identity of the Naval College and its surroundings.

7.1.3 The generated networks were then reviewed in order to check their viability, and the proposed routes modified accordingly. Key to this process was the use of Google Maps, in order to establish specific area constraints which could have a potential impact on route selection.

7.1.4 Two schemes required especial consideration – 5 (Greenwich Peninsula) and 6 (Greenwich Waterfront). These are considered in the following sections.

7.1.5 Area 5

7.1.6 The image below shows the proposed Greenwich Peninsula network being developed and implemented by Knight Dragon / Pinnacle Power (image supplied by Pinnacle Power):

- 70 -

Figure 7-2: Indicative network for Greenwich Peninsula

7.1.7 In the case where this scheme links in to the main Greenwich-wide GPS-powered network it is assumed that connection will be made at the Peninsula energy centre, which is the natural point of connection.

7.1.8 As such, for the modelling carried out within this document the Peninsula has been treated as a single connection with an annual demand of 64GWh, located at the position of the energy centre, above.

7.1.9 Scheme 6 – Greenwich Waterfront

7.1.10 It is possible that an initial short-term heat network will be implemented in the immediate vicinity of the Greenwich Power Station, as laid out in a note from Arup[16]. This will link the following loads (refer to referenced document for full details):

- Ernest Defence Estate
- Maze Hill – Tom Smith Close
- Maze Hill - office block
- Sam Manners House

7.1.11 It is proposed that this scheme is supplied with heat through the use of heat pumps, both in order to make use of the natural heat resource that is the Thames, and also to meet European funding requirements.

7.1.12 The network for Scheme 6 (which includes this area), was designed to ensure that the pipe route proposed within this document can be retained and form a part of the wider network. The pipeline route for the initial scheme is illustrated in the figure below:

Figure 7-3: Immediate short term network

[16] 218060 - *Immediate District Heating Connections,* Arup, 25th April 2014

7.2 Network routes

7.2.1 The network routes which are proposed for Schemes 1 (Plumstead), 2 (Woolwich), 6 (Greenwich Waterfront), 6 to Lewisham and 8 (Deptford) are illustrated in the figures which follow. Loads are also illustrated, using circle diameter to represent magnitude and colour to represent year of implementation.

- 73 -

Figure 7-4: Scheme 1 - Plumstead

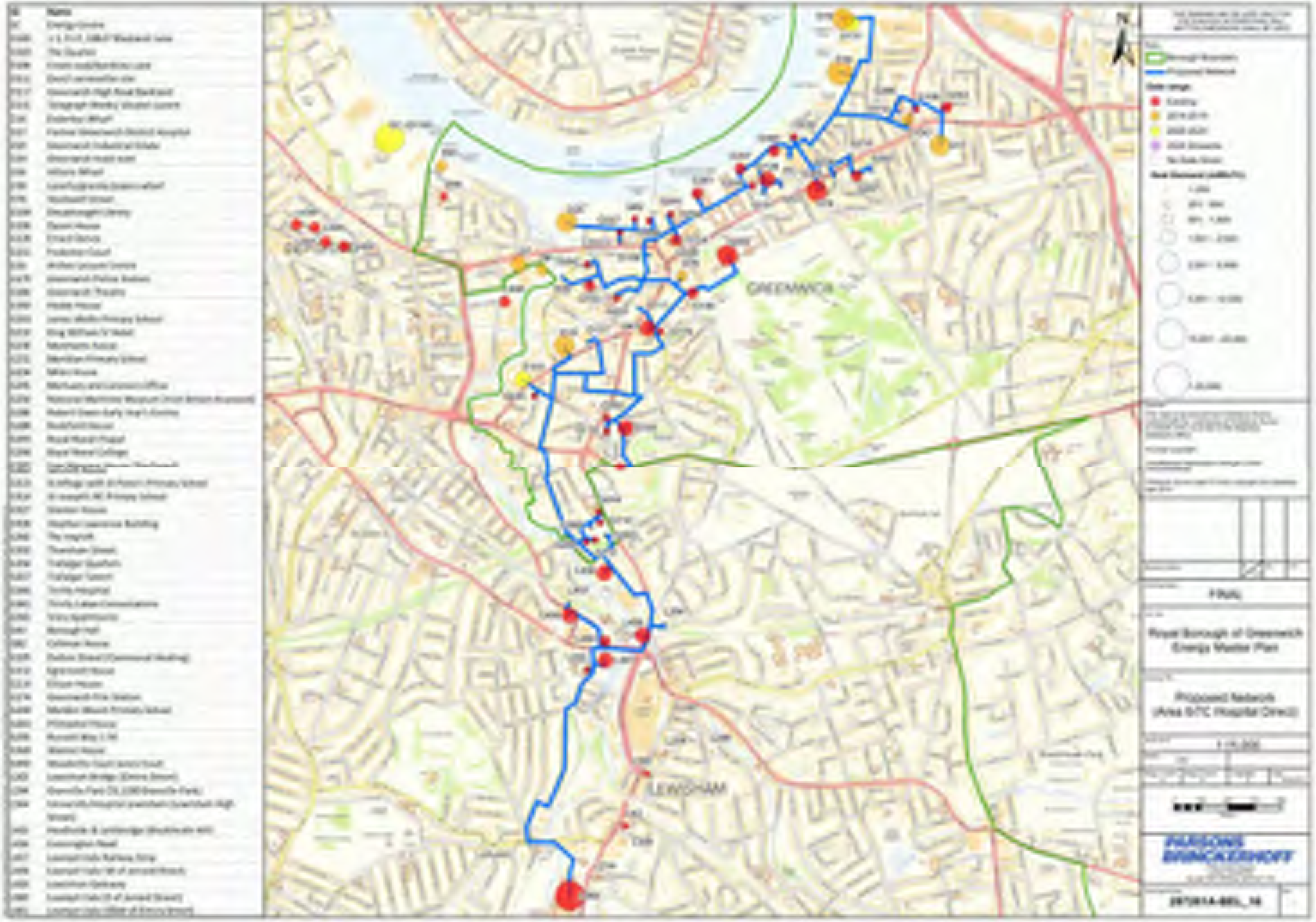
- 74 -

Figure 7-5: Scheme 2 -Woolwich

- 75 -

Figure 7-6: Scheme 6 Waterfront (showing future link to Scheme 5)

Figure 7-7: Scheme 6, with spur to Lewisham



- 77 -

Figure 7-8: Scheme 8 - Deptford

- 78 -

7.3 Phasing

7.3.1 Initial designs for a pipe network route for each decentralised energy cluster have been developed.

7.3.2 As has been described, the individual clusters should be considered as initial phases of a wider, cross-borough scheme. Through linking the clusters, heat provision will also be able to be centralised, most likely from the Greenwich Power Station (GPS). Linking smaller heat networks in this way provides a manageable and practicable means of developing a network, rather than attempting to construct a borough-wide scheme from the outset.

Table 7-1: Phased network implementation[17]

Scheme	2020-2024 Phase 1	2025-2029 Phase 2	2030-2034 Phase 3	2035 -
1 - Plumstead	Fully built out (subject to additional heat demand being identified)			
2 - Woolwich	Partial build-out	Partial build-out	Full build out	Connection to GPS
5 - Greenwich Peninsula	Own network with local CHP– Top-up supply from GPS	Own network with local CHP– Top-up supply from GPS	Full connection to GPS	Full connection to GPS and possible connection to Newham (subject to river crossing being implemented)
6 – Central Greenwich Waterfront	Partial build-out	Partial build-out	Full build out	Full build out ; connected to GPS
6 - Connection to Lewisham	Current operation	Current operation	Conversion to LTHW (?)	LTHW system; connected to GPS
8 – Deptford	Partial build-out	Full build out		Connection to GPS

7.3.3 It is proposed that the smaller schemes connect to the proposed Greenwich Power Station network in 2035, and the Greenwich Peninsula in advance of this,, subject to the agreement of Pinnacle Power. From an economic point of view this makes sense, as the CHP engines for the individual schemes (which generally have a 15-year service life) will be reaching the end of their operational lives. However, it is proposed that the following schemes are *not* connected:

- Scheme 1 - Plumstead
- The Kidbrooke development area

[17] NB – phases here refer to the notional network build-out phases analysed in this document – these do not refer to site-specific development phasing

7.3.4 Both of these are located too far from the bulk of the network to make connection economically feasible, when considering the loads. It is recommended that Scheme 6 (Greenwich Waterfront) meanwhile is connected to GPS from the outset (albeit with smaller heat generating equipment installed), and that the spur down to Lewisham is implemented to coincide with the installation of the full capacity of CHP plant at GPS in 2035.

7.3.5 Phasing of the individual networks themselves was carried out through examination of the network routes and date at which loads are available (i.e. forecast to be developed). Phases were selected with the aim of locating initial phases near areas of significant new development. These areas have an economic incentive to connect owing to the avoided costs of alternative heat provision. However, there are some cases where a new building will be constructed prior to the district heating network becoming available. In this case, a temporary boiler plant will be required to provide heat to the development in the short term. In general, and subject to local conditions, this could be in the form of containerised plant, avoiding the need for space to be reserved for a boiler room.

7.3.6 This issue has the potential to affect the following sites:

Table 7-2 Sites potentially requiring their own plant prior to DH connection

Site code	**Site name**	Scheme	Anticipated year of development completion	Phase of connection to network	Load magnitude (MWh/year)
D107	Mast Quay	Scheme 2	2020	Phase 3	782
D124	New Ferry approach	Scheme 2	2024	Phase 2	1,803
D115	Former Gala Bingo and Mortgramit Square	Scheme 2	2023	Phase 2	825
D4	Callis Yard	Scheme 2	2020	Phase 2	399
D40	Macbean Street	Scheme 2	2024	Phase 2	2,030
D114	Greenwich Waterfront Leisure Centre	Scheme 2	2023	Phase 2	433
D24	Greenwich Reach East	Scheme 6	2014	Phase 2	5,374
D76	Stockwell Street	Scheme 6	2016	Phase 3	772
D117	Greenwich High Road Backland	Scheme 6	2022	Phase 3	248
D26	Hiltons Wharf	Scheme 6	2015	Phase 3	374
D111	Davy's Winecellar site	Scheme 6	2022	Phase 3	413
D19	Greenwich Industrial Estate	Scheme 6	2014	Phase 3	3,806
D103	The Quarter	Scheme 6	2020	Phase 3	2289
D106	Creek Road/Bardsley Lane	Scheme 6	2020	Phase 3	433

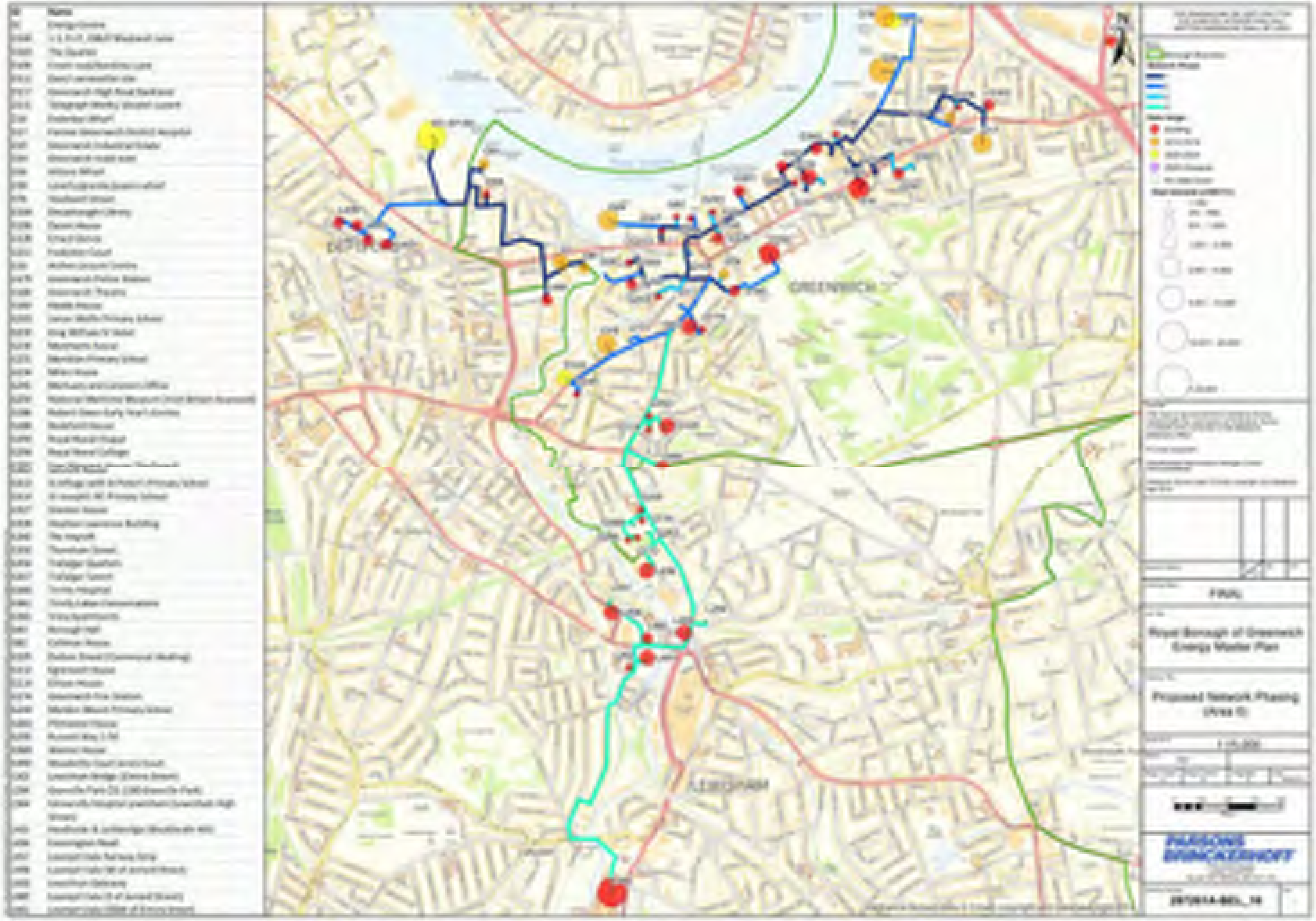
- 80 -

7.3.7 The image below illustrates the phased development of heat networks throughout the borough.

- 81 -

Figure 7-9: Scheme 2 phased implementation

Figure 7-10: Scheme 6 Phased implementation



- 83 -

Figure 7-11: Scheme 8 phased implementation

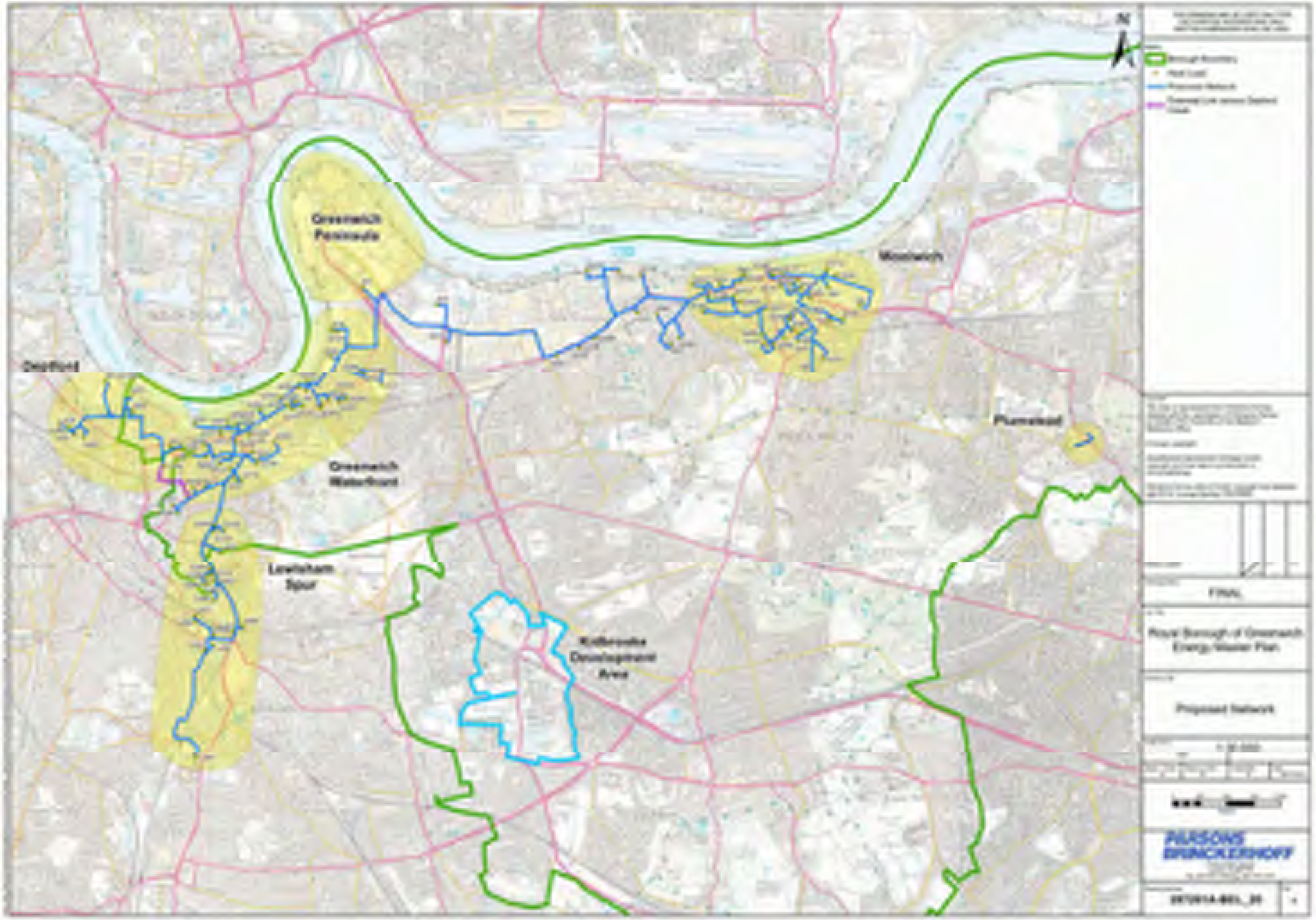
- 84 -

7.3.8 As can be seen, there is a gradual build-up from the initial individual network clusters which coalesce to form a wider cross- borough network, with heat provided from the Greenwich Power Station.

7.3.9 The ultimate scheme is one which links up the individual clusters to form a borough-wide scheme, with heat provided from Greenwich Power Station. This is illustrated in the figure below, together with indicative pipeline dimensions for the main spine and pumping station locations. This also includes additional developments along the route – in particular at Charlton Riverside. These demands and their magnitude are set out within Appendix 17.1.

- 85 -

Figure 7-12: Borough – wide scheme



7.4 Pipeline sizing

7.4.1 Network route selections were input into Parsons Brinckerhoff's proprietary pipeline model to establish the required pipeline dimensions. PB's 'Decentralised Energy Pipeline Model' is a MSExcel-based software developed specifically for the analysis of decentralised energy schemes and their heat supply systems at a strategic level.

7.4.2 The inputs into this model are the spatial distribution of loads (e.g. the lengths of networks joining loads), their magnitudes, anticipated return temperatures, diversity factors applicable to DHW usage and between commercial loads, typical pipe roughness factors, typical heat losses per m for different pipework diameters, and maximum allowable pressure drops and velocities.

7.4.3 The model calculates the required diameter of each element of a network based on appropriate temperature differentials and hence flow rates. This then informs cost estimation of the network based on per metre of trench cost indices for pre-insulated pipework of varying diameter.

Network design - temperatures

7.4.4 The size of connections and hence costs of network development is driven by the temperature differential that can be achieved across consumer connections. For example, from the base assumption of a 65 deg C return temperature, a further 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 often relatively 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 from the first stages of building design will require a combination of incentives, lower connection charges, guidance and requirements through planning conditions or similar.

7.4.5 The temperatures used to calculate pipeline diameters are those recommended by the District Heating Manual for London[18], which sets out the preferred operating temperatures for decentralised energy networks.

- Flow temperature – 110 deg C (peak load periods / network design temp[19])
- Return temperature – an approximate average of 65 deg C (with individual connections assigned varying return temperatures, accounting for a mix of existing and new connections)

7.4.6 The following return temperatures have been used within the modelling carried out:

Load type	Space heating return temperature	DHW return temperature

[18] http://www.londonheatmap.org.uk/Content/uploaded/documents/DH_Manual_for_London_February_2013_v1.0.pdf

[19] A variable flow and variable temperature system would be advocated for operational optimisation

Existing domestic	75	55
Existing commercial	75	N/A
New domestic	55	25
New commercial	55	N/A

7.4.7 Network modelling has been based around the assumption that early phase networks would be installed with the capacity to serve the fully built-out demands. Additional ‘future-proofing’ capacity has not been added to the full build-out peak loads identified. It is rather advocated that progressive improvements in terms of return temperatures would enable additional loads to be served by the same network.

Network design - loads

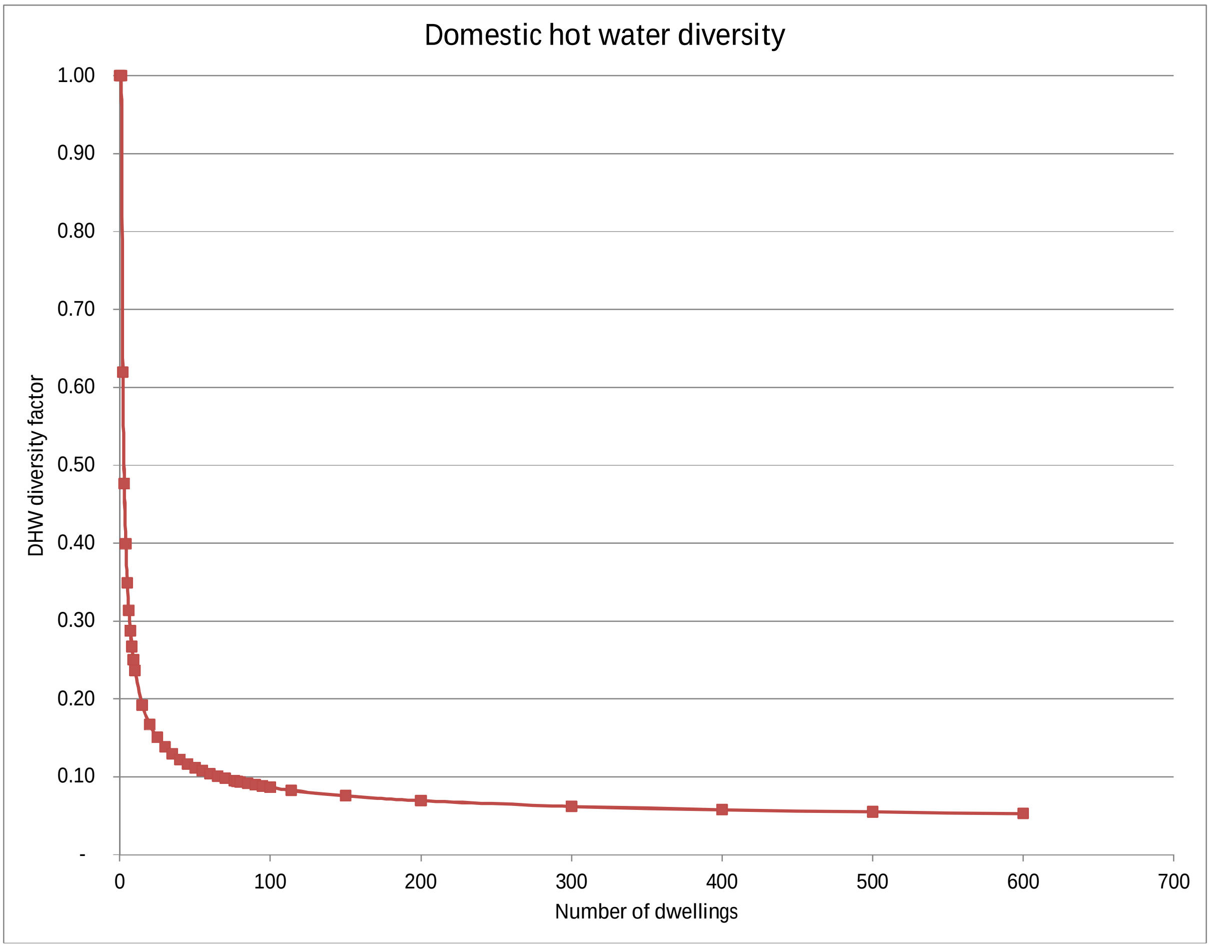
7.4.8 In terms of loads, each heat network is sized on the basis of the peak demands which will be required by each load. In terms of commercial loads, these were extracted from the profiled load for each demand. Because where hourly demands are used each demand is in effect an average over the one-hour period, an additional 30% was applied to each load to account for potential shorter-term instantaneous peaks.

7.4.9 When considering residential loads, a slightly different approach is taken. A broad assumption was applied that each dwelling has a maximum space heating demand of 3kW and a maximum instantaneous hot water demand of 35kW. These values were used within network modelling.

7.4.10 Households will have differing occupancy patterns and require hot water at differing times, meaning that peak heat demands will also differ temporally. As such DHW demands are lower in aggregate than suggested by the simple multiplication of the number of dwellings by each dwelling’s maximum requirement for hot water. To account for this a diversity factor is applied, as illustrated in the figure below[20].

[20] As per Danish standard DS439:2000 as referenced in SAV systems document ‘Heat interface Units / Plate Heat Exchange Substations – Explanatory notes regarding use of “Coincidence Factor” in LTHW flow rate calculations’,

- 88 -



7.4.11 Thus, for example, when 600 properties are connected to the scheme, their maximum heat demand is calculated by the following equation:

7.4.12 $\text{Peak demand} = \text{number of properties} \times \text{maximum dwelling heat demand} \times 0.05$

7.4.13 Where development is mixed use the following methodology was used:

- Where the split between annual non-residential and residential demands was known, load profiling was carried out on purely the non-residential buildings. The peak hourly load was then used for the non-residential element, with the domestic element input as described above.
- Where the split between the two use types was not known an average domestic demand of 4126 kWh/year for new build, or 11,324kWh/year for existing build was used to estimate the number of domestic properties and hence the split with non-residential. The procedure outlined in the bullet point above was then followed.

<u>Network design – pipe sizing</u>

7.4.14 The selection of pipe diameters is carried out within Parsons Brinckerhoff's pipeline modelling software, with sizes set by applying industry best practice with respect to the maximum pressure drops and flow velocities . The limits used within modelling are set out in the table below.

- 89 -

Table 7-3 Network design characteristics

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

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

7.5 Network design / materials

7.5.1 For the network installation within the borough for heat (and chilled water) distribution, PB recommends the use of pre-insulated steel 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, and hence it is primarily recommended for application in lower temperature, local heat networks.

- 90 -

SECTION 8

HEAT SOURCE SELECTION

- 91 -

8 HEAT SOURCE SELECTION

8.1.1 This section discusses the selection and sizing of heat sources to supply the networks identified in the sections above.

8.2 Heat loss

8.2.1 Distribution heat loss is a consideration when sizing heat supply technology, as losses along the route must be met, in addition to the heat loads. In addition, power will also be required to operate the network pumps. Parasitic demands, as calculated within Parsons Brinckerhoff's decentralised energy pipeline model are set out in the table below. (NB this only takes account of losses to the connection point of each load e.g. in a residential tower block there would be additional heat losses from the DH substation at the base of the block to the individual dwelling hydraulic interface units)

Table 8-1 Scheme extents and calculated heat losses in distribution

Scheme number	Annual heat loss (MWh/annum)	Annual heat demand at full build-out	Annual heat loss (% heat demand)	Total heat demand (MWh/annum)
1	57	810	7%	867
2	3,109	44,410	7%	47,519
6	3,936	56,230	7%	60,166
8	2,223	22,234	10%	24,457
Full scheme buildout	12,368	247,357	5%	259,725

8.3 Heat supply modelling and phasing

8.3.1 The phased implementation of heat networks does have implications for the selection of heat sources. Because loads join the networks in up to four phases, the selected CHP size needs to be a compromise between the Phase 1 demands and the ultimate heat demands. Thus initially the CHP will be oversized for the loads connected to the network, and by the end of the network implementation it will be undersized. The amount of top-up gas boiler generation installed will also vary throughout the project lifetime.

8.3.2 Initial engine sizing was based on a rule of thumb calculation which assumes that 70% of heat demand is met by the primary heat source, which runs for 6000 hours per year. Thus:

8.3.3 $$Heat\ output\ (kW) = \frac{Annual\ heat\ demand \times \%\ demand\ met}{Annual\ run\ hours} = \frac{Annual\ heat\ demand \times 70\%}{6000}$$

8.3.4 The initial engine sizes generated by this means were then refined through analysis within Parsons Brinckerhoff's CHP model.

8.3.5 Consideration was also given to the use of thermal storage. This is able to improve the operation of CHP engines through decoupling supply and demand. Thermal stores were sized with a capacity of six hours' CHP output.

8.3.6 Initial engine sizes for the various schemes are set out in the table below. Where a phased network implementation has been proposed, then the average heat demand across the different phases of the network expansion has been used as the basis for

- 92 -

initial selection. This is not relevant to Scheme 5 (Greenwich Peninsula), and Scheme 6 - extension to Lewisham – which will both only be linked in the case of the full borough-wide scheme.

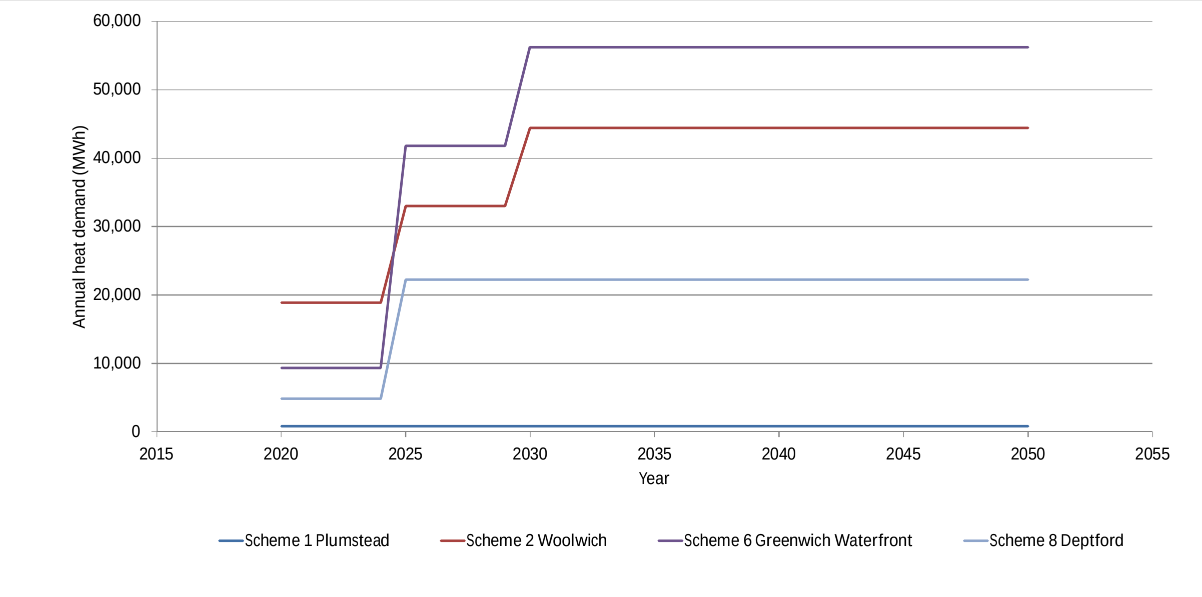
Table 8-2 Estimated heat demand and rule of thumb CHP size

Scheme	Annual heat demand (incl. losses, MWh/annum)	Initial “rule-of-thumb” CHP sizing (kW)
1 – Plumstead	867	101
2 – Woolwich	47,519	5544
6 – Greenwich Waterfront	60,166	7019
8 – Deptford	24,457	2853
Full scheme	259,725	30,301

8.3.7 In terms of the implementation of heat networks, a key consideration will be the dates at which new developments are constructed and thus are able to be connected. Heat networks may not be viable until a certain critical mass of new developments are able to be connected and take heat.

8.3.8 The graph below shows the development of heat demand over time for the five networks (excluding network losses).

Figure 8-1: Phased development of heat loads



8.3.9 As can be seen, there is some variation in heat build-up over time, although all schemes are anticipated to reach their full heat demand by 2035 (when considering the link to Lewisham Hospital).

8.3.10 Schemes 1 (Plumstead) and 8 (Deptford) reach peak heat demand fairly early, and could be good initial schemes to target for early implementation. Scheme 6 and 8 both see significant amount of heat load added in the later phases.

8.4 Modelling CHP engines

8.4.1 The following procedure was followed when modelling CHP engine capacities:

- Initial rule-of-thumb calculation applied to derive suggested engine size
- The efficiency of CHP engines varies with size. Engine data was obtained from manufacturers as a starting point, and different models were tested within Parsons Brinckerhoff's CHP modelling software to identify the most technologically suitable size.
- For each scheme a thermal store size was selected appropriate to engine capacity, but also applying a cap of $300m^3$. For the schemes which extend to Lewisham, this cap was raised to $500m^3$.

8.5 Scheme 1 – Plumstead

8.5.1 Scheme 1 is located some distance from the other schemes and as such is most suited to a stand-alone scheme rather than one which connects in to a wider Greenwich network. Two technologies have been considered: a gas-fired CHP engine and an air-source heat pump.

Combined heat and power plant

8.5.2 The following initial engine models were tested within Parsons Brinckerhoff's proprietary CHP modelling tool:

Table 8-3 Scheme 1 CHP sizes tested

Engine model	Thermal output (kW)	Electrical output (kW)	Fuel input (GCV, kW)
ENER-G 50	79	50	148
ENER-G 70	109	70	204
ENER-G 90	161	90	278
ENER-G 110	184	110	362

8.6 Scheme 2 - Woolwich

8.6.1 Scheme 2 is located to the north of the borough in the Woolwich area. It links in to the heat network already in place on the Royal Woolwich Arsenal development. This development has the potential to form part of a larger Greenwich-wide network. The site is also located adjacent to the River Thames, meaning that the use of heat pumps to extract heat from river water could be a possibility.

- 94 -

CHP sizing

8.6.2 With an initial “rule of thumb” sizing of 5544kW, the size of CHP means that a reciprocating engine is still the most effective technology choice in the present. The table below summarises the sizes tested:

Table 8-4 Scheme 2 CHP sizes

Engine model	Thermal output (kW)	Electrical output (kW)	Fuel input (GCV, kW)	Thermal store size (m3)
JMS 624	3766	4031	9936	300
2*JMS 612	2*1916	2*2000	2*4998	2*300
2*JMS 616	2*2560	2*2658	2*6665	2*300
2*JMS 620	2*3155	2*3349	2*8331	2*300

8.7 Scheme 5 – Greenwich Peninsula

8.7.1 Heat demands on the Peninsula will, during initial phases, be supplied by Pinnacle Power independently from the other heat networks discussed in this document. The proposal of this masterplan is that there is a two-stage development of the link to this area. The large load, and high heat density of the Knight Dragon development and the other key sites on the Peninsula (i.e. Arora Hotel, Greenwich Millennium Village, O2 Arena) means that this is an ideal area for decentralised energy provision. There is no doubt surrounding the technical potential of the area. However, there are complications in terms of commercial operation of a network here linked to the GPS, as Pinnacle is effectively the incumbent provider of heat to this area, and is in the process of seeking to expand its scope of supply to neighbouring developments. In the event that a different organisation were to operate the GPS (and this is purely speculative at this stage), the supply of heat from GPS to the Pinnacle development site would be a commercial arrangement between two energy providers.

8.7.2 However, it is not the role of this masterplan to try to speculate on preferred delivery structures for the GPS network, but rather to outline a preferred technical solution, which can then be pursued through whatever means are at the disposal of the stakeholders involved.

8.7.3 In terms of technical solution within the known constraints of the Peninsula, the working assumption has been that a 2MW CHP will be installed for the initial, known phases of development (although this figure is flexible and may change as other customers commit to taking heat from the system), with a top-up gas-fired boiler plant.

8.8 Scheme 6 –Greenwich Waterfront

8.8.1 Scheme 6 is based on Greenwich Waterfront, and is well situated for the provision of heat from the Greenwich Power Station. Initial “rule of thumb” calculations suggest a CHP size of around 7MW_{th}. The following CHP sizes were therefore modelled:

Table 8-5 Scheme 6 CHP sizes

Engine model	Thermal output (kW)	Electrical output (kW)	Fuel input (GCV, kW)	Thermal store size (m^3)
2 x JMS 616	2 x 1,916 = 3,832	2 x 2,000 = 4,000	2 x 4,998 = 9,996	300
2 x JMS 620	2 x 3,155 = 6,310	2 x 3,349 = 6,698	2 x 8,331 = 16,662	300
2 x JMS 624	2 x 3,766 = 7,532	2 x 4,031 = 8,062	2 x 9,936 = 19,872	300
3 x JMS 612	3 x 1,916 = 5,748	3 x 2,000 = 6,000	3 x 4,998 = 14,994	300

8.8.2 It should be noted that using more CHP engines can provide greater flexibility, through allowing a greater degree of turndown and thus lower loads to be met than could be achieved with larger engines.

8.8.3 It should further be noted that only the plant costs have been included in this analysis i.e. any remediation works to the shell of the power station / flues, asbestos removal etc., has been assumed to be carried out under separate budgets not accounted for here.

8.8.4 Of particular relevance to the Greenwich Waterfront, and also Peninsula schemes is the potential emergence of an energy facility at the Morden's Wharf site. Here, a company called Energy10 are understood to be developing a waste pyrolysis plant may form part of the supply mix moving forward in Greenwich. This is a technology that has various environmental sensitivities, and it is therefore recommended that RBG engage with both Energy10 and the Environment Agency to keep abreast of the potential for this site to contribute to heat distribution in the area. At the time of development of this report there was insufficient certainty surrounding this site to include in any modelling or strategic designs, but a watching brief is recommended to allow its integration at an early stage if appropriate.

8.9 Scheme 8 – Deptford

8.9.1 Scheme 8 comprises that part of Deptford situated to the West of the River Ravensbourne. Initial calculations suggest that the CHP should be in the region of 2.9MW. The following CHP sizes were modelled:

Engine model	Thermal output (kW)	Electrical output (kW)	Fuel input (GCV, kW)	Thermal store size (m^3)
ENER-G 1560	1719	1557	4164	256
JMS 612	1916	2000	4998	285
JMS 616	2560	2658	6665	300
JMS 620	3155	3349	8331	300

8.10 Full scheme

8.10.1 The full strategic scheme is based on an energy centre located at Greenwich Power Station, linking schemes 2 (Woolwich), 5 (Greenwich Peninsula), 6 (Greenwich waterfront) and the link down to Lewisham. Additional loads on the link across to Woolwich (including the strategic site of Charlton Riverside) are also included; these loads are set out in Appendix 17.1.

8.10.2 Initial calculations suggest a CHP total size of around 30MW. The following CHP sizes were modelled:

Engine model	Thermal output (kW)	Electrical output (kW)	Fuel input (GCV, kW)	Thermal store size (m^3)
SGT 400	17,208	12,400	40,800	5000
SGT 500	24,475	18,550	62,200	5000
SGT 600	34,145	24,170	79,700	5000
9*JMS624	11,298	12,093	29,809	800

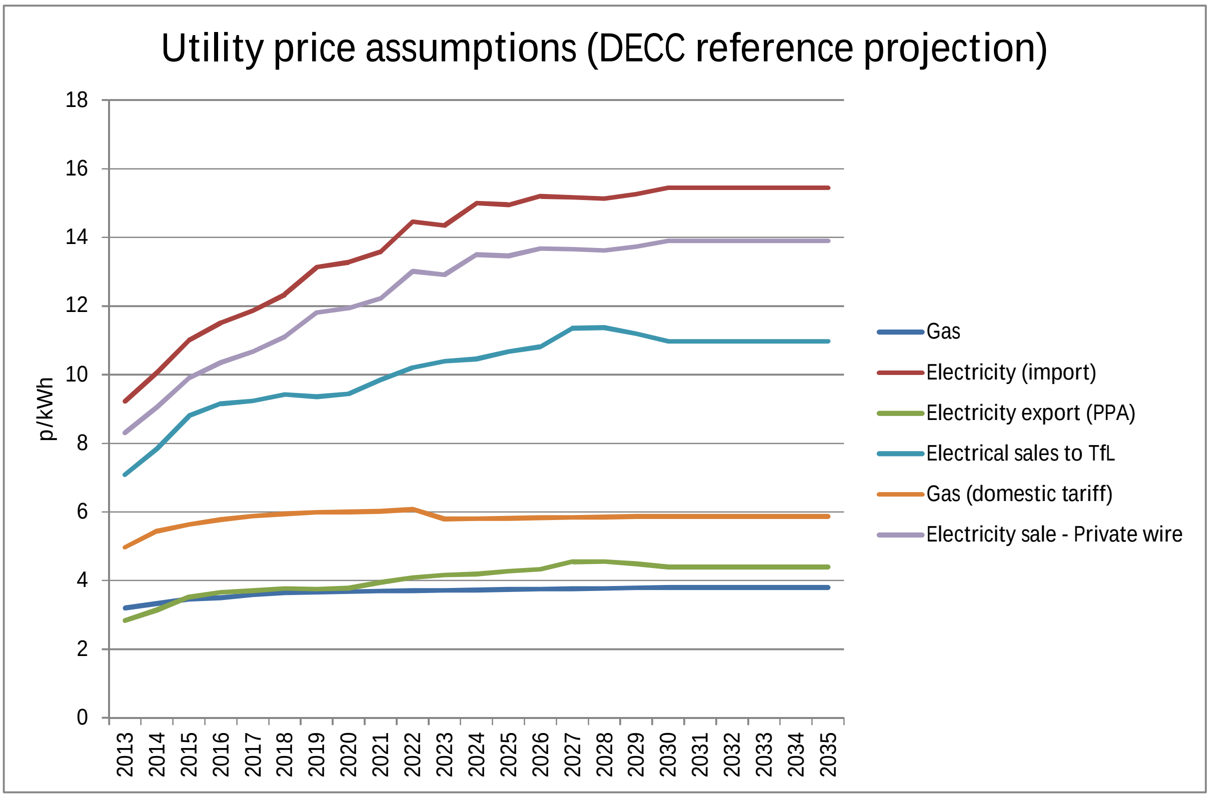
8.11 Economic considerations

Utility price changes through time

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

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

Figure 8-2 Utility price assumption illustration



Avoided costs

8.11.4 New development within the RBG will need to demonstrate compliance with Building Regulations and probably Code for Sustainable Homes (CfSH) levels in addition. CfSH covers a number of facets of building construction (e.g. water use, waste management, ecology, health aspects) of which energy consumption is a significant consideration.

8.11.5 Building to the different CfSH levels has certain cost implications, with meeting the higher levels being more costly than the lower ones. Connecting to a district heating network can help developers reduce their compliance costs. For example, if a development is able to connect to a RBG network, it will not have to provide low-carbon plant within an on-site energy centre providing a cost saving. This cost saving can be used as the basis for calculating developer contributions to network development costs.

8.11.6 At more detailed levels of assessment, contributions could be evaluated on the basis of the following table:

Table 8-6 Connection scenarios and avoided costs

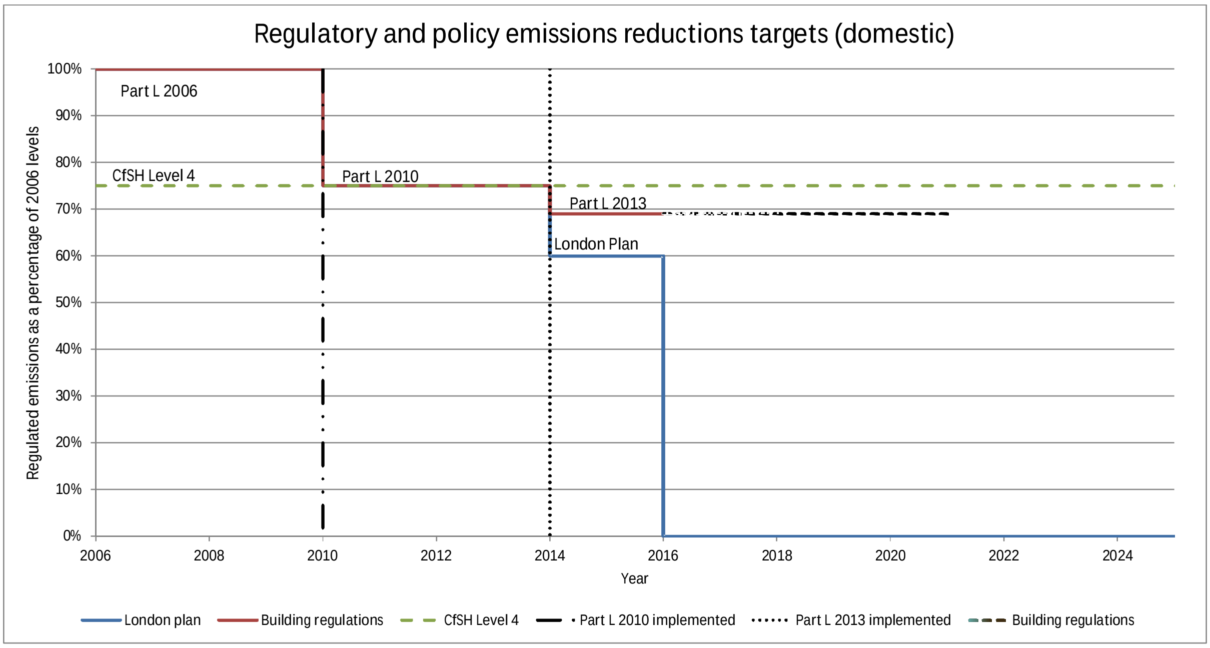
Scenario	Avoided costs
Connection to a DH network is available before completion of the first units / elements of the development.	Developer avoids cost of all primary heat supply plant on site. This includes plant, flues, M&E installation and energy centre space.
Connection to a DH network is available at some point between the first phase of completion and the total build-out of the site	Developer avoids cost of installation of all primary heat supply plant on site, but requires the hire / installation of temporary boiler plant to meet demands of early phase development
Connection to a DH network is only available after the completion of the development (within 5 years)	Cost of primary low carbon plant (e.g. gas-fired CHP) is avoided, but development would be anticipated to install its own boiler plant.
Connection to a DH network is only available after the completion of the development (5 years or more afterwards)	No avoided costs – low-carbon plant must be installed as on-site measure.

8.11.7 Connection charges can only be levied in the case of *new* developments. This is because *existing* sites will have existing heat supply equipment and therefore levying an upfront charge will dis-incentivise them to connect. Although connection charges are likely to be set following discussion with developers and further analysis, the avoided costs provide an indication of the levels of charge which are likely to be appropriate.

- 98 -

8.11.8 An indication of the carbon emissions reductions required by new developments is illustrated here:

Figure 8-3 Illustration of carbon targets



8.11.9 There is potential justification for developers to make a contribution to the cost of a DH scheme, but this depends on many factors specific to each site, including when planning permission was received (and therefore the Building Regulation and planning regime that applies), the degree to which required fabric measures might be impacted by a DH connection, the alternative supply options, etc. This level of detail should be incorporated at detailed feasibility level in dialogue with the developers of each site. This will allow the potential benefit to DH scheme roll-out of developer contributions to be assessed.

8.11.10 For the purposes of masterplanning this study has adopted a more generic approach and assumed a fixed level of contribution from new developments equivalent to a sum of £600 per kWe of estimated avoided CHP capacity (i.e. assuming that the 'alternative' technology would be local gas-fired CHP).

8.12 Economic analysis – heat sales price

8.12.1 As regards heat sales price the assumptions take into consideration the cost of gas, together with avoided costs of boiler maintenance and boiler replacement costs. Gas price is linked to DECC's statistical publication 'Quarterly Energy Prices – March 2014', and are indexed using the DECC energy and price projection 'reference scenario'.

8.12.2 The following assumptions have also been made:

- Typical new domestic gas boilers would operate at 90 percent boiler efficiency
- Avoided domestic boiler maintenance / servicing cost of £120 p.a.
- Avoided boiler replacement cost of £2500 on a 15 year cycle (annuitized).

- 99 -

- A 5 percent reduction in the overall cost of heat from this gas boiler base heat price has been applied to offer heat sales customers a saving on their 'alternative' supply scenario.

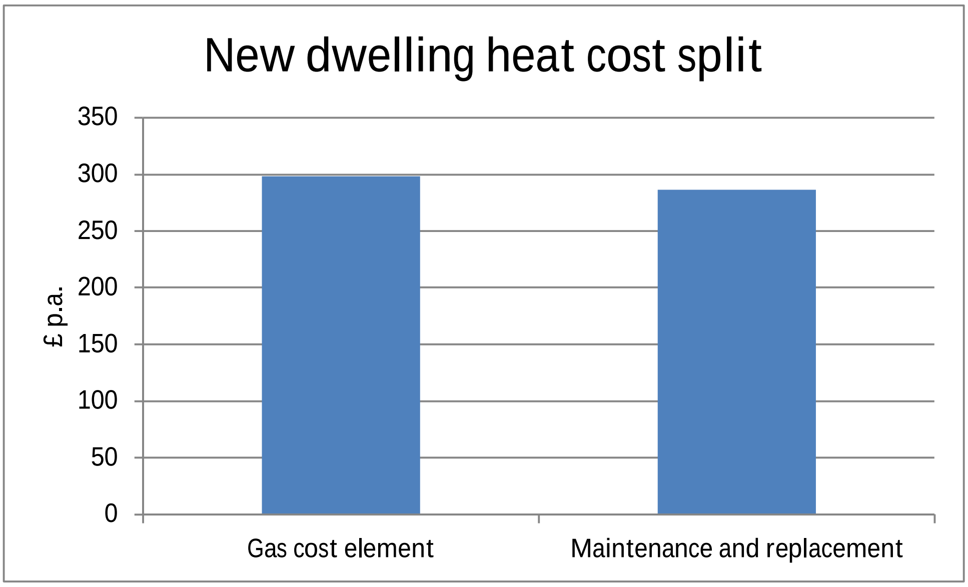
8.12.3 The following table illustrates this calculation process for new domestic customers:

Table 8-7 Calculation of new domestic heat sales price

Parameter	Value	Unit
Annual average gas bill	6,000	kWh
Assumed seasonal efficiency (new boilers)	90%	efficient
Units of heat delivered	5400	kWh heat
Gas unit cost (QEP, March 2014)	4.97	p/kWh
Gas cost	298.2	£ p.a.
Gas boiler replacement cost	2500	£
Replacement interval	15	years
Replacement cost annualised	167	£
Annual gas boiler maintenance	120	£ p.a.
Total cost of heat delivery via gas boiler	585	£ p.a.
Total unit cost of heat (all inclusive)	10.83	p/kWh
Proposed heat sales cost (heat from gas cost minus 5%)	**10.29**	**p/kWh**

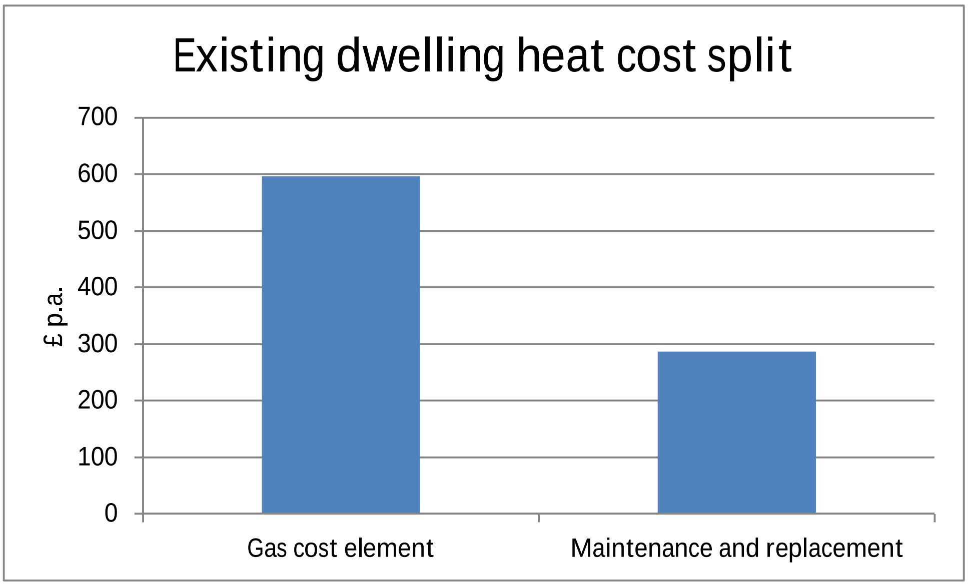
8.12.4 The following chart illustrates the constituent elements of these figures:

Figure 8-4 Elements of new-build domestic heat cost



8.12.5 The same calculation has also been carried out for existing domestic customers. This process assumes a higher typical gas volume (due to poorer quality construction of dwellings), and a reduced boiler efficiency. The split derived for existing domestic customers is as shown below:

Figure 8-5 Existing dwelling split between fixed and variable heat cost elements



8.12.6 For existing residential blocks, therefore, a heat sales price that reflects the smaller portion of 'fixed cost' elements has been adopted.

8.12.7 Heat sales prices for non-domestic customers have been based on the assumption that replacement and maintenance costs reflect 20% of overall heat unit prices. The avoided costs for non-domestic customers have been based on a non-domestic gas tariff (DECC, services sector, 2013). Existing non-domestic customers are assumed to be incentivised to connect by avoiding boiler maintenance and replacement costs i.e. the heat sales price adopted for this sector reflects only gas unit costs and boiler efficiency. In overall terms, therefore, the following table of heat sales prices has been derived and applied in the scheme modelling for this report:

Table 8-8 Summary of assumed heat sales values

Customer type	Heat sales value	Unit
New domestic	10.29	p/kWh (heat delivered)
New non-domestic	4.71	p/kWh (heat delivered)
Existing domestic	8.42	p/kWh (heat delivered)
Existing non-domestic	4.00	p/kWh (heat delivered)

SECTION 9

CURRENT BARRIERS TO DEPLOYMENT

- 103 -

9 CURRENT BARRIERS TO DH DEPLOYMENT

9.1.1 As can be seen in the analysis presented within this report, at the level of technical potential, it would appear that there is opportunity in the borough's built environment to implement district heating. However, if this is an efficient and economically attractive solution, why has it not happened already?

9.1.2 This section draws both on recent research commissioned by DECC[21] and PB's own experience of DH implementation.

9.1.3 Factors with the greatest impact on DH deployment identified in DECC's report are replicated below in Table 9-1.

Table 9-1: Barriers to establishing a heat network (Executive 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 (**)

21 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.

9.1.1 This Table 9-1 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 DH depolyment. This can be condensed arguably into the statement that it is the risk of investment and the difficulty of sourcing capital for DH systems that is the most significant barrier to DH deployment currently. A key challenge of this study 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.

9.1.2 Table 9-1 seems to represent the key barriers to DH once a scheme has been identified, but for the built environment in Greenwich a further set of challenges could also be associated with the identification of suitable networks for feasibility / viability testing. Development issues include:

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

9.1.3 Means of moving towards a system that circumvents or overcomes these issues are suggested in the delivery section of this report.

SECTION 10

ELECTRICITY SALES

- 107 -

10 ELECTRICITY SALES

10.1.1 The value of electricity generated through a decentralised energy scheme equipped with CHP can be maximised through the use of private wire networks. Whilst the wholesale price of electricity to the grid is around 2-5p/kWh, a private wire network – whereby an electricity network is installed between an energy centre and nearby electricity users – is able to maximise the value of energy generated by enabling retail values to be obtained (e.g. around 8-12p/kWh).

10.1.2 This may also be carried out through the use of 'netting-off' or 'sleeving' arrangements. Under this process, a power purchaser is able to form a direct contract with a third-party electricity supplier (i.e. a CHP operator), contracting to buy their electricity but using the grid distribution network. This allows the generator to obtain commercial prices, whilst the customer can benefit from, for example, the lower carbon content of the electricity generated. This arrangement is more suited to commercial customers which have higher load factors[22] and can guarantee to purchase significant quantities of electricity.

10.1.3 A further future option for electricity sale is the arrangement known as "licence lite". The licence should allow generated electricity to be procured by the public sector, providing generators with a higher price than would be obtained if they sold power directly to the grid under a traditional 'power purchase agreement'. This electricity would then be sold at cost price to other public sector organisations. PB has liaised with GLA to establish the stage of development of this mechanism. The GLA has advised that as at July 2014, whilst there is broad political support for the concept it is still too early in its development to incorporate the mechanism in business planning.

10.1.4 PB would strongly recommend that electricity private wire sales are pursued for the RBG schemes identified wherever possible. The key network identified as part of this study, the GPS strategic scheme, will sell its generated power directly to the TfL network.

10.1.5 The electricity sales prices assumed in the techno-economic analysis are as follows:

Table 10-1 Assumptions for electricity sales routes

Sales route	Price assumption	Value in 2013	Source
Export to grid	65% of wholesale electricity prices	2.84p/kWh	Based on DECC energy price projections (September 2013)
Private wire sales	90% of electricity import prices	8.30p/kWh	Based on DECC energy price projections (September 2013)
Sale to TfL (GPS scheme)	2.36p/kWh above wholesale	7.09p/kWh	Based on indicative price provided by

[22] Load factor is the ratio of average load to peak load in a given time period. A higher load factor means that average load is closer to peak load, i.e. there is a more constant electricity demand.

	electricity prices		TfL, and linked to DECC energy price projections (wholesale)

SECTION 11

ENERGY SOURCES FOR HEAT GENERATION

- 111 -

11 ENERGY SOURCES FOR HEAT GENERATION

11.1 Technology choices (generalised analysis)

11.1.1 This section comprises a summary of the possible heat sources which could be used to supply decentralised energy schemes within the Royal Borough of Greenwich. As well as traditional heat sources, opportunities to use waste heat are also considered within this section.

11.2 Secondary heat sources

11.2.1 Secondary sources of heat, or sources of waste heat, are those which are either the by-product of a process, or are available from the environment. Typical sources of secondary heat are listed within the table below, together with comments on the availability of the heat sources within Greenwich. Information on the resources available within the borough of Greenwich has been obtained from the GLA's report *London's Zero Carbon Energy Resource: Secondary Heat, Report Phase 1*, January 2013[23].

Table 11-1 Secondary heat sources

Secondary heat source	Description	Relevance to Greenwich
Ground source heat pumps	Ground temperature remains at relatively stable throughout the year. Heat may be extracted using heat pumps.	This source of heat could be used within Greenwich, although is more likely to be suited to smaller scale systems (i.e. heating individual buildings) rather than wider decentralised energy schemes.
Air source heat pumps	Heat may be extracted from outside air and its temperature raised using a heat pump.	This technology may be used in Greenwich, but again is more suited to individual buildings rather than wider district heating schemes. The amount of heat which can be extracted is proportional to air temperature, meaning that less heat can be extracted in winter, when demand is highest.
Reservoirs, watercourses and aquifers	Heat can be extracted from reservoirs and watercourses using heat pumps. A licence may be required from the Environment Agency for the extraction of water from certain sources.	Greenwich is sited adjacent to the Thames, and an extraction licence already exists at GPS. Water has a relatively high thermal capacity meaning that reasonably high amounts of heat can be extracted. In addition, its circulation aids heat transfer

23 https://www.london.gov.uk/sites/default/files/130220%20031250%20GLA%20Low%20Carbon%20Heat%20Study%20Report%20Phase%201%20-%20Rev01.pdf

- 113 -

Power station rejection	Significant amounts of waste heat are rejected from conventional power stations.	There are no operational power stations within RBG (i.e. excluding GPS). However, the SELCHP and the Riverside Resource Recovery facilities (EfW power plants) could provide heat in the longer term. These are covered in more detail below.
Industrial heat sources	Some industrial heat sources (e.g. chemical and food processing plants) provide relatively high amounts of waste heat. This can be significantly variable, however.	There are no known relevant process loads within the borough.
Data centres	Data centres produce a significant amount of waste heat, which may be extracted using heat pumps.	No data centres are mapped within the borough. Generally, the location of commercial data centres is kept secret, and so locations may not be known.
Water treatment works	Low temperature heat is released from bacterial activity on sewage. Heat may be obtained from the treated sewage by passing it through a heat exchanger before discharge. As in the case of watercourses, a heat pump is required.	There are no significant sewage treatment works within RBG. The closest significant facility is Crossness STW, adjacent to the RRRL plant in Bexley.
London Underground	Heat may be recovered either from stations themselves, or from mid-tunnel ventilation shafts using heat exchangers. Although the temperature within tunnels will vary throughout the year, it is generally higher than the surrounding air temperature.	There are a limited number of tube stations within the borough.
Electrical substations	Large transformers are oil cooled, and heat extracted from this process can be used within district heating systems. Generally only transformers operating at voltages of 33/11kV and above would produce enough heat to make extraction worthwhile (estimated at 300kW of heat per transformer)	There are no transformers of a suitable size located within the borough.
Sewer heat mining	Heat may be extracted from waste flowing through sewers	Some sewers of significant size flow through the borough

- 114 -

11.2.2 Benefits of using waste heat can be significant. These include:

- Reduced cost of heat compared to traditional sources
- Reduced reliance on the volatile fossil-fuel market
- Potential for very low carbon heat supply, as waste heat is generally regarded as carbon neutral, or very low carbon.

11.2.3 However, there are some key considerations. Firstly, by its very definition waste heat is of a low temperature, and this will need to be raised using heat pumps prior to use within a district heating network. As such, it is best suited to use on low temperature networks – to reach higher temperatures requires greater electrical input which, under typical market conditions, makes operation uncompetitive with gas. The efficiency of heat pumps is known as coefficient of performance (CoP); typically this is around 3 to 4.

11.2.4 Secondly, efficient operation of a low temperature network requires the secondary systems installed within buildings to have sufficient heat transfer capacity and be designed to deliver low return temperatures. This generally means the installation of large radiators or underfloor heating systems. However, this is considered best practice for district heating systems in general - maximising the temperature differential increases the amount of heat which can be transferred within a certain pipe size and reduces heat losses from the network, leading to greater efficiency and reduced costs. However, in view of this, such supply would be best suited to new buildings within the borough, where this technology could be installed from the outset, rather than in existing buildings where a potentially costly retrofit would be necessary.

11.2.5 Thirdly, the use of waste heat lends itself best to a decarbonised grid, where the carbon content of the electricity used within heat pumps is low. Thus this technology could be a good contender for use in the longer term when it is expected that new-build nuclear and large-scale wind generation will lead to significant decarbonisation of grid electricity.

Electrical substations

11.2.6 A map showing the approximate location of major National Grid transformers in Greater London is shown below[24]. As can be seen, there are no significant sites within the RBG.

24 http://www.london.gov.uk/sites/default/files/130220%20031250%20GLA%20Low%20Carbon%20Heat%20Study%20Report%20Phase%201%20-%20Rev01.pdf

<u>Power stations</u>

11.2.7 There are two major potential sources of heat located in or near the Royal Borough of Greenwich. These are:

- Greenwich Power Station (GPS)
- Riverside Resource Recovery (RRR) Energy from Waste (EfW) facility in the London Borough of Bexley

11.2.8 Greenwich Power Station is a gas/oil fired back-up plant to the London Underground network, able to provide emergency power in the event of a power failure from the National Grid. Owing to its location close to Greenwich town centre, Greenwich Peninsula and Deptford it has the potential to supply significant amounts of heat to decentralised energy networks within the north-west of the borough. Consultants have been employed by TfL to assess the opportunity for potential additional generation, and the outputs of this study will not be available until after the delivery of this masterplan.

Thamesmead AD facility

11.2.9 An AD plant was proposed for the Thamesmead area, to process food waste both from the RBG and the neighbouring borough of Bexley. Heat generation was predicted to be 12.8GWh per year, varying from month to month, from a maximum of 1.34GWh in June to a minimum of 0.69GWh in February. However, development of this facility is no longer being taken forward.

11.2.10 Nevertheless, in broader, strategic terms it is assumed that this site is considered suitable for energy developments of a similar nature, and hence it is assumed that at some point in the future, plant may be constructed that has potential to supply heat to buildings in the east of the borough, and to the nearby Belmarsh Prison in particular. The location of the proposed plant is illustrated in the figure below.

Figure 11-1: Location of proposed Thamesmead AD plant

11.2.11 As can be seen, the site is located very close to HMP Belmarsh (immediately to the west of the AD plant site in the illustration above). Should the AD plant go ahead, the prison, as a high heat user, should be strongly encouraged to form part of a future network served by low-carbon heat from the plant.

Riverside Resource Recovery

11.2.12 Located to the east in the neighbouring borough of Bexley, the RRR facility processes 670,000 tonnes of waste per annum and exports around 470GWh of electricity.

11.2.13 The plant is designed with the capability of providing heat for district heating uses. However, it is located some distance to the east of RBG, (around 4km from the Thamesmead AD plant) which would make a connecting heat transmission main expensive. In addition, a report concluded that "the density of heat customers in the local area is substantially lower than is typical for district heating systems in the UK."[25]

11.2.14 Despite the design of the plant being compatible with DH supply, to PB's knowledge, no heat off-take has to date been implemented at the RRR site though there have been a number of developments that have come forward in the vicinity of the plant.

11.2.15 In strategic terms, for the purposes of a masterplan for RBG where there is already a potential heat supply plant within the borough boundary (i.e. GPS) with the potential to supply heat to the eastern waterfront of the borough, the safeguarding of the DH supply route to/from the RRR site would only add marginal benefit at substantial additional cost (in terms of larger diameter pipes). The proposal here for DH pipe network would in any case allow for the supply of heat from the RRR facility (i.e. in an east-west direction) up to the carrying capacity of the pipework proposed under the outline designs contained here. The position of this report is that the infrastructure capacities proposed (designed on the basis of west-east supply from GPS) should not be increased on the assumption that *additional* supply capacity may be required at some point in the future from RRR. Other strategic links are considered more important in this context i.e. the Silvertown Tunnel link.

<u>Watercourses/ reservoirs</u>

11.2.16 Although this technology is less widespread than air and ground source heat pumps, heat can also be extracted from water via heat pumps. Water has the following advantages when compared to air and ground source heat pumps:

- Flow of water provides constant provision of heat
- Greater thermal capacity (and thus greater scope for heat extraction) when compared to air source heat pumps
- Lower installation costs versus ground source heat pumps (no need to dig trenches or sink boreholes)

11.2.17 Within Greenwich the obvious water source is the river Thames. As the GPS has an existing abstraction licence and the abstraction infrastructure it is likely to be the most cost-effective location for a water source heat pump.

<u>Sewer heat mining</u>

11.2.18 The map below shows the location of Thames Water trunk sewers within London together with the heat which might be extracted from them. As can be seen, there are several major sewers running through the borough, with the potential for fairly significant heat extraction.

[25] http://www.coryenvironmental.co.uk/page/rrrcasestudy6.htm

Figure 11-2 Potential sewer heat mining map

11.3 Technology choices (generalised analysis)

11.3.1 This section provides an analysis of the available heat supply technologies, together with an assessment of their viability for the provision of heat to decentralised energy schemes within RBG, and the timeframe within which they might be implemented (i.e. for kick-start schemes, medium-term phases or longer-term supply).

11.3.2 The following technologies are reviewed:

- Natural gas fired CHP
- Biogas fired CHP
- Biomass gasification CHP
- Solid biomass CHP
- Municipal Solid Waste (MSW) or Refuse Derived Fuel (RDF) CHP

Natural gas fired CHP

11.3.3 This is the most commonly used type of CHP, as such the technology is well developed and readily available. Two main engine types are available: reciprocating engines, which are generally available in sizes from around 10kW output up to a typical maximum of 4-5MW, although engines of up to 10MW are available; and gas turbines, which are available from around 1WM output to the scales found in utility power stations.

- 119 -

Biogas –fired CHP

11.3.4 Reductions in the carbon content of heat may be made through burning biogas rather than natural gas within a reciprocating engine or gas turbine CHP. The main sources of biogas are listed below:

- Landfill gas: Landfill sites produce a mixture of gases, with methane a significant component (generally around 50%). This may be burned within a specially adapted CHP engine. However, yields are often variable and unpredictable.
- Anaerobic digestion: An organic feedstock, typically sewage, food or animal waste, is fermented within a temperature-controlled digester. A methane rich biogas is produced, consisting of around 60% methane, 40% CO_2 and traces of other gases[26].

11.3.5 As there are no landfill sites within the borough, this energy source may be discounted.

11.3.6 The other possibility is the use of biomethane produced offsite. Under this process, biogascould be produced offsite (i.e. outside the borough), near the source of the feedstock, cleaned to remove CO_2 and other impurities, leaving just methane, which can be injected into the National Transmission System and supplied to sites in the borough to generate renewable heat and power.

11.3.7 The process is administered through the Green Gas Certification Scheme (GGCS), part of the Renewable Energy Association (REA). The GGCS tracks (contractually, rather than physically) the passage of biogas through the national gas grid, from point of injection through to its end use. This eliminates the possibility of double counting of biogas sales, providing certainty for end users that what they are buying is effectively green gas. The plant that is installed locally under this type of scheme would be natural gas fired plant.

Table 11-2: Biogas fuelled reciprocating engine key performance criteria (notional 2MWe unit)

Parameter	Value
Carbon emissions factor (fuel) $kgCO_2$ / kWh	0.098
Typical electrical efficiency (%)	40
Typical thermal efficiency (%)	40
Typical availability (%)	92

Biomass gasification CHP

11.3.8 Biomass gasification is a further source of biogas, and involves heating wood-based biomass in a controlled atmosphere to form a synthetic “wood gas” or syngas. The following key items of plant would be required:

- Wood store
- Fuel transfer systems
- Gasifier

[26] http://www.biogas-info.co.uk/index.php/what-is-anaerobic-digestion.html

- 120 -

- Gas cleaning equipment
- Gas storage tank
- CHP engine
- Selective catalytic reduction (SCR) NOx
- Ground based enclosed flare stack

11.3.9 The following points should furthermore be noted:

- As the gasification process is not easily modulated it is necessary to provide an onsite gas store to decouple the supply of gas and its use within a CHP engine. A fuel store is also required to allow sufficient quantities of feed stock to permit the gasifier to operate as required. This is likely to be delivered by articulated vehicle.
- PB's experience with gasifiers suggests that owing to the strict fuel specification requirements as little as 20% of the biomass feed stock may be of suitable dimensions for utilisation by the gasifier. Fuel specifications relate both to the size and moisture content of the wood. Although this may be mitigated by using specially prepared briquettes of compressed sawdust this significantly increases costs compared to, for example, wood chip.
- Although there are a number UK suppliers which can provide syngas-compatible engines, in dealing with small scale gasification CHP technology PB has not yet encountered a system that can demonstrate acceptable levels of availability. The technology is beset with issues surrounding fuel handling and quality; this results in the consequent production or tar in the system, leading to regular significant maintenance to clean the plant. For this reason an availability of 55% can be considered as representative.

Table 11-3 Biomass gasification and CHP performance assumption

Parameter	Value
Carbon emissions factor (fuel) $kgCO_2$ / kWh	0.028
Typical electrical efficiency (%)	28
Typical thermal efficiency (%)	22
Typical availability (%)	55

<u>Solid biomass CHP</u>

11.3.10 Solid biomass CHP plants take two forms: either steam turbines, in which the working fluid is water; or an organic Rankine cycle (ORC) engine, which uses an oil as the working fluid. In general, the latter are smaller (owing to the denser fluid), permit lower temperatures and pressures to be used, and as a result have less stringent safety requirements and are lower cost.

11.3.11 A variety of fuels may be burned, these include wood chip, wood pellets (made from compressed sawdust or other wood products), crop residues such as straw and crops grown especially for energy use such as miscanthus or short-rotation coppice.

11.3.12 Generally, the main items of plant required are:

- Biomass fuel store and fuel transfer mechanism
- Biomass Boiler and ancillary equipment to raise steam from wood fuel
- Steam Turbine and ancillary steam plant
- Alternator and ancillary electrical equipment
- Steam to low temperature hot water heat exchanger

11.3.13 A key consideration in relation to biomass systems is the availability of a ready supply of fuel, together with access requirements for delivery.

Table 11-4 Solid biomass CHP performance assumptions

Parameter	Value
Carbon emissions factor (fuel) $kgCO_2$ / kWh	0.028 (wood pellet)/ 0.009 (wood chip)
Typical electrical efficiency (%)	15
Typical thermal efficiency (%)	48
Typical availability (%)	92

Glycerol CHP

11.3.14 Glycerol, or glycerine, is a by-product of biodiesel production. For every tonne of biodiesel produced, around 100kg of crude glycerine is formed; this has a high salt content and must be refined prior to use.

11.3.15 Within the UK there are very few refineries with the capability to refine glycerine, so the supply at fuel grade is currently limited and of relatively high price.

11.3.16 The fuel is burned in a modified diesel engine.

11.3.17 Typical performance characteristics are set out in the table below:

Table 11-5 Glycerol CHP performance assumptions

Parameter	Value
Carbon emissions factor (fuel) $kgCO_2$ / kWh	0.0108
Typical electrical efficiency (%)	35
Typical thermal efficiency (%)	45
Typical availability (%)	92

11.4 Heat sources for kick start phases

11.4.1 During the early phases of decentralised energy scheme provision within the borough (i.e. a time frame of around 10 to 15 years into the future), it is recommended that established, readily available technologies such as gas-fired CHPs be installed. This would allow schemes to quickly become operational, especially within the regeneration areas / areas of significant development within the borough.

11.4.2 It is strongly recommended, however, that the installed technology allows compatibility with future energy sources. To this end, the installed systems should:

- Operate at low temperatures, in order to minimise heat losses on the network and allow future use of waste heat which would be provided at a lower grade
- Maximise the difference between network flow and return temperatures to minimise the diameter of pipework required to transfer heat, thus reducing cost.

11.4.3 The *London District Heating Manual* recommends the following temperatures be used on either side of HIUs:

Table 11-6 London District Heating Manual recommended design temperatures

Parameter	Flow temperature (deg. C)	Return temperature (deg. C)
Primary side space heating (deg C)	110 to 80	55
Primary side DHW (Deg C)	70	25
Space heating (new development) (Deg C)	70 to 80	40 to 50
Space heating (renovation) (Deg C)	80	60
DHW (new development) (Deg C)	55	10
DHW (renovation) (Deg C)	55	10

11.4.4 However, temperatures as low as 70 flow and 30 return can be achieved on the primary side.

Municipal Solid Waste (MSW)

11.4.5 MSW involves burning household waste to generate heat and electricity. Although there are no plants located within the borough of Greenwich, the following are located nearby:

- SELCHP (South East London Combined Heat and Power) - located in south Bermondsey, the plant has an electrical output of 35MW, and provides heat to the Southwark Low Carbon Heat Network
- Riverside Resource Recovery – located in Belvedere in the Borough of Bexley.

11.4.6 Both of these could potentially provide heat to the network, although they are located at some distance from the proposed route – especially in the case of the Riverside Resource Recovery facility. In addition, SELCHP is also now providing heat to the Southwark Heat Network, and is also anticipated to expand this customer base, which could limit the amount of heat available to other networks.

- 123 -

SECTION 12

COSTS, TECHNO-ECONOMIC MODELLING, VIABILITY AND CIL

- 125 -

12 COSTS, TECHNO-ECONOMIC MODELLING, VIABILITY AND CIL

12.1 Results

12.1.1 The outputs from the economic modelling outlined in the sections above are presented in this section. For Schemes 1 (Plumstead), 2 (Woolwich) and 8 (Deptford) the sensitivity of each scheme's performance to two electricity sales prices has been analysed. The two prices adopted are:

- export to the grid (i.e. power purchase agreement)
- electricity sales via a private wire network

For scheme 6, and the Greenwich-wide network, it is assumed that all electricity generated would be sold to TfL.

12.1.2 It must be noted that the potential for private wire sales is speculative (i.e. electricity sales customers have not been identified as part of this study), and these results are included here as an illustration of the importance of this element for scheme viability, and as an indicator of how delivery should be managed.

12.1.3 Capital costs in analysis at this stage have not included any contingency.

12.1.4 Results are presented as discounted cumulative cashflows and net present values over a 25 and a 40-year timeframe, using a discount rate of 6%. For each scheme, the CHP sizes as set out in Section 8.3 are set out.

12.1.5 The cost assumptions here also do not contain a potential uplift in funding available from ECO – which would be linked to the connection of residential properties and the resultant carbon savings achieved.

12.1.6 Scheme 1 - Plumstead

<u>Wholesale electricity</u>

12.1.7 The graph below shows the performance of the four different CHP options over a forty-year timeframe. As can be seen, there is little difference between them, although the ENER-G 50 performs slightly better from an economic perspective. The 'steps' at 2034 and 2039 represent replacement costs for elements of the installation through time.

- 127 -

Figure 12-1: Discounted cumulative cashflow, Scheme 1, exported electricity

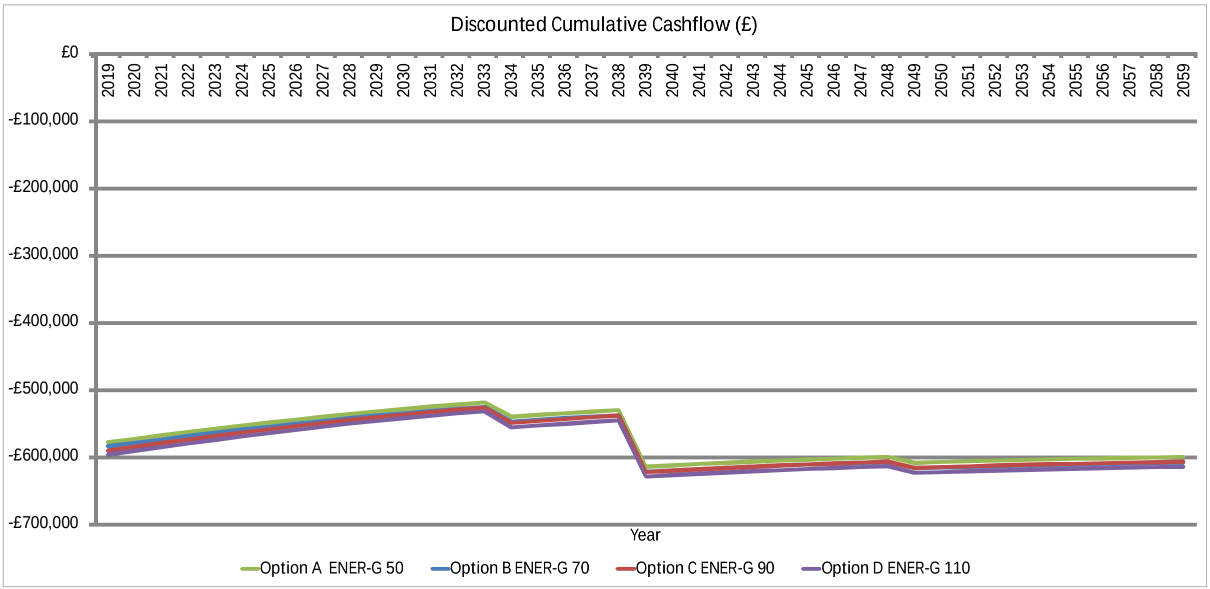
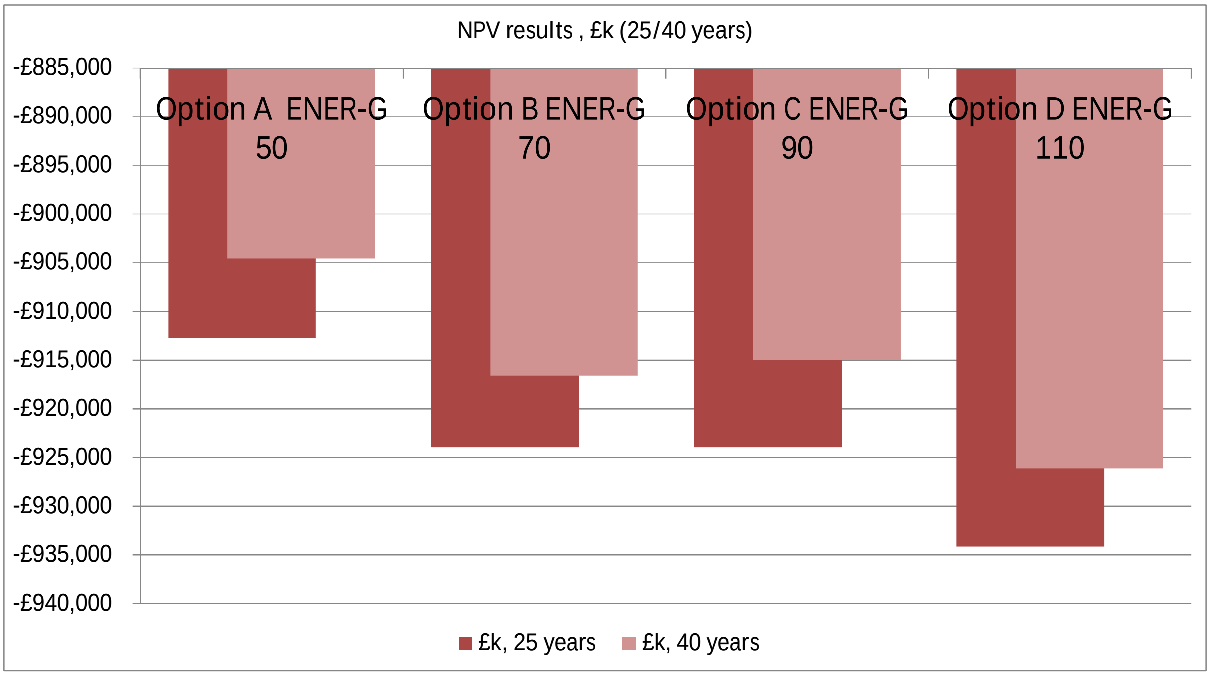
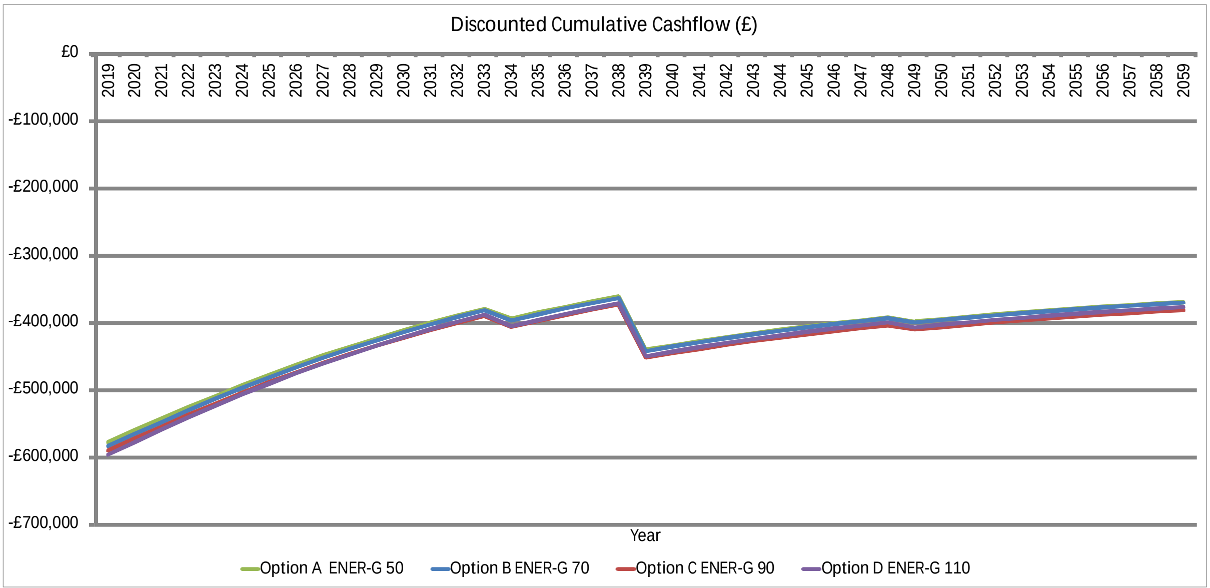


Figure 12-2: 25 and 40 year NPVs, Scheme 1, export electricity



Private wire electricity sales

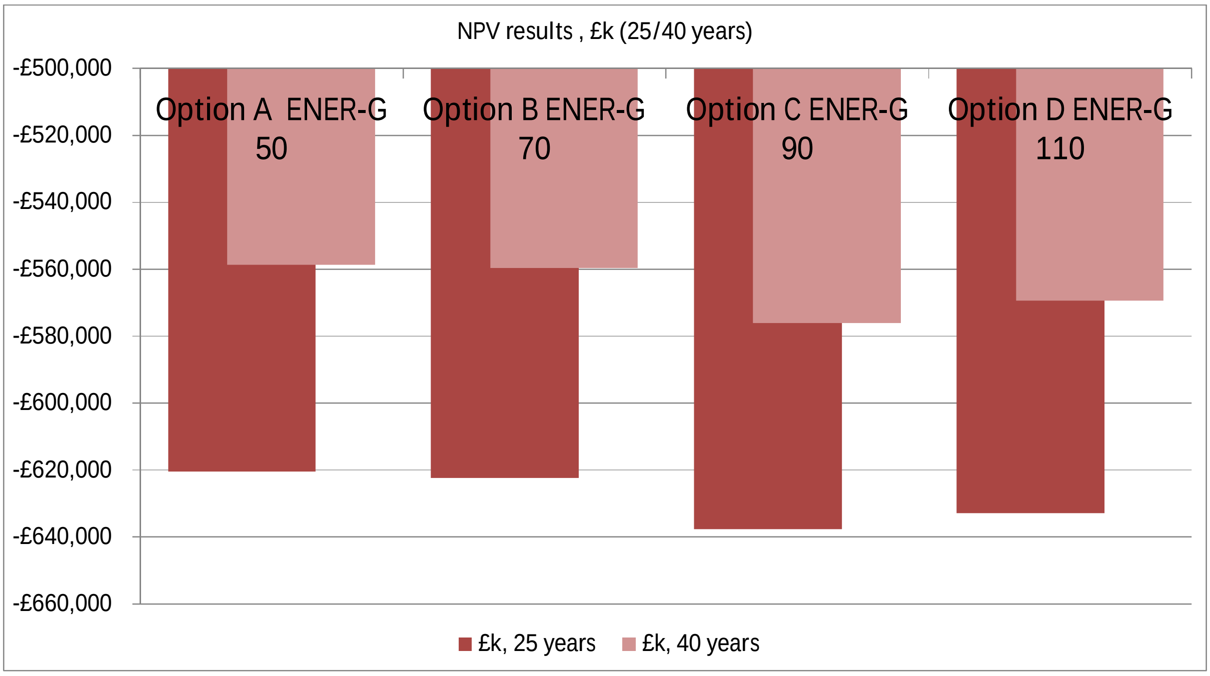
Figure 12-3 Scheme 1 – private wire electricity sales



12.1.8 Of note here is the impact that electricity sales price is able to have on the performance of the scheme. In order to ensure that the implemented scheme delivers a sustainable financial performance, the implementation of a private wire network should be fully investigated. It is envisaged that this could involve consideration of locating the CHP at the school, and matching its capacity to the available electrical demand of the Plumstead Manor Secondary School, or alternatively running cables alongside the DH link back to the school if the energy centre is located on the development site.

12.1.9 NPV graphs showing the scheme's financial performance over a 25 and 40 year timeframe are provided in the figure below.

Figure 12-4: Scheme 1 NPV, private wire electricity sales



12.1.10 It can be seen that there is a 'funding gap' calculated for Scheme 1 of around £600k (under a private wire scenario). Whilst the scheme is relatively simple, the small heat loads do not allow the economies of scale of installation required to make this a more commercially viable venture.

12.1.11 Scheme 2 - Woolwich

<u>Wholesale electricity</u>

12.1.12 The performance of the four different engine combinations trialled under Scheme 2 is shown in the graphs below. There is some difference between the performance of the four engines, and the smallest engine, the JMS 616, delivers the best performance of those analysed.

Figure 12-5: Scheme 2 - Discounted cumulative cashflow, export electricity

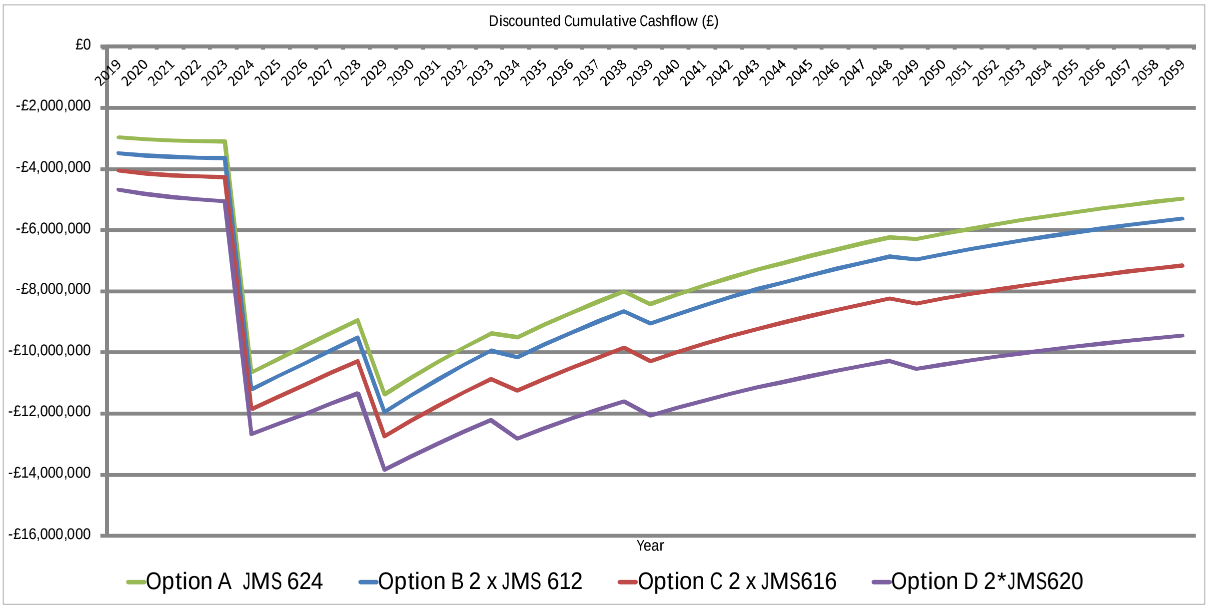
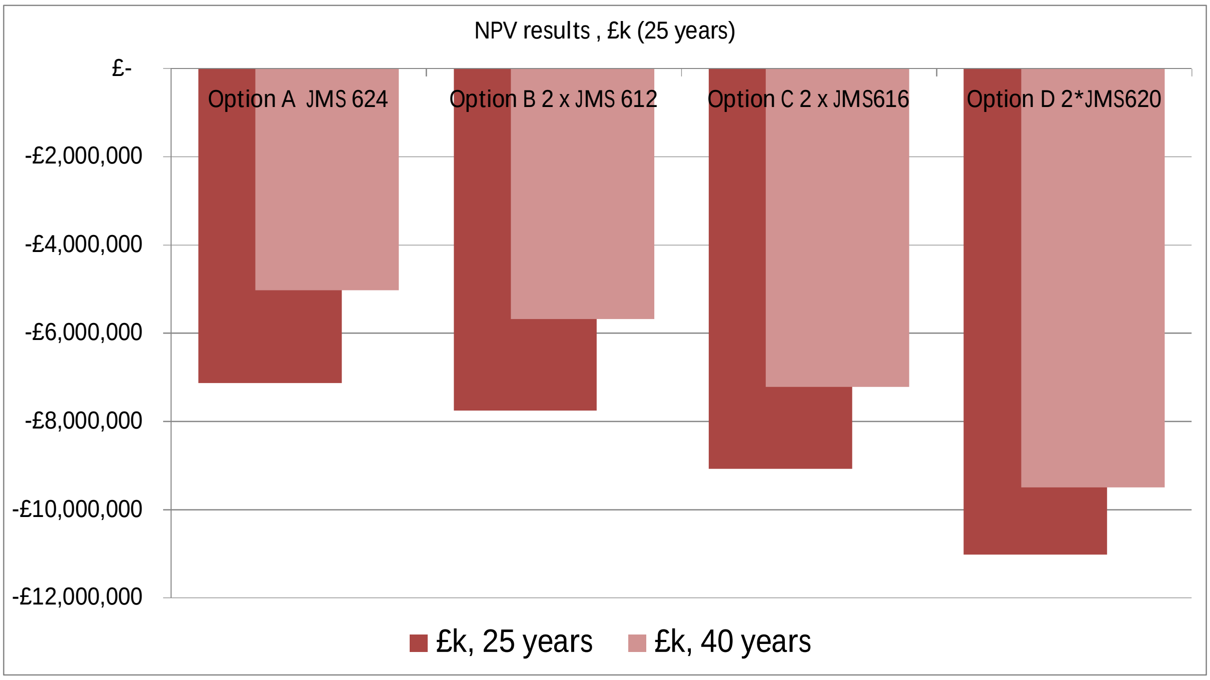


Figure 12-6: Scheme 2 - 25 and 40 year NPV, wholesale electricity



<u>Private wire electricity sales</u>

12.1.13 The performance of Scheme 2 if the electricity is sold via a private wire network is illustrated in the two figures below. As can be seen, the scheme performs strongly financially, with the largest CHP, the JMS 624 performing the best.

Figure 12-7: Discounted cumulative cashflow, Scheme 2, private wire electricity sales

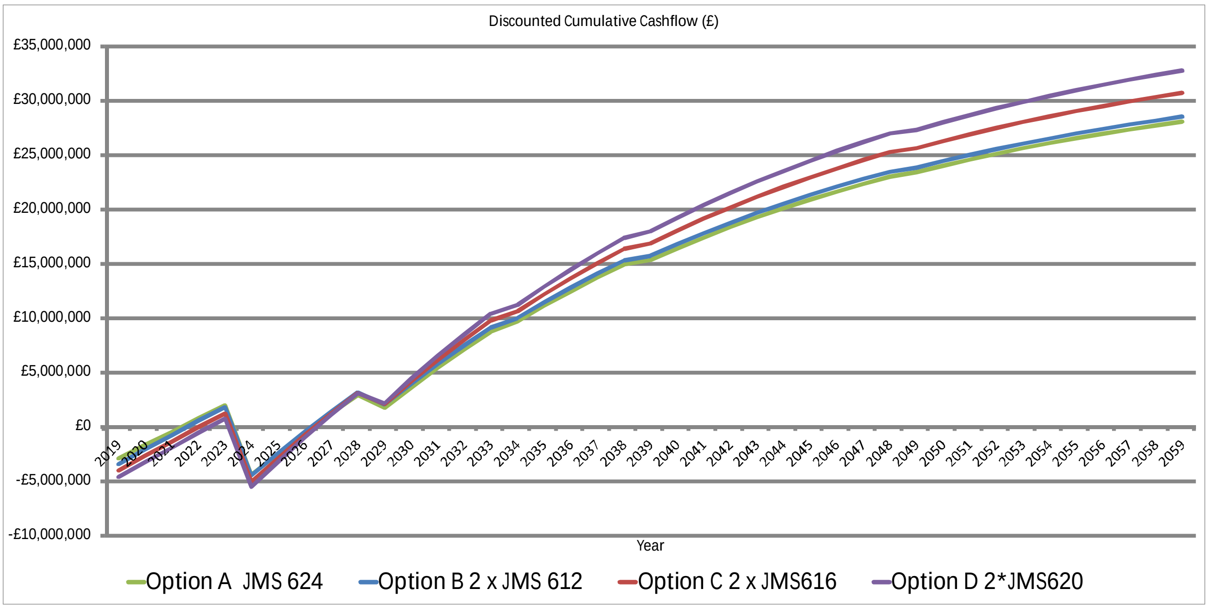
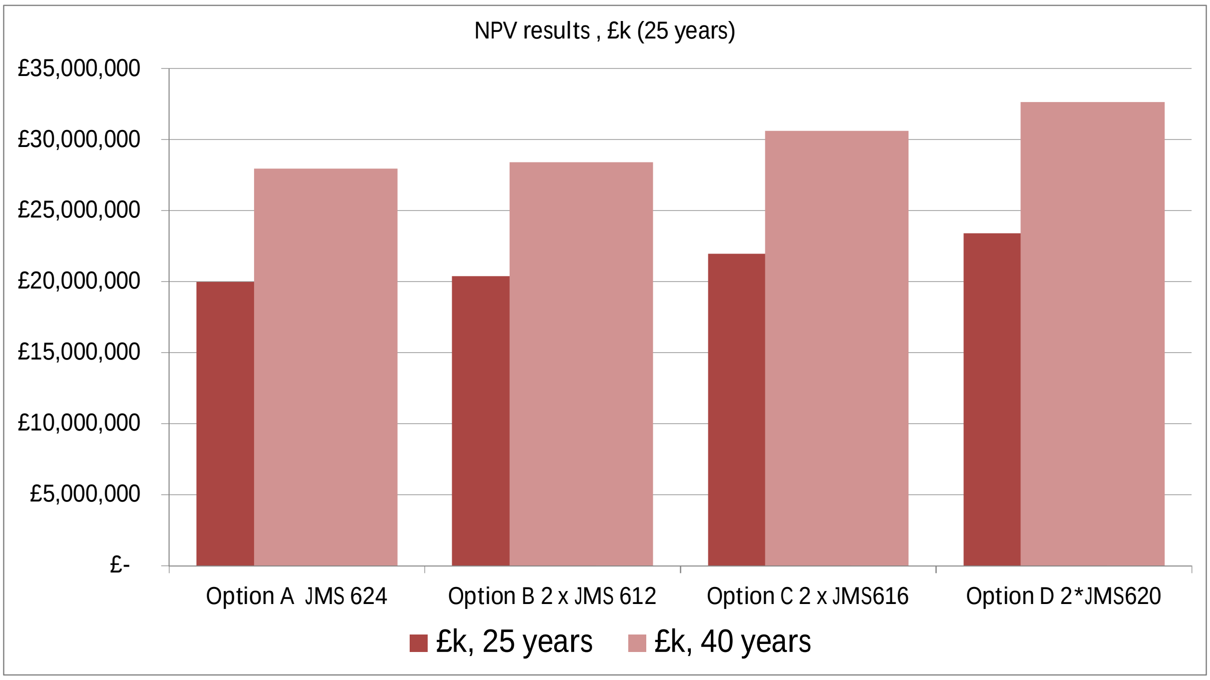


Figure 12-8: 25 and 40 year NPV, private wire electricity



12.1.14 These results clearly illustrate the importance of obtaining maximum value for the electrical revenue stream associated with CHP. As noted above, a customer base for electricity sales under this scheme has not been identified, and hence these results are speculative. They are included here to illustrate the additional value that private wire sales can deliver to the operational income of a CHP scheme. There would also be capital cost implications associated with the private wire infrastructure required, that are not reflected in the capital costs shown above. Further design work for this scheme should focus on the potential to supply large individual sites with power.

- 132 -

12.1.15 Scheme 6- Greenwich Power Station Waterfront

12.1.16 As the energy centre for Scheme 6 is Greenwich Power Station, it is assumed that all electricity generated will be sold to TfL. The graphs below show the discounted cumulative cashflow and NPV results under this scenario only. As can be seen, it is the largest engine, the JMS 624 which performs the best for this scheme. This scheme assumes that the Greenwich Peninsula is a separate entity supplied by the Pinnacle Power energy centre. Consideration of the impact of connecting the peninsula and other loads is given within the 'full scheme' analysis.

Figure 12-9: Discounted cumulative cashflow, Scheme 6, electricity sales to TfL

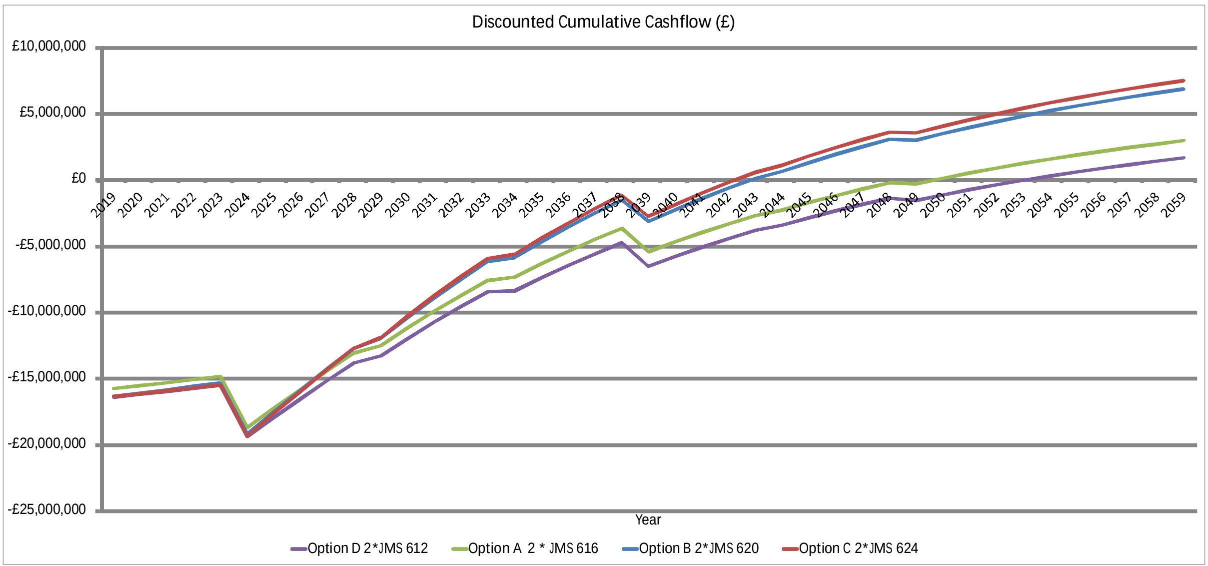
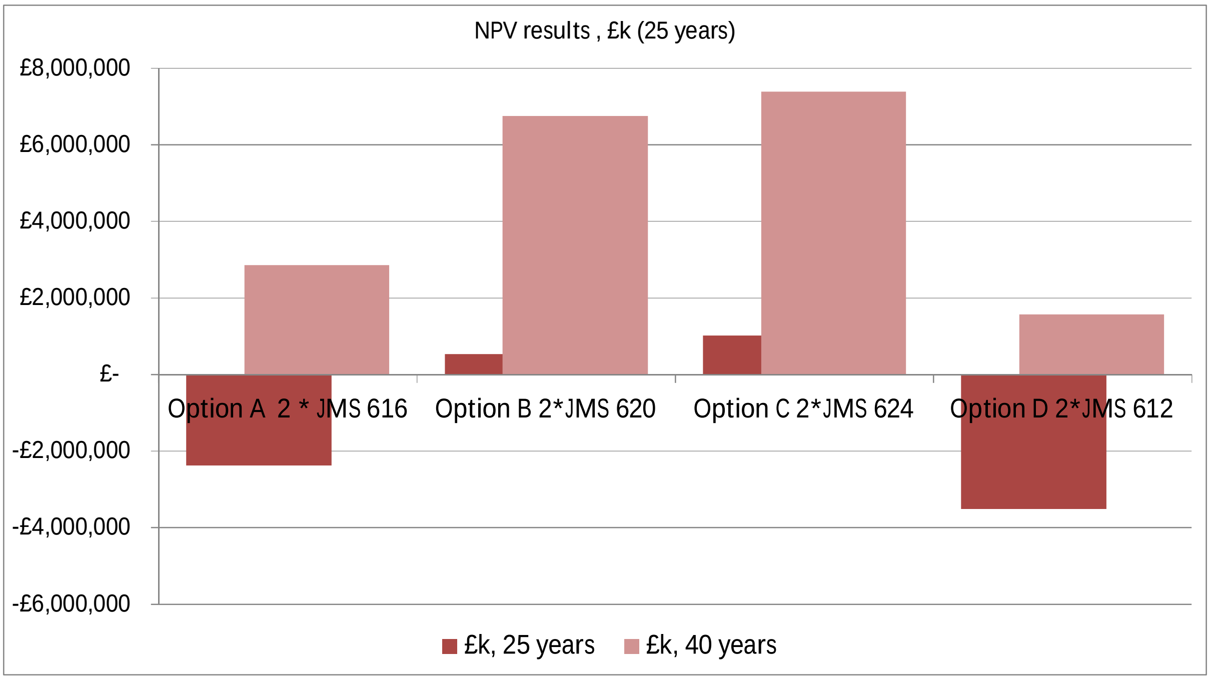


Figure 12-10: GPS Waterfront, NPV results (6%, 25 and 40 years)



12.1.17 Scheme 8 – Deptford

<u>Exported electricity</u>

12.1.18 The economic performance of Scheme 8 is illustrated in the graphs below. The largest heat customer for this scheme would be the Convoy's Wharf development, which accounts for 72% of the total annual load. As the Convoy's Wharf development would need to install a district heating network on site in any case, it is assumed that its associated energy centre building would be made larger to accommodate the additional capacity required to supply the rest of the network, and that this cost would be borne by the developer. Thus the cost of the energy centre building has not been included within modelling.

Figure 12-11: Discounted cumulative cashflow, Scheme 8, exported electricity

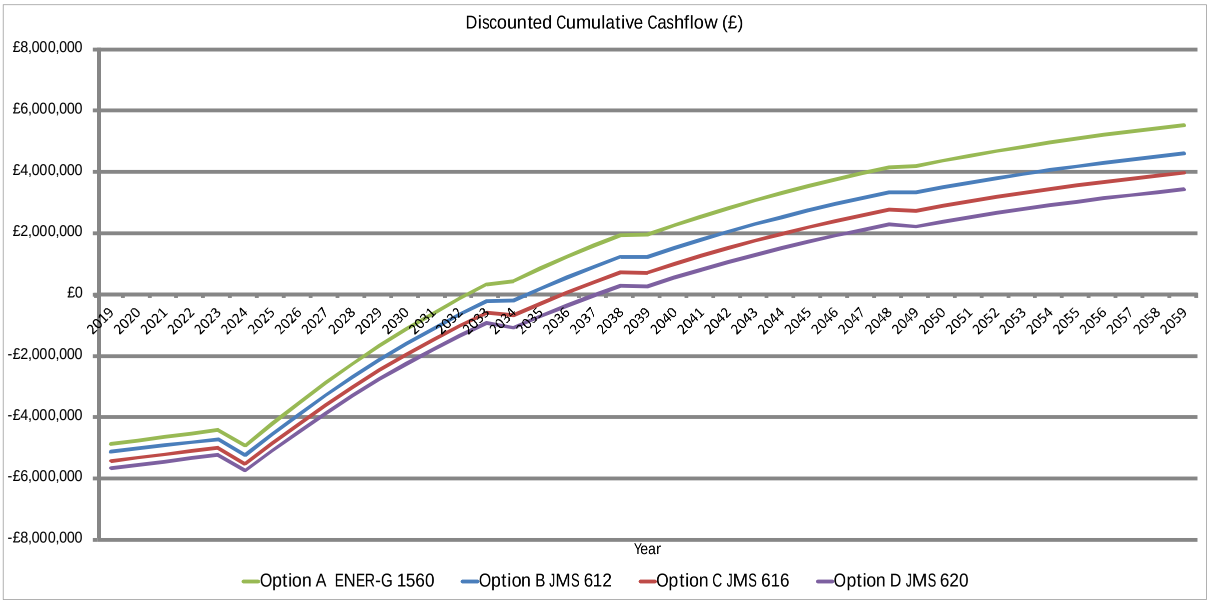


Figure 12-12: 25 and 40 year NPVs, Scheme 8, exported electricity

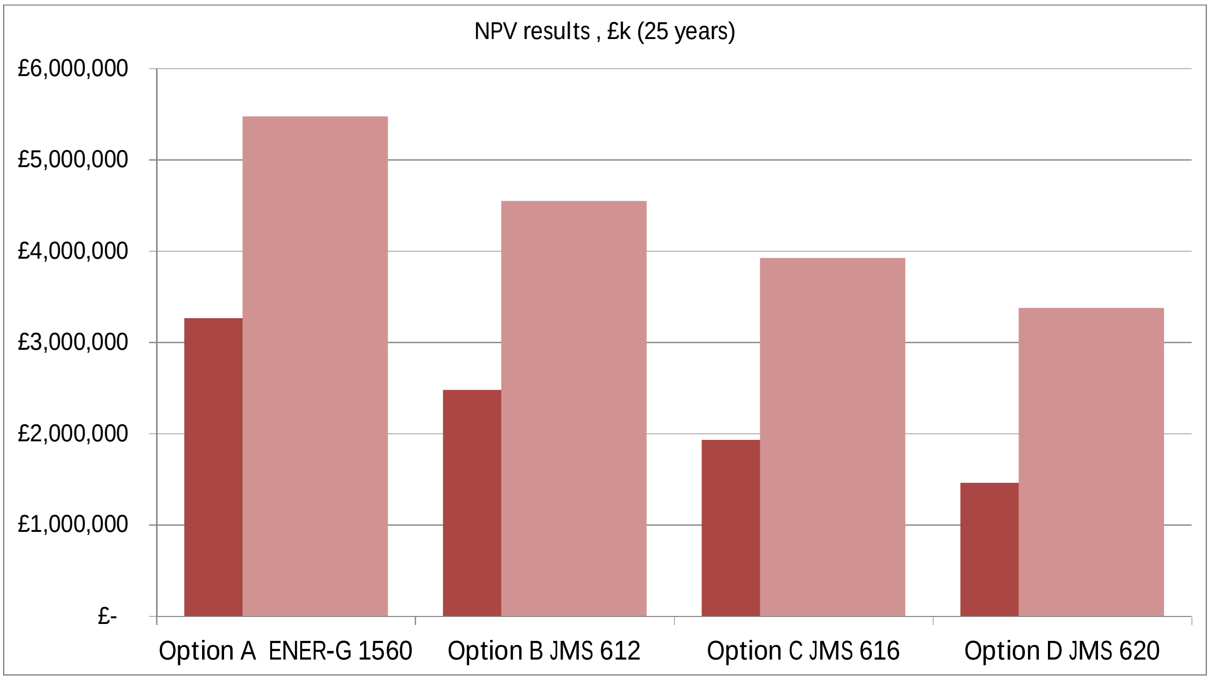
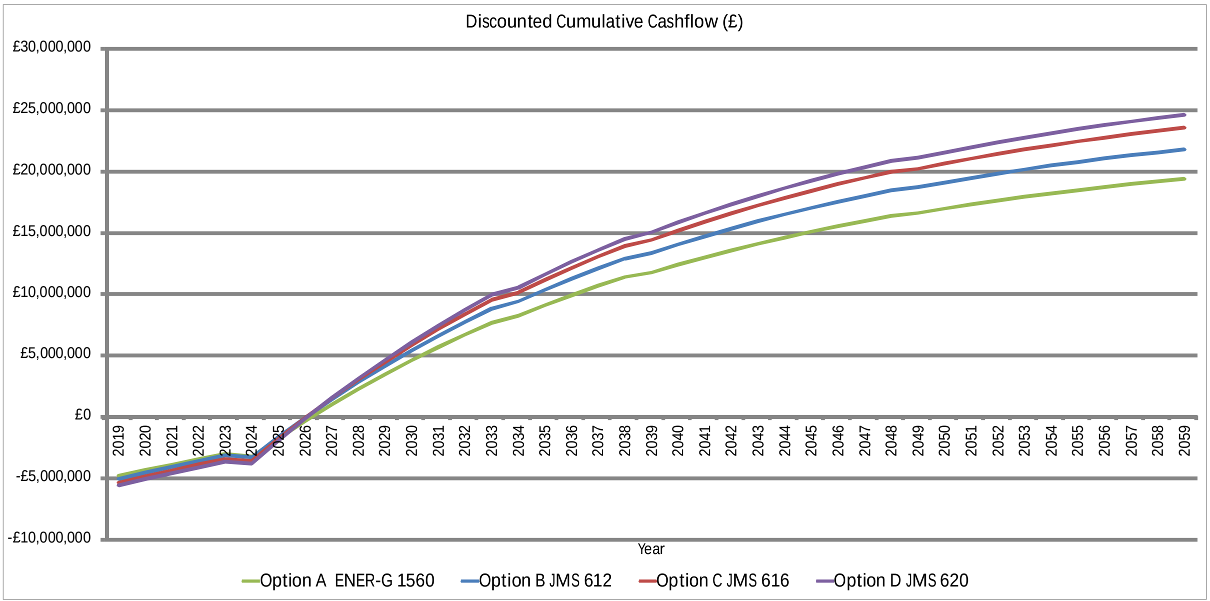
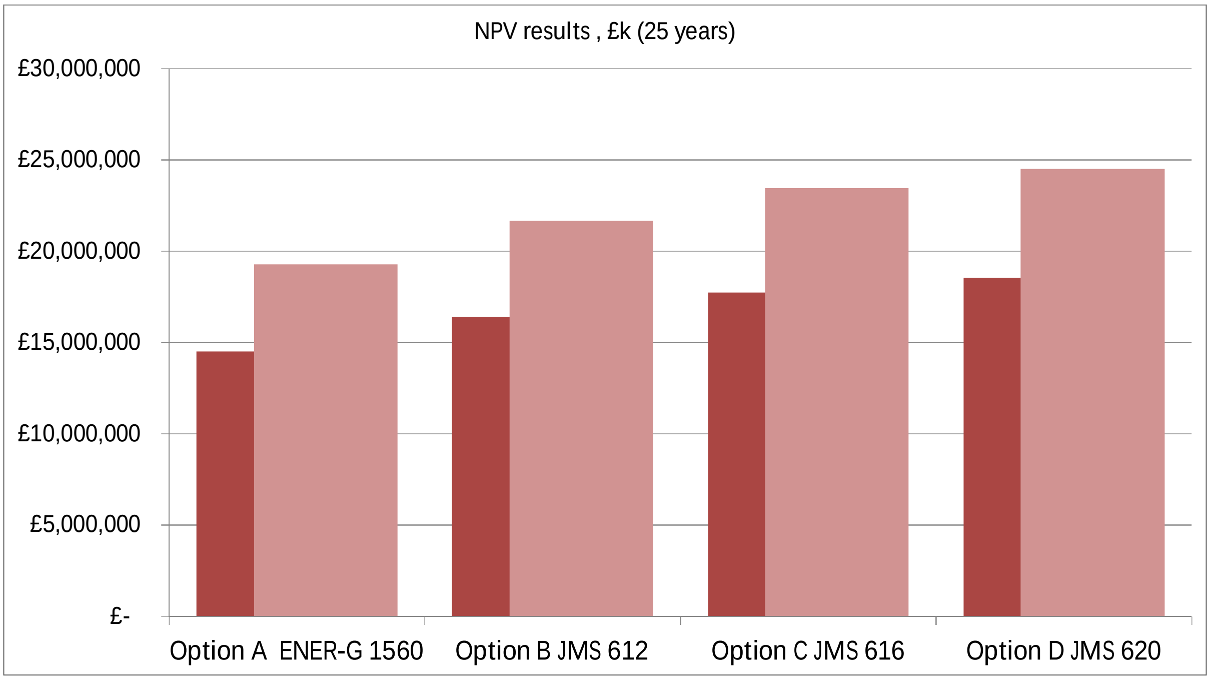


Figure 12-13: Discounted cumulative cashflow, Scheme 8, private wire electricity sales



- 135 -

Figure 12-14: 25 and 40 year NPVs, Scheme 8, private wire electricity sales



12.1.19 These results illustrate a healthy cashflow position under both electricity sales scenarios, and reflect the higher heat density seen under this scheme in comparison to the other networks analysed.

12.1.20 The ability to sell a significant portion of electricity generated on site (i.e. at Convoy's Wharf) will depend on the site design and whether an energy centre operator would be willing to consider sales to domestic customers (on this largely residential development). This key site is also in Lewisham, so delivery of this scheme will require close cross-borough working between Lewisham and RBG.

12.1.21 Full strategic network build-out

12.1.22 In addition to the individual schemes analysed above, consideration has also been given to the potential performance of an overarching network that links these key nodes and centralises supply to the GPS for all of the schemes identified. There are, of course, numerous difficulties to overcome in this aspiration, including:

- Fragmented ownership – potentially different ESCos would be operating different schemes unless early strategic procurement places all schemes under the control of a single operator
- Scale and risk – the implementation of a wide-area strategic network implies significant capital spend and associated risk
- Multiple stakeholders – the implementation of a scheme of this nature would require dialogue with multiple parties and legal agreements to ensure all interests are protected.

12.1.23 Analysis has been based upon linking the key networks identified in this report -i.e. Schemes 2, 6, and 8 and with the further addition of inclusion of the Greenwich

- 136 -

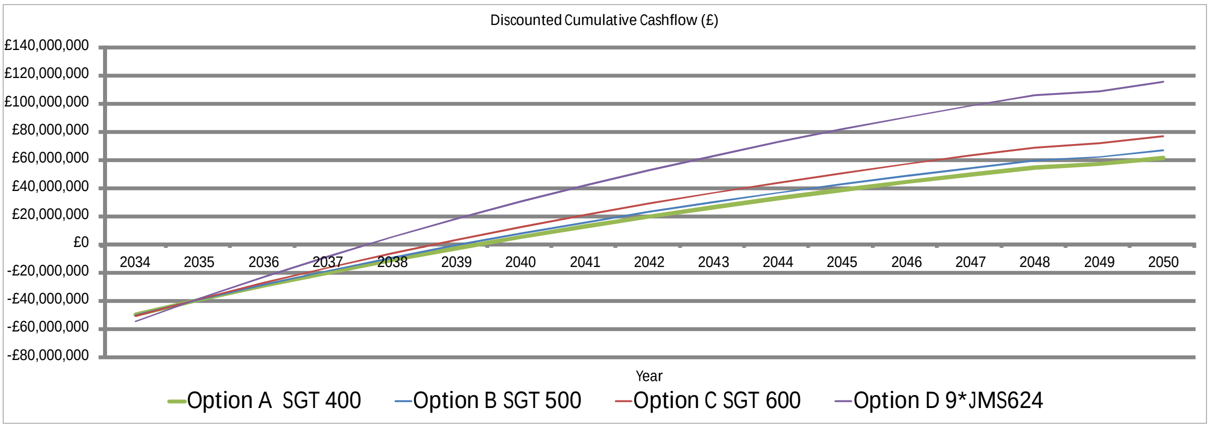
Peninsula loads, and also linking to Lewisham hospital as a key load to the south of the GPS. More speculative connections across the river (via the Silvertown Tunnel) have not been included at this stage, but should not be discounted if the tunnel goes ahead.

12.1.24 The economic performance of this scheme has been based upon assuming connection of the schemes from a purely technical perspective – i.e. only considering the costs associated with the additional heat generation plant, linking elements of district heating main, etc, and *not* considering the commercial position that operators of the individual schemes may take. This report effectively assumes that the kick-start networks could be taken on by a single central operator at the cost equivalent to the individual scheme's cost position at the time of takeover.

12.1.25 This full network includes the Greenwich Peninsula loads and the network that has been assumed to be constructed by Pinnacle Power to serve the Peninsula sites. The sale of heat to this area is assumed to be on a bulk supply basis (i.e. at the Peninsula energy centre demarcation point).

12.1.26 On this basis, the following discounted cumulative cashflow is generated:

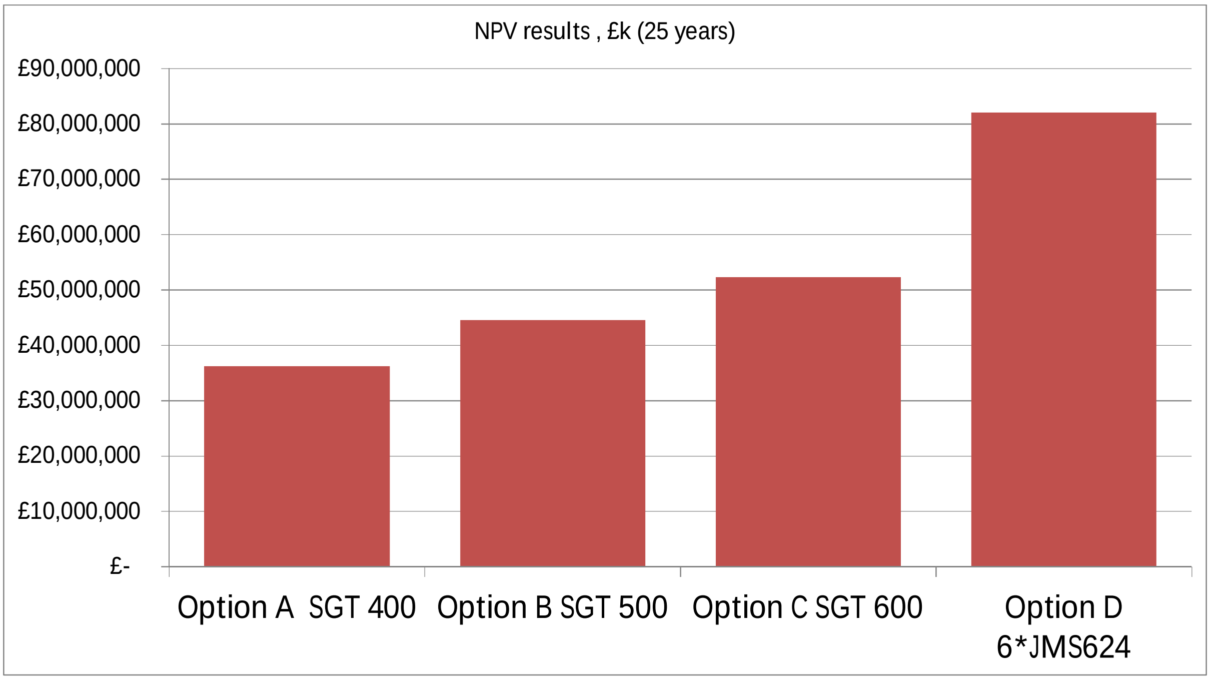
Figure 12-15 Full strategic network discounted cashflow



12.1.27 This chart also indicates that the most economic scheme appears to be the more electrically efficient gas-fired engine (rather than turbine) options. However, this technology-specific result is strongly predicated upon the spark-spread[27] predictions in the timeline that are derived from the base tariff assumptions and indexation. It is assumed that the selection of plant for the GPS will be made by TfL and will be informed by a number of factors including, their view of forward prices the physical space available and other related considerations – these are being investigated by TfL under a separate workstream.

[27] Difference between the price which can be achieved for electricity and heat

Figure 12-16 Full strategic network NPV (6%, 25 years)



12.1.28 This chart illustrates that the full strategic network offers substantial return on the basis of this techno-economic analysis. This highlights that the key barriers are likely to be commercial and potentially political, rather than technical in terms of this scheme's viability in implementation.

12.1.29 Summary

12.1.30 Of key note within the results presented in this section is the significant impact which electricity sales price is able to have on the performance of the schemes. Selling via a private wire network – and thus being able to access a higher price per kilowatt-hour – is, unsurprisingly, able to greatly increase the NPVs of the schemes examined.

12.1.31 To this end, when sizing CHP plant as designs move forward, it is recommended that they be partially selected on the basis of electricity demands which can be served – via a private wire network, rather than solely on the basis of heat demands (although care should be taken to ensure that the CHP is not oversized for the heat demands present – i.e. that heat is not dumped excessively). The identification of key high-power demand sites such as data centres, process factories, or similar may be key to this.

12.2 Funding gaps

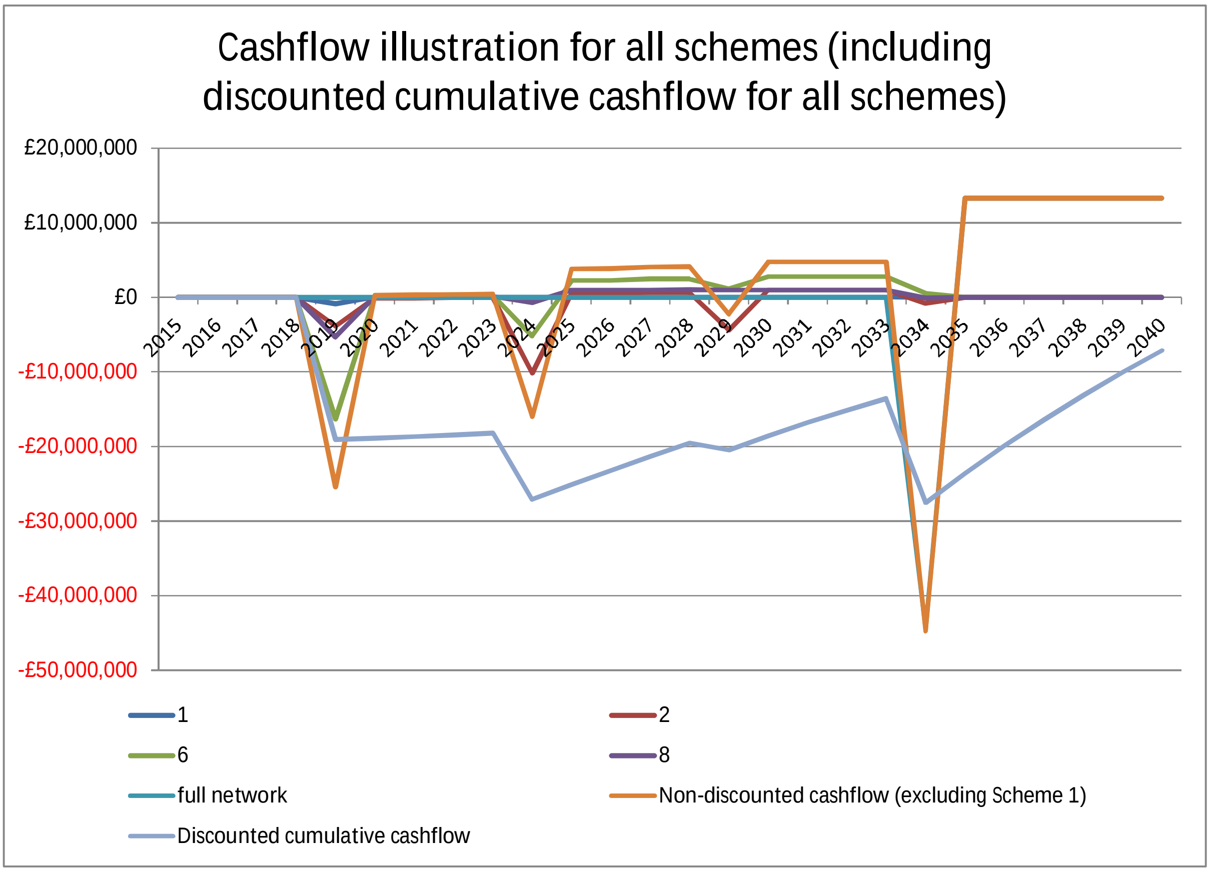
12.2.1 The techno-economic analysis outlined above has identified that in order to deliver the schemes across the borough and make progress towards the carbon reduction targets required; there is funding gap (i.e. negative NPVs at 6% discount rate over 25 years) as identified below.

12.2.2 The approach used to evaluate the total funding gap is to combine the non-discounted cashflows of all the schemes, and to identify the whole life cost of all of

- 138 -

these schemes over a 25 year period. Graphically, the non-discounted cashflows are illustrated below:

Figure 12-17 Gap funding calculation illustration



12.2.3 When discounting the cumulative cashflow from all schemes over 25 years at 6% discount rate the 'funding gap' identified for these projects is as illustrated by the 'Discounted cumulative cashflow' line on the graph above:

Table 12-1 Funding gap as proxy for CIL setting

Funding gap, calculated at 6% discount rate, 25 years from 2015
£7m

12.2.4 The Community Infrastructure Levy is designed, inter alia, as a means to help strategic projects such as district energy be delivered. The sum of the NPV results (6% 25 years) of the identified schemes is considered here to be a 'proxy' for the level of CIL support that these projects would require. This is only an indicative figure, as this approach does not take into account the degree to which funds would be required at the 'front-end' of the projects to implement them, nor the cost of funding.

12.2.5 It may also be noted that the basis of this report is likely to represent an underestimate of the potential actual heat demands emerging as new developments /

- 139 -

refurbishments over the project timeframe. Further development sites are likely to come forward in the vicinity of the networks proposed here, which would increase income from heat sales at marginal overall additional cost (assuming reasonable proximity to the networks proposed). This would improve the overall project performance.

12.2.6 It should also be noted that this cashflow also delivers a positive NPV at the Treasury Green Book recommended assessment criteria for infrastructure projects – i.e. 3.5% discount rate over 25 years. The NPV figure under this assessment criterion is £685k.

- 140 -

SECTION 13

WHERE SHOULD DISTRICT ENERGY BE IMPLEMENTED FIRST?

- 141 -

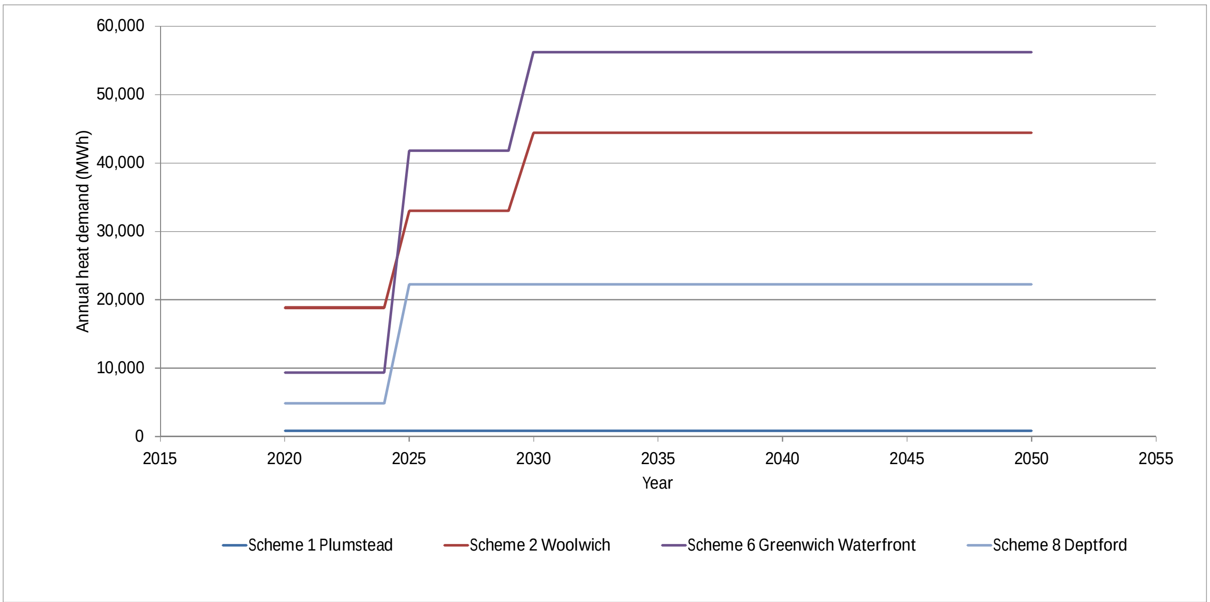
13 WHERE SHOULD DISTRICT ENERGY BE IMPLEMENTED FIRST?

13.1.1 Implementation of district heating networks within the RBG will require both the coincidence of development loads to connect, and the establishment of a suitable vehicle for delivering projects.

13.1.2 The early date of emergence of the Plumstead scheme, coupled with its relatively small scope / scale indicate that this scheme could be an excellent early project on which to test the formation of a delivery vehicle. This scheme consists of only two loads – an existing school (assumed to be within RBG's control), and a new residential development. Thus this project could be a useful testing ground for the relationship and tensions between the private and public sectors in a project of a manageable scale. However, the poor financial performance of this scheme as it currently stands would be improved with additional load, and RBG's decision as to whether to pursue this scheme may depend on assessment of the likelihood of other development coming forward in the immediate vicinity in the near future.

13.1.3 Thereafter, the sequence of proposed implementation has been derived from the build-out programmes for the developments which would provide loads for the various schemes. The emergence of loads is illustrated here:

Figure 13-1 Load development of schemes



13.1.4 The emergence of developments across these schemes does not neatly fall into a sequential pattern, and hence it is not easy to prioritise developments on timing alone. However, when combined with the financial performance of the schemes, the following table of priorities has been derived:

Table 13-1 Scheme phasing

Schemes	Timescale	Notes

Scheme 1 – Plumstead	Immediate – in line with King's Garages site development (go / no-go decision dependent on view of potential for additional load to be connected)	Small-scale, test opportunity, low economic return, mix of public and private sector
Scheme 6 – Greenwich Waterfront	Immediate - in line with funding opportunities from GLA and identified site loads	Small-scale scheme based on heat pump technology and connection of development sites as per DEPDU study
Scheme 6 – Greenwich Waterfront	2016 – The emergence of this scheme will depend both upon the development of large sites towards the Peninsula (i.e. Enderby's, Lovells, former Greenwich district hospital) and upon negotiations with existing loads (and tying up with their existing plant replacement cycles i.e. Naval College, Maritime Museum). Also to be taken into account is the process of permitting relating to the UNESCO World Heritage Status of the area.	Larger network based on gas-fired generation technology supplying Greenwich Town Centre and loads towards Peninsula possibly in combination with a 'kickstart' heat pump system
Scheme 2 – Woolwich	2018-2020 - This assumes that it will be difficult to impact the Woolwich Centre, Love Lane masterplan areas immediately, but that a scheme could materialise with the Bathway Quarter, Connaught Estate and DLR station developments, and thereafter grow to capture the Woolwich Centre loads.	Medium-scale, early-phase design of scheme must consider full-scale build-out, but also be development led in terms of early connections. Potential to incorporate significant existing demands
Scheme 8 – Deptford	2020 – This scheme's emergence will be linked to the Convoy's Wharf development predominantly.	Cross-borough working, mix of development.
Full network	2030 – Dependent upon the commercial structures operating and the shape of development moving forward during this period.	High capital investment required, and associated risk. Significant reward and strategic benefit.

SECTION 14

CARBON CALCULATION

- 145 -

14 CARBON CALCULATION

14.1 Borough-wide emissions

14.1.1 The project rationale section quantified the carbon reductions targets that can be attributed to the Royal Borough of Greenwich. In order to maintain compatibility with these targets, the factors that are adopted in this assessment are those that were also used to calculate these borough-wide emissions.

14.1.2 The estimated carbon emissions reduction target (to achieve mayoral aspirations in 2025) across the Borough is 459 ktonnes CO_2 per annum.

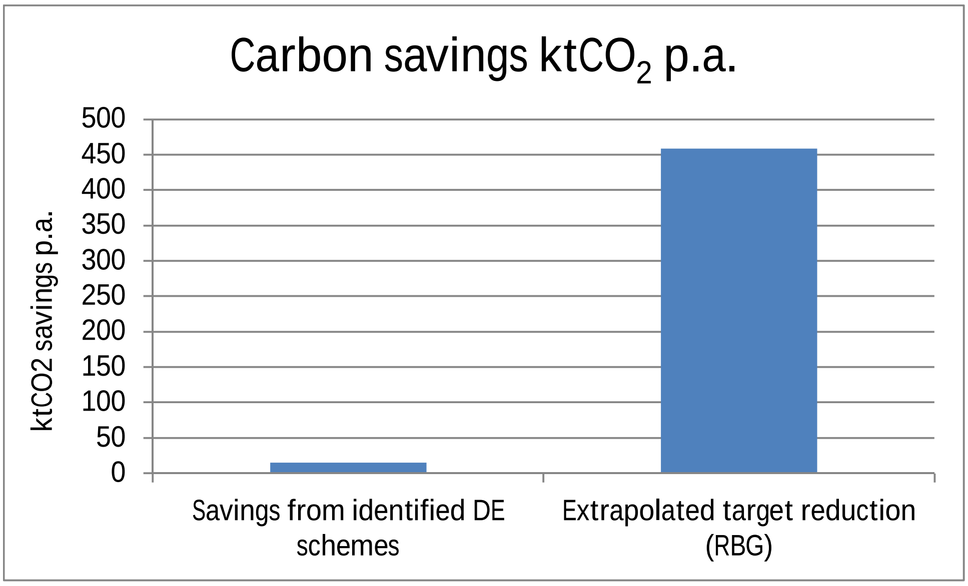
14.1.3 A summary of the emissions savings that are calculated to be generated by the different schemes by 2025 is shown below:

Table 14-1 Emissions savings in 2025

Scheme	2025 emissions savings (tCO_2 p.a.)
1 - Plumstead	54
2 - Woolwich	4,186
6 - Greenwich waterfront	7,494
8 - Deptford	3,618
Total	**15,351**

14.1.4 This table illustrates that only 15ktonnes CO_2 savings p.a. are predicted through this modelling to be delivered by DE networks. In comparison to the extrapolated target this compares as illustrated below:

Figure 14-1 Projected carbon savings and extrapolated target



14.1.5 This does not take into account various other DE initiatives in the borough – i.e. Kidbrooke Village DH scheme, the Pinnacle Power energy centre on the Greenwich

Peninsula. Nevertheless, where there is significant new development, there is normally an increase in building quantum. Even under generous assumptions relating to the balance between increasing demands on a site like Greenwich Peninsula and energy efficient supply, it can be seen that there is likely to be significant shortfall between the extrapolated RBG target and the carbon savings delivered through DE projects. This suggests that efforts both in terms of DE and other mechanisms must be pursued aggressively in order to approach the carbon savings needed.

14.1.6 Other factors will also contribute towards carbon savings (i.e. decarbonisation of the grid, Green Deal take-up, etc.). These have not been estimated here.

- 148 -

SECTION 15

DELIVERING THE MASTERPLAN

- 149 -

15 DELIVERING THE MASTERPLAN

15.1.1 This report identifies an accessible technical potential for the expansion of DH within the Royal Borough of Greenwich to 2050, and considers what actions are required to deliver this potential. This section considers some of the historical means of delivery of decentralised energy, and also considers the planning / funding options that RBG could utilise moving forward.

15.1.2 It is split into the following main sections:

- Potential ownership and operation structures
- Points of planning intervention
- Sources of funding
- Implementation mechanisms

15.2 Background to commercial arrangements for district heating in the UK

15.2.1 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 driven by the lack of public funding for infrastructure projects but also by the acceptance that systems need to be managed and maintained in a commercially viable manner, requiring a range of technical and commercial skills not always available in the public sector.

15.2.2 Therefore the process of investigating potential business models for district-heating based ESCOs and energy services schemes starts with an acknowledgement that, until recently, there were no private sector companies capable of delivering large scale DH 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.

15.2.3 There are a few examples of city DH 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.

15.2.4 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 the carbon footprint of buildings overall. This has created a market for ESCOs amongst developers seeking to contract out their carbon reduction 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

- 151 -

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.

15.3 Potential approaches for development of DH

15.3.1 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 below. 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 15-1: Approaches to delivering district heating

Description	Funding	Construction	Ownership	O&M	Examples
Public Sector - traditional	Local authority funds Grant funding over 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 over 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 / Cofely GdF Suez
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, E.ON Myatt's Field
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

15.4 Ownership of DE assets, operation, ESCOs

15.4.1 Local authorities have more recently been unwilling to become involved *directly* in the delivery and on-going operation of DE assets. 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.

15.4.2 However, should RBG wish to develop a role more akin to that of an ESCO operator (i.e. broadly in line with the Public Sector Traditional model outlined in the table above Table 15-1) then there are some key benefits, which are outlined below.

Table 15-2: Benefits of RBG as utility services provider

Benefits
RBG’s ability to access low cost finance (Prudential Borrowing or Public Works Loan Board)
RBG 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

15.4.3 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 RBG’s long-term aspirations and policy targets.

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

Table 15-3: RBG 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, DH 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

15.5 Operation of schemes

15.5.1 The requirement for skilled and experienced resources is not restricted to scheme development. There is some evidence 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 DH 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.

15.5.2 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.

15.6 RBG as distribution asset owners

15.6.1 One means through which RBG could significantly alleviate some of the current key risks and barriers to DH 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 RBG 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.

15.6.2 A number of key actions on RBG would be linked to this route, including:

- Creating a suitable vehicle to allow this asset ownership model to be implemented
- Ensuring that RBG's role as planning authority and asset owner would not breach anti-competition laws
- Committing the financial resource to the scheme required to install future-proofed networks with the anticipation of long-term paybacks that are linked to customer take-up risk
- Devising an equitable heat-transfer charging regime that is informed by potential load growth projections

15.6.3 The key risk that RBG would face under this model is the growth of operational income in line with a customer base, and the uncertainty regarding the take-up of connection to the system. This risk is to a degree within the council's gift to mitigate,

- 154 -

through planning policy implementation, but is also linked to market conditions and geographic factors (i.e. will development emerge sufficiently close to the network?).

15.7 RBG as whole system owner

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

- 155 -

15.8 Points of planning intervention

15.8.1 The implementation of district heating networks can be incentivised at the planning stage, with measures implemented to encourage the connection of new developments.

15.8.2 There is a strongly DH supportive existing regional planning framework (The London Plan), and local policies that also support renewable energy and community heating infrastructure. It is therefore suggested that it is the *implementation* of these policies that must now be robustly carried forward. There is technical guidance available from the GLA and the document 'District Heating Manual for London'. The council should ensure that officers are comfortable dealing with the technical aspects of applications, and that they are aware of the advice available from other bodies in assessing development plans coming forward.

15.8.3 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 heating system design can only be applied to new developments or major refurbishments requiring 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.

15.8.4 High infrastructure costs will be a barrier to viable DH scheme development across the Royal Borough of Greenwich 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 DH 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 central boiler house. This reduces the extent of DH network infrastructure requirement in the event of a wider DH scheme coming forward that links these developments, as there is a single point of connection from which each development can be served.

15.8.5 Where a district heating pipe network is either installed or planned, new development should be required to connect, as maximising the connected loads is of key importance in achieving an economically viable scheme. Policy should mandate that the onus be on the developer to prove that connection to the network is not feasible, should they elect not to do so. This should be the case both for future networks described within this document (within a reasonable timescale), but also for those existing networks – such as at Kidbrooke Village.

15.8.6 The table included with the network design section of this report (Table 7-1: Phased network implementation) highlights the potential need for provision of local heat supply plant before a network emerges. This underlines the need to have policy in place early, in order to help elicit clear commitment from developers to connect when networks emerge.

15.8.7 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.

- Space provision within plant rooms for installation of the plate heat exchanger and pipework for interfacing the DH 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 DH scheme.

- Secondary system designs that complement the optimisation of DH network design and subsequent reduction of network costs. Specifically:

  - Low loss headers and DH stab-in points downstream of the header to enable hydraulic prioritisation of DH heat over boiler heat in the event of a baseload network connection in which heat from a DH 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.

15.8.8 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 expensive. The cumulative impact on a DH network that connects several developments with these features would be significant in terms improving efficiency.

- 157 -

15.9 Funding Mechanisms

15.9.1 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.

15.9.2 Potential funding mechanisms include:

- Carbon offset funds
- Allowable Solutions
- Planning obligations
- Community Infrastructure Levy

15.9.3 Carbon offset funds

15.9.4 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 further tighten standards to deliver a further 6% reduction across the anticipated build mix.

15.9.5 There are a number of measures which developers can adopt to reduce carbon emissions, but local constraints may mean that it is not possible to apply 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.

15.9.6 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.

15.9.7 Carbon offset funds in other London boroughs

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

15.9.9 Implementation in Tower Hamlets

15.9.10 Tower Hamlets' *Supplementary Planning Document (SPD): Planning Obligations*[28] sets out the council's approach to planning obligations in the borough, and covers the full range of obligations and charges.

15.9.11 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)

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

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.

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]

15.9.12 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 CO_2 reduction measures must be made and a contribution will also be sought.

15.9.13 Tower Hamlets is seeking to have a CIL adopted in 2014 (following Examination in Public hearings that took place in May 2014, and submissions of further evidence in July / August 2014).

15.9.14 Implementation in Islington

15.9.15 The London Borough of Islington has a carbon offset fund in place, implemented through Section 106 agreements. The council's Environmental Design SPD[29] 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, 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.

15.9.16 The council is also in the process of implementing a CIL[30] 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.

15.9.17 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

[29] http://www.islington.gov.uk/publicrecords/library/Planning-and-building-control/Publicity/Public-consultation/2012-2013/(2012-10-22)-Environmental-Design-SPD-FINAL.pdf
[30] 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

carbon offset payments and monitoring of CO_2 savings delivered will be managed by the council."

15.9.18 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. RBG could adopt a similar CIL strategy, and funds from this could be used to implement low carbon schemes within the borough, including district heating systems.

15.10 Allowable Solutions

15.10.1 The Government is committed to an 80% reduction in carbon emissions levels by 2050. One element of the approach to delivering these savings is the use of 'allowable solutions' to assist developments achieve zero carbon targets.

15.10.2 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 the requirements of the Code for Sustainable Homes. 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.

15.10.3 The Allowable Solution framework is still in development, however if it is correctly designed Allowable Solutions could help the deployment of district energy. It is conceivable that an RBG Allowable Solutions fund could, subject to appropriate accreditation, receive capital from developers wishing to offset their carbon reduction obligations which could then be used to fund investment in DE infrastructure.

15.10.4 Planning Obligations – 'Section 106'

15.10.5 Planning obligations, also known as Section 106 Agreements (negotiations that take place under the terms of Section 106 of the Town and Country Planning Act 1990), are legally binding commitments made by developers to mitigate the impacts of a development – for example, greater use of local schools, parks, roads etc. – by contributing to the local community. They are used to make otherwise unacceptable developments acceptable in planning terms and payment may either be in cash or in kind (e.g. construction of affordable housing). Regulation 122 of the Community Infrastructure Levy Regulations (see below) defines a planning obligation as follows:

A planning obligation may only constitute a reason for granting planning permission for the development if the obligation is:

(a) Necessary to make the development acceptable in planning terms;

(b) Directly related to the development; and

(c) Fairly and reasonably related in scale and kind to the development.

15.10.6 Community Infrastructure Levy

15.10.7 The ability to apply Community Infrastructure Levies (CILs) came into force on 6th April 2010, with the aim of improving the predictability and fairness of planning obligations. They are fixed, non-negotiable and applied to all new developments (although exceptions can be made in certain circumstances).

15.10.8 A levy is made per square metre of new development, to support the local planning authority's wider local and sub-regional development plans. The magnitude of the levy is proposed by the authority, but they are required to demonstrate that the rate does not put overall development in the area at risk. Authorities must also take account of other funding available for infrastructure projects (for example from central government) and demonstrate that there is a clear funding gap which the levy will fill. Authorities are not obliged to make a levy, and can set it at zero should they wish.

15.10.9 It can be seen that there is some similarity between the CIL and the imposition of planning obligations under the TCPA. The Department for Communities and Local Government defines the relationship between the two as:

'*The levy is intended to provide infrastructure to support the development of an area rather than to make individual planning applications acceptable in planning terms*.'

15.10.10 This means that there may be some site-specific instances when a Section 106 agreement may need to be implemented in addition to a CIL before planning permission is granted. However, the two operate in a complementary way and there are measures in place to ensure that developers are not double-charged. It should also be noted that after 6th April 2015 the ability of councils to implement planning obligations will be very restricted, and so a CIL is recommended. Additional advantages include:

- Their fixed nature, which also makes them less time consuming and complicated than Section 106 agreements, which are open to negotiation between council and developer.
- Typically Section 106 agreements are applied solely to major developments; CIL agreements, however, will allow contributions also to be captured from smaller developments.
- Royal Greenwich is likely to have a local CIL regime in place by 1st April 2015. Under current proposals Greenwich's CIL regime will allow CIL contributions to be used for heat network infrastructure.

15.10.11 Heat Network Delivery Unit

15.10.12 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.

15.10.13 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.

15.10.14 HNDU will manage a fund of £7m over two years, to invest in the development phase of heat network schemes. The HNDU was launched in 2013, receiving applications from LAs. HNDU support contributes to the cost of procuring technical reports and advice on different phases of a heat network's development. The first three rounds of funding are now closed (Round 3 closed on 27th June 2014), and whilst it is not yet known how much funding will be allocated as part of Round 3, over £4m was allocated in Rounds 1 and 2.

- 161 -

15.10.15 One action on RBG is therefore to continue to work with the HNDU (and DECC) and ensure that best use of made of the funding available.

15.11 Appraisal of potential options

15.11.1 The funding and ownership options given in the tables in this section above have varying advantages and disadvantages which generally fall under the following headings:

- Cost of funding
- Risk versus control
- Availability of resources/skills

15.11.2 These elements are discussed below:

15.11.3 Cost of funding

15.11.4 The cost of funding is critical for DH 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. 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 DH 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.

15.11.5 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 usually 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.

15.11.6 Risk versus control

15.11.7 Public sector organisations are generally risk averse and there has historically been a tension between the desire of local authorities 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.

15.11.8 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.

15.11.9 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 RBG need to be considered.

15.11.10 Availability of resources and skills

15.11.11 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 scheme. 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.

15.12 Risks and opportunities

15.12.1 In order to investigate and 'localise' generic risks and opportunities that typically apply to district energy projects, PB held a workshop at the Woolwich Centre on the 5th June, with key representatives from both within the council and the wider stakeholder group invited.

15.12.2 A list of the concerns and opportunities that were raised at this workshop are contained within the appendices to this report, in the form of a 'risk register', that PB would recommend is maintained as a 'live' document to take forward to further stages of project development. This register should be enhanced and more detailed risks added as individual projects progress towards implementation. In this section of the report we have summarised a number of the keys items that we would see potentially impacting the likelihood of DH delivery in the borough. These risks / opportunities are drawn from a combination of PB's past experience of DH delivery, and the concerns raised at the risk workshop by attendees:

Table 15-4 Selection of key risks / opportunities

Risk / opportunity	Potential mitigation / strategic approach to enhance opportunity
Is there sufficient high-level political borough commitment to district energy? Is there sufficient political stability to see this type of project implemented?	Engage early with senior officers of local authority, and keep officers updated on progress / intentions / benefits of investment
The density / quantum of development in the borough represents a great opportunity for DE implementation	Ensure that maximum benefit flows to public sector schemes from this high development density which suits DH roll-out

Risk / opportunity	Potential mitigation / strategic approach to enhance opportunity
Will additional generation plant negatively impact air quality in the borough?	There will inevitably be some local increase in emissions from large plant. Overall impacts must be evaluated against reduction in emissions from local boilers.
Schemes crossing administrative boundaries could lead to enhanced cross-borough working practices	Deptford / SELCHP, the Silvertown Tunnel, and potential connections to the Riverside Resource Recovery plant all represent opportunities to work with other boroughs.
Will it be possible to make a convincing commercial case for developers to connect?	Ensure that all benefits to developers are communicated, and that the business case for schemes is built upon assumptions that allow a commercial case for developers to be made.
This type of project should provide opportunity for the borough to reduce carbon emissions, stimulate regeneration and create jobs	These benefits can all be generated, if individual schemes are delivered correctly.
The GPS network is a key element of this masterplan – who will take ownership of it?	The scale of the GPS network and its strategic significance mean that the public sector, and council officers with RBG in particular, must take ownership of elements of this project. This does not preclude private sector involvement.
Can the technical difficulties of the physical installation be overcome?	Ensure that appropriate phases of design are completed, and that contractors and consultant engineers with appropriate experience are employed.
There is a risk of multiple networks operating in the borough under different ownerships – will these compete and prevent a wider, strategic scheme from emerging?	This will remain to be seen, but at this stage, it is certainly true that a form of strategic control over different network elements would be desirable. However, there are already several market stakeholders (i.e. GMV network operator, Pinnacle Power, TfL).
Will the DH systems installed match the needs of residents?	A correctly designed and financed system will deliver benefits to residents.
How will a DH scheme based around the GPS deal with the UNESCo World Heritage status of the Royal Naval College and surroundings?	This will be the subject of dialogue with UNESCO, English Heritage and local planning.
Will the timeline of the DH networks match developer requirements?	This is essential and must be developed as schemes are moved forward to detailed feasibility stage.

- 164 -

15.13 Customer charters

15.13.1 One further item which should be considered is the necessity for consumer charters. An important aspect of developing public trust in the value / reliability and safety of DH systems is the provision of a standard customer care charter for schemes, which could potentially be included in DE-related planning conditions.

15.13.2 The Combined Heat and Power Association (CHPA) is working to set up a Heat Customer Protection Scheme which will include approving ESCO customer care charters and the provision of a dispute arbitration service.

"The Independent Heat Customer Protection Scheme aims to establish a common standard in the quality and level of protection for household customers and micro-businesses, i.e. the end-users of district heating networks" (Executive summary, Independent Heat Customer Protection Scheme, May 2014)

15.13.3 Progress is being made this scheme lead by a number of CHPA members. They have produced a second draft document[31] (May 2014) through work with active market participants including ESCOs such as EON and SSE. The working group also includes representatives from consumer protection organisation 'Which?'.

15.13.4 The aim is to launch the scheme in 2014.

31 http://www.heatcustomerprotection.co.uk/images/Independent%20Heat%20Customer%20Protection%20Scheme%20Revised%20Proposals.pdf, accessed 26th June 2014

SECTION 16

CONCLUSIONS AND RECOMMENDATIONS

- 167 -

16 CONCLUSIONS AND RECOMMENDATIONS

16.1.1 The high level of regeneration and development planned within RBG over the coming years represents a significant opportunity for the implementation of district energy.

16.1.2 Greenwich Power Station represents a unique physical asset for the borough and the wider surrounding area. There is an exciting opportunity to generate long-term benefits through the confluence of TFL's interests and the amount of new development within the vicinity.

16.1.3 Centralising supply of heat will enable the use of alternative fuels or secondary heat sources at larger, more efficient and economic scales. The GPS has a wharf and access to the Thames, attributes that could facilitate the use of biomass as a fuel source through providing an easy delivery route, and/or the use heat pumps taking energy from the river.

16.1.4 Given the largely existing private residential (where RBG will have fewer powers of intervention) and relatively diffuse nature of the borough, the decentralised energy schemes have been developed within this masterplan only address a small portion of the overall built environment. The schemes are predominantly in the waterfront areas where the higher heat demand densities and development levels allow more viable schemes to emerge. Decentralised energy as a result is predicted only to deliver savings in a small portion of the borough, leaving significant carbon savings to be delivered through other means.

16.1.5 A whole life discounted cashflow calculation of a 'funding gap' for the identified schemes in the borough is £7m (for a 25 year period). This is before any CIL support for heat networks or other funding mechanisms are taken into account.

16.1.6 The following table illustrates some parameters for the schemes identified.

Table 16-1 Key parameters of identified schemes

	Scheme 1	Scheme 2	Scheme 6	Scheme 8	Full Scheme
	Plumstead	Woolwich	Greenwich Waterfront	Deptford	Strategic network
Technical parameters					
Annual heat demand (excl. losses) (kWh p.a.)	810,252	33,945,846	53,346,956	20,567,893	218,128,802
Peak heat demand (kWth)	831	41,756	65,386	6,173	219,605
Total network length (m trench)	249	7,598	8,739	2,709	30,484
Financial parameters					
Network capital cost	£251,000	£9,440,000	£12,298,000	£3,455,000	£43,887,000
Scheme capital cost	£886,000	£3,834,000	£16,525,000	£5,441,000	£59,066,000
Carbon savings up to 2034 (tCO_2)	804	59,534	89,976	40,302	
Carbon savings for full scheme 2035-2055 (tCO_2)					499,686
Linear heat density (MWh / m network)	3.25	4.47	6.10	7.59	7.16

16.2 Recommendations/ next steps

- The strategic recommendation of this report is to centralise the generation of heat and power to the Greenwich Power Station in the long term. This will allow for significant scale (and concomitant efficiencies and economies) of combined heat and power generation. The GPS has a high-capacity gas supply (300MW) and connection to the TfL electricity network. This means that in some key respects, the GPS is an excellent location for installing CHP plant.

- Protection of a strategic district heating link to Royal Docks and Canary Wharf areas is strongly recommended as part of the Silvertown Tunnel works (should this road project be taken forward). Two major energy centres south of the Thames in the form of the GPS and a new energy centre on the Greenwich Peninsula are coming forward, and the loads around Canning Town, Royal Docks and Canary Wharf represent major load centres with high heat densities. The potential to link these demands and heat generation centres should be enabled at the time of the tunnelling works across the river. Given the infrequency of opportunities of this nature to install DH pipework, it would be recommended that this strategic infrastructure is installed with at least 500mmNB DH pipework.

- It is recommended that the RBG consider the likelihood of further development coming forward within close proximity and within a reasonable time-scale of the Plumstead scheme identified in this masterplan. However, the scheme as currently conceived only generates marginal operational income at present, and additional loads are required to render this opportunity worth pursuing. On the basis of the currently identified opportunity, it is recommended that this scheme is not pursued.

- RBG should hold internal and external facing discussions, including liaison with HNDU / DECC in order to establish what form a suitable delivery vehicle might take for the implementation of both early phase schemes and a wider strategic linking network.

- Liaise with the London Borough of Lewisham to evaluate the potential for joint working both in Deptford, and in terms of a long-term link to Lewisham Hospital (which would require conversion to LTHW to be compatible with this network).

- Ensure that in the areas surrounding existing (and planned) DH schemes developments coming forward are made DH ready with immediate effect. This should allow a critical mass of DH compatible development to be tracked, and for RBG to highlight potential opportunities to incumbent scheme operators.

- Should alternative proposals for energy generation plant adjacent to Belmarsh Prison come forward, this plant should be obliged to connect (heat and potentially power) to Belmarsh Prison or demonstrate why this is not feasible.

- RBG should engage with the prospective developers of the Morden's Wharf site, Energy10, and the Environment Agency in order to evaluate whether a waste pyrolysis plant may form part of the supply mix moving forward in Greenwich.

- RBG should engage with English Heritage and Unesco World Heritage in order to establish the processes that will be required to implement a DH system within the boundaries of the Royal Naval College or surroundings.

- 170 -

17 APPENDICES

17.1 Appendix A - Loads considered in different schemes

Area 1 - Plumstead

Address	Annual Heat Demand (MWh)
Existing buildings	
Plumstead Manor Secondary School (Sixth Form Negus Centre)	373
New developments	
Kings highway garage	437

Area 2- Woolwich

Address	Annual Heat Demand (MWh)
Existing buildings	
Bill Walden House (Sheltered) (Communal Heating)	389
Elliston House	1,147
Fitness First Ltd	619
Frances Street (Block 4)	354
Frances Street 179-285	354
Greenwich Heritage Centre	219
Kingsman Street 1-99	303
Mulgrave Primary School	291
Mulgrave Primary School and Early Year's Centre	233
Old Library (Greenwich Local Labour and Business)	202
Riverside House	722
Royal Artillery Museums	1,115
St Mary Magdalene CE Primary School	341
St Peter's RC Primary School	154
Woolwich Dockyard (Communal Heating)	5,426
Woolwich Dockyard Day Centre	187
WOOLWICH FERRY OFFICES	700
WOOLWICH FIRE STATION	289
Woolwich Town Hall	948
New developments	

Above DLR station	616
Callis Yard	399
Connaught Estate	2,511
Crossrail OSD	684
Love lane masterplan	3,961
Macbean Street	2,030
Mast Pond Wharf	366
Royal Arsenal Warren Masterplan	10,040
Woolwich Centre	2,012
Mast Quay	782
Bathway Quarter	2,723
Greenwich Waterfront Leisure Centre	433
Former Gala Bingo and Mortgramit Square	825
Spray Street	1,230
New Ferry approach	1,803

Area 6 – Greenwich Waterfront

Address	Annual Heat Demand (MWh)
Existing buildings	
Dreadnought Library	932
Dyson House	443
Ernest Dence	1,365
Frobisher Court	105
Arches Leisure Centre	2,878
Greenwich Police Station	341
Greenwich Theatre	638
Haddo House	677
James Wolfe Primary School	443
KING WILLIAM IV HOTEL	131
MERCHANTS HOUSE	394
Meridian Primary School	211
Miles House	210
Mortuary and Coroners Office	264

National Maritime Museum (Visit Britain Assessed)	4,680
Robert Owen Early Year's Centre	171
Rockfield House	369
Royal Naval Chapal	193
Royal Naval College	435
Sam Manners House (Sheltered)	785
Selcroft House	935
St Alfege with St Peter's Primary School	137
St Joseph's RC Primary School	172
Stanton House	369
Stephen Lawrence Building	209
The Hayloft	236
Thornham Street	430
Trafalgar Quarters	345
Trafalgar Tavern	821
TRINITY HOSPITAL	606
Trinity Laban Conservatoire	894
Vista Apartments	241
Borough Hall	2,389
Coltman House	430
New developments	
1-3, 9-27, 33&37 Blackwall Lane	681
The Quarter	2,289
Creek road/bardsley Lane	433
Davy's winecellar site	413
Greenwich High Road Backland	248
Telegraph Works/ Alcatel-Lucent	2,156
Enderbys Wharf	4,663
Former Greenwich District Hospital	4,859
Greenwich Industrial Estate	3,806
Greenwich reach east	5,374
Hiltons Wharf	374
Lovells/granite/pipers wharf	6,286
Stockwell Street	772

- 173 -

Area 5 – Greenwich Peninsula as single load

Address	Annual Heat Demand (MWh)
Area 5	64,004

Area 8 - Deptford

Address	Annual Heat Demand (MWh)
Existing developments	
Charlotte Turner Centre	281
Lapwing Tower (Taylor Close, Lewisham)	614
Marine Tower (Abinger Grove, Lewisham)	614
Mermaid Tower (Abinger Grove, Lewisham)	614
Dolphin Tower (Abinger Grove, Lewisham)	614
Kent and Sun Wharf	557
	New developments
Creekside Village East	984
Creekside Village West	2045
Paynes & Borthwick Wharfs	939
Convoys Wharf	14,932

Additional loads in full network

Address	Heat_Demand_mWh
Loads in branch to Lewisham Hospital	
Dutton Street (Communal Heating)	1,445
Egremont House	431
Ellison House	343
GREENWICH FIRE STATION	285
Morden Mount Primary School	274
Pitmaston House	249
Russett Way 1-54	329
Warner House	211
Woodville Court/Jervis Court	391

LEWISHAM BRIDGE (ELMIRA STREET)	387
Granville Park CEL (100 GRANVILLE PARK)	131
UNIVERSITY HOSPITAL LEWISHAM (LEWISHAM HIGH STREET)	19,480
Heathside & Lethbridge (BLACKHEATH HILL)	1,177
Connington Road	1,474
Loampit Vale Railway Strip	180
Loampit Vale (W of Jerrard Street)	1,221
Lewisham Gateway	1,485
Loampit Vale (E of Jerrard Street)	650
Loampit Vale (E&W of Elmira Street)	2,370
Other additional loads	
The Reach	101
Mayron Road/Grove Estate	778
Morris Walk Estate	3,387
ENVIRONMENT AGENCY	280
Gallon Close, 24-47 (Communal Heating)	297
Gallon Close, 24-47 (Communal Heating)	103
Hickin Close, 35-58 (Communal Heating)	212
Barney Close, 79-101 (Communal Heating)	101
Woodhill Primary School	314
Royal Mail Greenwich and Charlton Delivery Office	580
Cleveley Close 2-22 (Communal Heating)	268
Charlton Riverside	6,521

- 175 -

17.2 Appendix B – Capital Cost Assumptions

17.2.1 Scheme 1 – Plumstead

	ENER-G 50	ENER-G 70	ENER-G 90	ENER-G 110
CHP engine	£123,000	£128,000	£131,000	£141,000
Energy centre	£0	£0	£0	£0
Controls and instrumentation (inc metering)	£102,000	£102,000	£102,000	£102,000
Electrical works	£49,000	£49,000	£49,000	£49,000
Flue	£30,000	£30,000	£30,000	£30,000
Top-up boilers	£112,000	£112,000	£112,000	£112,000
Gas connection	£20,000	£20,000	£20,000	£20,000
HIUs (commercial)	£23,000	£23,000	£23,000	£23,000
Pipework (water)	£25,000	£25,000	£25,000	£25,000
Pipework (gas)	£15,000	£15,000	£15,000	£15,000
Pumps	£63,000	£63,000	£63,000	£63,000
Thermal Store	£10,000	£14,000	£20,000	£20,000
Ventilation	£4,000	£4,000	£4,000	£4,000
DH network	£251,000	£251,000	£251,000	£251,000
Professional services fees (engineering)	£35,000	£35,000	£35,000	£35,000
Professional services fees (other)	£41,000	£41,000	£41,000	£41,000
TOTAL	**£900,000**	**£910,000**	**£920,000**	**£930,000**

- 176 -

17.2.2 Scheme 2 – Woolwich

SCHEME 2				
	JMS 624	**2*JMS 612**	**2*JMS 616**	**2*JMS620**
CHP engine	£1,896,000	£2,237,000	£2,720,000	£3,322,000
Energy centre	£868,000	£1,041,000	£1,132,000	£1,146,000
Controls and instrumentation	£184,000	£184,000	£184,000	£184,000
Electrical works	£750,000	£750,000	£750,000	£750,000
Flue	£500,000	£500,000	£500,000	£500,000
Top-up boilers	£1,879,000	£1,879,000	£1,879,000	£1,879,000
Gas connection	£20,000	£20,000	£20,000	£20,000
HIUs (commercial), Phase 1	£150,000	£150,000	£150,000	£150,000
HIUs, commercial, Phase 2	£86,000	£86,000	£86,000	£86,000
HIUs, commercial, Phase 3	£135,000	£135,000	£135,000	£135,000
Pipework (water)	£413,000	£413,000	£413,000	£413,000
Pipework (gas)	£172,000	£172,000	£172,000	£172,000
Pumps	£210,000	£210,000	£210,000	£210,000
Thermal Store	£256,000	£256,000	£256,000	£256,000
Ventilation	£205,000	£205,000	£205,000	£205,000
DH network Phase 1	£2,867,000	£2,867,000	£2,867,000	£2,867,000
DH Network Phase 2	£2,429,000	£2,429,000	£2,429,000	£2,429,000
DH Network Phase 3	£4,144,000	£4,144,000	£4,144,000	£4,144,000
Professional services fees (engineering)	£1,500,000	£1,500,000	£1,500,000	£1,500,000
Professional services fees (non-engineering)	£1,500,000	£1,500,000	£1,500,000	£1,500,000
TOTAL	**£20,163,000**	**£20,677,000**	**£21,251,000**	**£21,868,000**

17.2.3 Scheme 6 – Greenwich Waterfront

	2 * JMS 616	2*JMS 620	2*JMS 624	2*JMS 612
CHP Plant	£2,720,000	£3,322,000	£3,322,000	£3,356,000
Energy centre	£0	£0	£0	£0
Controls and instrumentation	£239,000	£239,000	£239,000	£239,000
Electrical works	£750,000	£750,000	£750,000	£750,000
Flue	£500,000	£500,000	£500,000	£500,000
Top-up boilers	£3,329,000	£3,329,000	£3,329,000	£3,329,000
Gas connection	£20,000	£20,000	£20,000	£20,000
HIUs (commercial), phase 1	£131,000	£131,000	£131,000	£131,000
HIUs (commercial), phase 2	£340,000	£340,000	£340,000	£340,000
HIUs (commercial), phase 3	£207,000	£207,000	£207,000	£207,000
Pipework (water)	£687,000	£687,000	£687,000	£687,000
Pipework (gas)	£285,000	£285,000	£285,000	£285,000
Pumps	£33,000	£33,000	£33,000	£33,000
Thermal Store	£256,000	£256,000	£256,000	£256,000
Ventilation	£340,000	£340,000	£340,000	£340,000
District heating network phase 1	£6,119,000	£6,119,000	£6,119,000	£6,119,000
District heating network phase 2	£5,160,000	£5,160,000	£5,160,000	£5,160,000
District heating network phase 3	£1,019,000	£1,019,000	£1,019,000	£1,019,000
Professional services fees (engineering)	£1,500,000	£1,500,000	£1,500,000	£1,500,000
Professional services fees (other)	£1,500,000	£1,500,000	£1,500,000	£1,500,000
TOTAL	**£25,140,000**	**£25,740,000**	**£25,740,000**	**£25,770,000**

17.2.4 Scheme 8 – Deptford

	ENER-G 1560	JMS 612	JMS 616	JMS 620
CHP plant	£1,119,000	£1,360,000	£1,661,000	£1,896,000
Energy centre building	£0	£0	£0	£0
Controls & instrumentation	£112,000	£112,000	£112,000	£112,000
Electrical works	£364,000	£364,000	£364,000	£364,000
Flue	£84,000	£84,000	£84,000	£84,000
Gas boiler	£833,000	£833,000	£833,000	£833,000
Utilities	£20,000	£20,000	£20,000	£20,000
HIUs - commercial	£166,000	£166,000	£166,000	£166,000
Pipework - water	£61,000	£61,000	£61,000	£61,000
Pipework - gas	£25,000	£25,000	£25,000	£25,000
Pumps	£15,000	£15,000	£15,000	£15,000
Thermal Store	£243,000	£256,000	£256,000	£256,000
Ventilation system	£30,000	£30,000	£30,000	£30,000
DH network Phase 1	£2,629,000	£2,629,000	£2,629,000	£2,629,000
DH network Phase 2	£825,000	£825,000	£825,000	£825,000
Professional services fees (engineering)	£258,000	£258,000	£258,000	£258,000
Professional services fees (other)	£306,000	£306,000	£306,000	£306,000
TOTAL	£7,090,000	£7,340,000	£7,650,000	£7,880,000

17.2.5 Full scheme – extra-over costs for full network on initial schemes

Full Scheme				
	SGT 400	**SGT 500**	**SGT 600**	**6*JMS624**
CHP plant	£7,500,000	£7,800,000	£8,460,000	£10,515,000
Energy centre building	£20,000	£20,000	£20,000	£20,000
Controls & instrumentation	£300,000	£300,000	£300,000	£300,000
Electrical works	£750,000	£750,000	£750,000	£750,000
Flue	£500,000	£500,000	£500,000	£500,000
Gas boiler	£3,259,000	£3,259,000	£3,259,000	£3,259,000
Utilities	£20,000	£20,000	£20,000	£20,000
HIUs - commercial	£0	£0	£0	£0
Pipework - water	£1,488,000	£1,488,000	£1,488,000	£1,488,000
Pipework - gas	£618,000	£618,000	£618,000	£618,000
Pumps	£893,000	£893,000	£893,000	£893,000
Thermal Store	£427,000	£427,000	£427,000	£427,000
Ventilation system	£1,076,000	£1,076,000	£1,076,000	£1,076,000
DH pumping stations	£530,000	£530,000	£530,000	£530,000
DH network (strategic links)	£18,694,000	£18,694,000	£18,694,000	£18,694,000
Cost of procurement of kick-start schemes (non-discounted cashflow position)	£18,923,000	£18,923,000	£18,923,000	£18,923,000
Professional services fees (engineering)	£1,500,000	£1,500,000	£1,500,000	£1,500,000
Professional services fees (other)	£1,500,000	£1,500,000	£1,500,000	£1,500,000
TOTAL	£58,000,000	£58,300,000	£58,960,000	£61,010,000

17.3 Appendix C – Risk Register (pdf only)

- 181 -